Delivering strong and sustainable growth in the UK:

A special decade for innovation and investment

Special report for the

LSE Growth Commission

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The Grantham Research Institute on Climate Change and the Environment was established in 2008 at the London School of Economics and Political Science. The Institute brings together international expertise on economics, as well as finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute – Climate Change and the Environment at Imperial College London. www.lse.ac.uk/GranthamInstitute

The LSE Growth Commission was set up to provide authoritative and evidence-based policy recommendations that target sustainable and inclusive long-term growth in the UK. Some of its first set of recommendations in 2013, notably on infrastructure, were turned into concrete action by UK policymakers. The Growth Commission is funded by the Higher Education Innovation Fund (HEIF) and the Economic and Social Research Council (ESRC). Its co-chairs are Tim Besley, Stephen Machin, who made valuable contributions to this report, and Nicholas Stern, co-author of this report.

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Authors' declaration

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All of the views expressed in this work are those of the authors and are independent of the funding institutions.

This report is intended to inform decision-makers in the public, private and third sectors. It has been reviewed by internal and external referees before publication.

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Summary

The UK is entering a new decade with a government that has committed to reaching net-zero emissions of greenhouse gases by 2050, to redefining the UK's role in the world, and to reducing regional disparities through the 'levelling up' agenda. These are interdependent ambitions and efforts to address them must recognise this. Done right, in 2030 the UK could have higher living standards, and better health and wellbeing, underpinned by UK businesses innovating and adopting cutting-edge zero-carbon technologies and practices fit for the mid-21st century.

However, the need for these significant economic and social changes is set within a context of ongoing poor productivity performance in the UK. Investment in zero-carbon infrastructure, while critical, will not be enough to attain sustainable and inclusive growth: large-scale sustainable investment in innovation and skills across the country is also required. There has been substantial progress in setting the ambition and direction for sustainable investment. Nonetheless, a step-change is now needed, urgently, in both the amount of investment – public and private – and in the coherence of the policies and institutions that can direct this investment to have maximum impact. Policymakers, investors and other key stakeholders need to work together to align climate change adaptation and mitigation actions with a net-zero emissions trajectory, and to promote international competitiveness in zero-carbon goods and services, given that some countries are already gaining comparative advantage. Immediate action with a long-term, predictable but dynamic outlook is needed.

Four interconnected drivers show that now is the time for action

i) **As the scale and urgency of the global response required to tackle climate change are growing, so too is the opportunity for the UK to enhance its international leadership role as 'Global Britain':** There is increasing recognition of the need for strong and urgent action to tackle climate change, with markets and governments making the transition to zero-carbon economic development and growth. The UK has shown leadership with its commitment to net-zero emissions by 2050 and can set an even stronger example internationally by taking more concrete actions on sustainable investment ahead of the COP26 UN climate conference in November. The invention and diffusion of zero-carbon technologies and practices are necessary across infrastructure and other economic assets. As climate action is scaled up, careful consideration will need to be given to the multiple narratives that accompany plans to decarbonise. The pathway to net-zero must be perceived across the UK as a whole-economy opportunity to deliver material benefits to communities, as opposed to creating costs and inconveniences for households.

ii) **A new economic model is needed post-Brexit to address the UK's poor productivity and move towards a circular economy:** Investments in complementary assets of infrastructure, innovation and skills are crucial for the UK to address its ongoing poor productivity performance, rebalance the economy from consumption towards investment and build strong foundations as the country moves into a new, post-Brexit phase. To be consistent with the commitment to net-zero emissions such investments must help the UK build its innovation strengths in related environmentally sustainable technologies, goods and services, which will enable the country to gain an increased share of new and growing international markets. Innovation policy needs to go beyond merely correcting market failures to be 'mission-driven', creating and shaping markets for zero-carbon innovation activity. It is also necessary to improve resource efficiency through 'circular economy' principles: achieving an economy that is restorative and regenerative through its utilisation of outputs as inputs in a continual cycle.

iii) **The benefits of regionally-balanced growth are increasingly being recognised:** Well planned and sustainable investments will build local capacity and generate economic opportunities, helping to address the UK's large and persistent regional disparities and improve labour market resilience across the country. There is also recognition of the co-benefits of sustainable growth, which include improved health and wellbeing from cleaner, more efficient and liveable cities.

These changes will raise productivity and living standards and help build communities' sense of identity and pride across the UK.

iv) **The economic climate is right for investment:** Interest rates have been low in the UK for some years and are expected to remain so for the foreseeable future. Despite this, investment has remained low in comparison with international competitors. Bond yields indicate that the markets are signalling for more, and not less, public investment, which, together with a stable policy commitment to sustainable growth, will crowd in private investment.

Immediate actions can catalyse a step-change in innovation and investment

The UK is facing deep-rooted challenges in the broad areas of infrastructure, innovation and skills. A strategic approach is required to understand these challenges and how they are interlinked, at both a national and regional level. The economic and climate challenges faced by the UK require *long-term* policies that are also dynamic in the face of technological change, the advance of climate science and emerging evidence on the relative success of different policies. However, there are a number of measures that can be implemented at this critical moment. These would enhance the UK's international leadership credentials, directly impact investment rates in the UK and create both a short-term boost to growth and improved growth prospects for the medium to long term. The Cabinet Office and HM Treasury have overall responsibility for ensuring implementation.

The actions are:

a) **Establish a National Investment Bank with a focus on managing and reducing risk in infrastructure projects to leverage private finance.** The Bank should have an explicit sustainability mandate and should seek out net-zero-aligned projects for which risk levels need to be reduced. A combination of the right financial instruments that lower the cost of capital, and operating under a shareholder structure, can make these projects viable investment propositions, enabling and fostering the participation of the private sector. Ultimately, the Bank would facilitate the movement of capital at scale towards net-zero-aligned projects that cannot currently be financed by the market. Initially there should be a targeted focus on managing and reducing risk in infrastructure projects, although the Bank's mandate could be carefully broadened over time. Project origination and appraisal processes should be rooted in regional development plans and infrastructure needs.
Action lead: HM Treasury

b) **Harness the UK's green finance capabilities to deliver on innovation and investment demands across all regions.** The UK has been world-leading in greening the global finance system and spurring innovation but has been less effective in delivering domestic green investment. Building on the UK's leadership in implementing the Task Force on Climate-related Financial Disclosures (TCFD) and establishing the Green Finance Institute, the Government should now set out a roadmap for bringing the financial system into alignment with the goals of a resilient, net-zero economy – rooting green finance in bottom-up investment needs across the country.
Action lead: Green Finance Institute

c) **Create a shared global agenda of investment in zero-carbon infrastructure and innovation among Parties at COP26, leading by example.** In the months leading up to COP26 in November 2020, the UK can use its role as the conference's president to bring together Parties around a shared global agenda for investments, setting an example through an ambitious programme of sustainable investments in the UK and abroad. *Action lead: COP26 Team within the Cabinet Office in close consultation with a range of other government departments*

d) **Overhaul technical and governance processes to ensure public investment is net-zero-aligned and resilient.** This overhaul should cover a range of aspects, including reviewing the discount rates and carbon prices used in HM Treasury's Green Book, ensuring regulatory bodies place net-zero and resilience at the heart of investments, and reviewing R&D spend.
Action lead: HM Treasury

e) **Give clearer recognition to the roles of anchor institutions such as universities and further education colleges as drivers of place-based, sustainable growth**. As anchor institutions making

strategic contributions to local economies, and as hubs of innovation, universities create enormous potential when working in partnership with industry and ambitious local leaders. Such interactions should be strengthened in order to maximise positive spillovers. The recent underfunding of further education (FE) colleges needs to be reversed, as they play crucial roles in improving labour market outcomes for the large share of young people who do not attend university, in building resilience in the existing workforce via lifelong learning, and in improving the technical skills that will aid the diffusion of new innovations into the economy. *Action leads: Department for Education, Department for Business, Energy and Industrial Strategy, UK Research and Innovation*

f) **Ensure that policy decisions in infrastructure, innovation and skills are consistently aligned with the aim of sustainable and inclusive growth.** This will involve choices – for example, investments made in public infrastructure projects may be at the expense of another area requiring funding. Decisions should be based on the likelihood of positive systemic impacts, taking into account complementarities between different forms of capital and utilising the latest innovations in public participation such as Citizens' Assemblies to ensure that new policies are fair for all and therefore receive public support. It is important that decision-making powers are devolved where appropriate. This should be informed by the capacity in regional or local governments, with consideration given to the appropriate spatial economic unit to make an intervention, and the market failures or barriers to sustainable growth in different contexts. *Action lead: HM Treasury in close consultation with local government, and by extension communities, across the UK*

g) **Utilise public sector procurement to pilot sustainable technologies.** Public sector procurement should seek to promote innovation and creative zero-carbon solutions in areas where the Government is a large buyer. Successful procurement strategies can trial and create demand for goods and services and can then be adopted by the private sector in the UK and overseas. This could enable the UK to delivery significant emissions reductions (recognising that the public sector directly accounted for 4 per cent of total energy consumption in the UK in 2018, and produced further indirect emissions) while also enhancing the UK government's reputation for pushing the boundaries of decarbonisation. *Action leads: HM Treasury and the Crown Commercial Service*

h) **Set out a timetable with key funding commitments into the medium term to deliver net-zero emissions, with lines of accountability for delivery**. While a significant step-change in investment is urgently needed, immediate measures need to be designed as part of a broader strategy to address the complex underlying challenges set out here. The actions needed to set the UK on a sustainable and inclusive growth trajectory include both targeted investments now and forward-looking policy and funding programmes to strategically mobilise further investment. Setting out timetables of funding with clearly demarcated responsibility across the economy can ensure investments are made that pave the way towards net-zero emissions in 2050. *Action lead: HM Treasury*

The 2020 Budget provides an opportunity to set out specific investment in decarbonisation of the economy

The Committee on Climate Change (CCC) has set out, sector by sector, how the UK can achieve net-zero emissions of greenhouse gases by 2050. HM Treasury will soon publish its National Infrastructure Strategy, describing how government can respond to the National Infrastructure Commission (NIC)'s National Infrastructure Assessment and the recommendations of the CCC. Three indicative examples are provided below that could be included in the Budget, due on 11 March, aligned with the CCC's and NIC's positions. These could catalyse innovation and investment and direct it towards three critical sectors that require further, deeper decarbonisation: **buildings, transport** and **industry**. Projects are also urgently needed to begin addressing emissions from land use and land use change, with key actions set out in the CCC's recent report on reaching net zero in the land use sector. Taking actions in all of these areas will create jobs, and measures should be taken to ensure workers have the right skills and equipment to deliver high quality projects under decent working conditions.

- **Heat for buildings – demand and supply:** Buildings are responsible for 17 per cent of the UK's annual emissions of greenhouse gases. The Budget could use the £6.3 billion committed for energy efficiency in the Conservative Party's 2019 general election manifesto for one or more concessional debt products, disbursed by the new National Investment Bank we propose. On the supply side, a roadmap to decarbonise heating for buildings should include building standards reform, targeted R&D and demonstration hydrogen and heat pump projects, as well as a coordinated approach to the supply chain to deliver high-skilled jobs.
- **Electric vehicle charging infrastructure:** Transport accounts for 23 per cent of the UK's annual emissions of greenhouse gases, with road transport the single largest contributor. Significant investment in infrastructure for charging electric vehicles is required, without crowding out the private sector. The £28 billion committed for roads in the 2019 election manifesto must all be used to leverage private investment in charging infrastructure. The £1 billion committed specifically for charging infrastructure should be focused on developing infrastructure in parts of the UK with lower traffic and population densities relative to congested areas. Consulting UK businesses to gradually develop the Autonomous and Electric Vehicles Act into a clear regulatory framework for charging infrastructure – but taking care not to impede innovation – could help to make the case for private investment stronger.
- **Carbon capture and storage (CCS) for industry:** Industry accounts for 21 per cent of the UK's annual emissions from greenhouse gases. CCS forms a critical component of the Committee on Climate Change's net-zero scenario. It is likely to be needed both for zero-carbon hydrogen production in the short to medium term and to secure UK jobs in heavy industry that are aligned with net zero. The £800m promised for new CCS infrastructure should be invested carefully to ensure it leverages private capital and should be accompanied by regional skills programmes. The National Investment Bank we propose could make long-dated concessional debt available for CCS infrastructure in the zero-carbon industrial clusters that are under development, particularly for pipelines and storage, which have received comparatively less funding than carbon capture facilities. This should be accompanied by long-term policy frameworks to make CCS commercially viable – most crucially, carbon pricing.

Increasing investment could deliver a range of benefits including additional GDP growth

Coordinated action to channel public sector investment into productive and sustainable assets, together with appropriate institutions and policies, will provide long-term and consistent direction for the private sector and help to crowd in further investment. In this way, a shift to clear, stable policies and institutional frameworks on infrastructure and other investments can raise the investment rate. An incremental capital output ratio of around 4 (that is, assuming that £4 of additional net investment will generate £1 of extra GDP) implies that around 0.25 percentage points could be added to the GDP growth rate for every 1 percentage point by which this package of policies increases the net investment rate. Further gains are to be expected from improving skills alongside increased innovation and its diffusion.

Taken together, these actionable policies and commitments can increase investment, productivity and economic and societal wellbeing in the UK. The country will stand a realistic chance of achieving its commitment to bringing greenhouse gas emission to net zero by 2050, while strengthening its global position in the zero-carbon economy of the future.

1. Introduction: 2020 – Entering a special decade for innovation and investment

The UK is entering a new decade with a government that has committed to reaching net-zero emissions of greenhouse gases by 2050, to redefining the UK's role in the world and to reducing regional disparities through the 'levelling up' agenda. These are interdependent ambitions, and efforts to address them must recognise this. In fulfilling these commitments there is a significant opportunity for the UK to drive sustainable, inclusive growth and decarbonisation through a coordinated programme of long-term public and private investment. This is needed urgently given that the UK's progress in preparing for and tackling climate change is not currently aligned with a net-zero emissions trajectory. Furthermore, the country is falling behind in the international competitiveness stakes as others gain comparative advantage in zero-carbon goods and services. Immediate action with a long-term but dynamic outlook is needed. Done right, in 2030 the UK could have higher living standards and improved health and wellbeing, with UK businesses innovating and adopting cutting-edge zero-carbon goods and services and infrastructure fit for the mid-21st century.

This policy report summarises the case for increased and sustainable investment. This was set out in a previous report in the series by Rydge et al. (2018) as a systemic approach of transforming the financial system to mobilise investments across infrastructure, innovation and skills. The current report makes evidence-based recommendations for how this can be achieved. Furthermore, it highlights particular areas of the economy where the public sector could leverage private investment and in so doing contribute to achieving the Government's strategic priorities of regionally balanced growth and decarbonisation.

Public investment for sustainable and inclusive growth

Investment in infrastructure, while crucial, will not be enough to attain sustainable and inclusive growth. Large-scale sustainable investment in innovation and skills across the country is also required to deliver the necessary initiatives and to realise the benefits from the associated economic opportunities in the short, medium and long term. The UK's sustainable investment needs must be met through a combination of public and private sector investment. Increased and well planned public sector investments in productive, sustainable assets, combined with coherent, long-term policy will help leverage private sector investments in infrastructure assets, R&D and workforce skills.

Given the current economic context, increased public investment will require increased public borrowing. Borrowing for productive investment could reduce public debt in the long term via its positive impacts on economic growth and associated tax revenues. While some investments may generate a direct fiscal return, others might seek to create broader public benefits and spillovers such as improved connectivity, health and wellbeing, which in turn may be expected to raise labour productivity and hence economic growth in the future.

The Government should seek to recognise and capture these different types of direct and indirect returns as it makes decisions on investment. Viewing public net assets as a measure of 'wealth' as opposed to merely a measure of revenue streams or liabilities could help the Government to make more strategically beneficial investment decisions (Cable, 2016).

2. Four interconnected drivers show that now is the time for action

The following drivers indicate that now is the time to act:

- As the scale and urgency of the global response required to tackle climate change are growing, so too is the opportunity for the UK to enhance its international leadership role as 'Global Britain'
- A new economic model is needed post-Brexit to address the UK's poor productivity and move towards a circular economy
- The benefits of regionally-balanced growth are increasingly being recognised
- The economic climate is right for investment

i) As the scale and urgency of the global response required to tackle climate change are growing, so too is the opportunity for the UK to enhance its international leadership role as 'Global Britain'

Markets and governments globally are starting to make the transition to zero-carbon economic development and growth, in increasing recognition of the need for strong and urgent action to tackle climate change. The UK has shown leadership with its commitment to net-zero emissions by 2050 and can set an even stronger example by taking more concrete actions on sustainable investment ahead of the COP26 UN climate conference in November. A successful hosting of COP26 could provide the foundations to deliver on the Government's ambitions to redefine the UK's place in the world as 'Global Britain'[1]. COP26 will be a landmark event in the international climate change negotiations, and a strong COP president could play a key role in shifting the global economy away from a high-carbon pathway. However, in order to be viewed as a credible global leader in tackling climate change, the UK needs to overhaul its policy framework to reflect the urgency of net zero. The UK is falling behind in both its preparedness for the effects of climate change and in its policies and plans to reach net-zero emissions. If the UK misses its Fourth and Fifth Carbon Budgets (covering the periods 2023–27 and 2028–32) – as currently looks likely – reaching net zero by 2050 will be considerably harder than if it cut emissions by the required amounts within those timeframes (CCC, 2019).

The decisions the UK makes in the next 10 years will define whether or not it maintains its position as a global leader in tackling climate change into the long term. Investments in infrastructure need to be carefully considered. Infrastructure assets have a long life-expectancy – ranging from 10 to 20 years for roads through to 50 years-plus for rail tracks, bridges and transmission lines (Gibson, 2017). The UK needs to lock in to a zero-carbon, resilient pathway that avoids building high-carbon or vulnerable infrastructure that will rapidly lose value. The recent decision to rule plans for a third runway at Heathrow Airport illegal due to their incompatibility with the Paris Agreement on climate change makes clear that the Government must take account of its domestic and international commitments on reducing emissions of greenhouse gases when making decisions about long-lived infrastructure projects. Across infrastructure and other economic assets the invention and diffusion of zero-carbon technologies and practices are crucial; increased investment and collaboration between government, industry and research institutions will be key to achieving this. There is an urgent need for ambitious policymaking that emphasises innovation of technologies while also rolling out existing solutions at a scale that can drive down costs.

A clear rationale lies behind some of the interventions that could help put the UK on the path to net-zero emissions when they are appraised against traditional economic planning indicators, such as the productivity improvements associated with improved public transport. However, the investment case for certain measures may rest on a long-term commitment to efficient and ambitious decarbonisation pathways. For instance, the value of energy efficiency measures in highly inefficient homes today lies in large part in the avoided *future* electricity demand and in reducing the need for installing new electric heat pumps as the buildings sector decarbonises.

[1] See www.gov.uk/government/collections/global-britain-delivering-on-our-international-ambition

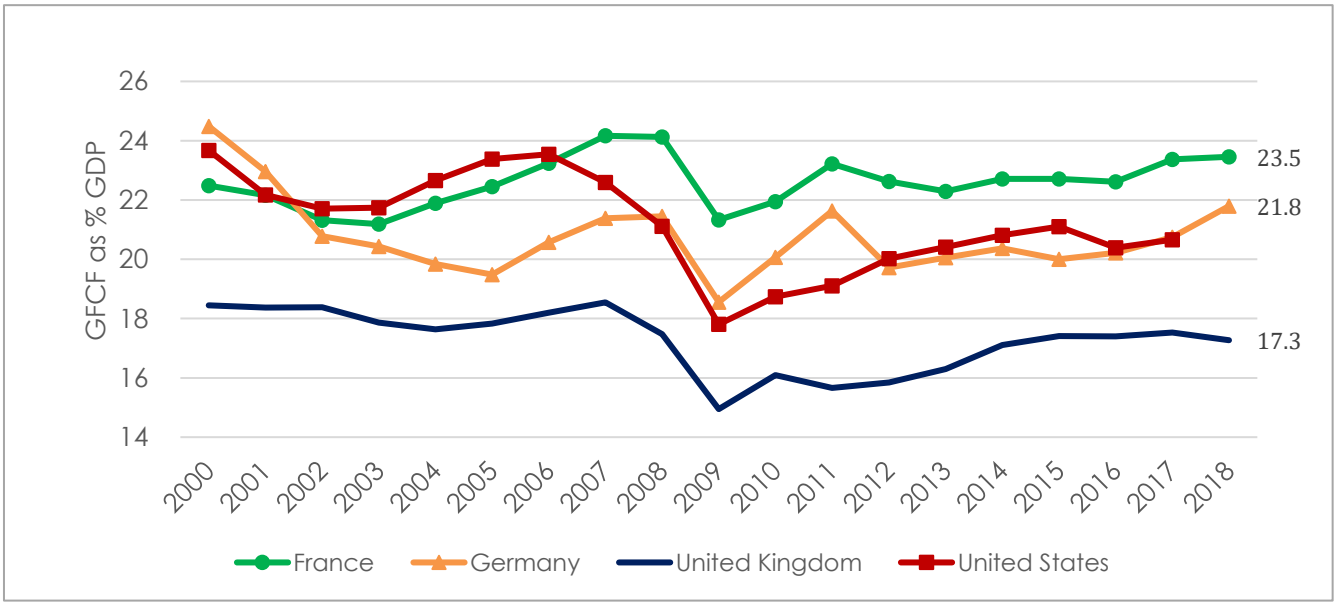
Careful consideration will need to be given to the narratives that accompany plans to decarbonise. The pathway to net zero must be perceived across the UK as a whole-economy opportunity to deliver material improvements to communities, as opposed to creating costs and inconveniences for households. For instance, revenue from carbon pricing could be used to mitigate the potential financial impact of other decarbonisation measures on vulnerable households (Burke et al., 2020a and b).

ii) A new economic model is needed post-Brexit that addresses the UK's poor productivity and move towards a circular economy

The UK's productivity performance since the financial crisis has been particularly poor by both historical and international standards, and this has widened the longstanding gap in productivity levels between the UK and its main international comparators (Valero and Van Reenen, 2019). Increased investment in infrastructure, innovation and skills is required to restore productivity growth. To be consistent with net-zero commitments, such investments must help the UK build its innovation strengths in related environmentally sustainable technologies, goods and services, which will enable the country to realise domestic opportunities and gain an increased share of the international markets of the future. Innovation policy needs to go beyond merely correcting market failures to be 'mission-driven', creating and shaping markets for zero-carbon innovation activity (Mazzucato, 2018). The UK can also leverage its strength as a green finance centre to mobilise capital towards zero-carbon innovation.

The UK's gross fixed capital formation as a share of GDP is relatively low compared with other countries (see Figure 1 for a comparison with three of its main comparators). Given the well-known inadequacies across infrastructure types that have acted as a barrier to both national growth and its regional distribution, large-scale investments in long-term and sustainable assets are needed. Following a period of economic and political uncertainty, positive, long-term signals are required to mobilise institutional capital and individual savings.

Figure 1. Gross fixed capital formation (GFCF)* as a share of GDP in the UK, France, Germany and United States, 2000–18



**Note: Gross fixed capital formation, also called investment, is defined as the acquisition of produced assets, minus disposals. Source: OECD*

Regarding innovation, both publicly and privately financed R&D in the UK persistently lags behind R&D in the UK's main international peers as a share of GDP; total UK gross domestic expenditure on R&D in 2017 represented 1.69 per cent of GDP, well below the EU's provisional estimate of 2.07 per cent (ONS, 2019). While the UK's current target of achieving expenditure of 2.4 per cent of GDP on R&D by 2027 is welcome, this target date should be brought forward given the role that innovation must play in the UK's sustainable and inclusive growth pathway.

The UK has comparative advantage in its university and research system but does less well on commercialisation. The Dowling Review of Business-University Research Collaborations has emphasised the need for better collaboration between business and academia (Dowling Review, 2015), while more recently it has been observed that R&D policies have focused on addressing specific market failures as opposed to generating and directing demand for innovation in line with societal goals such as decarbonisation (Jones, 2019). This latter approach is necessary, at scale, given the urgency of the response required to tackle to climate change. Unsworth et al. (2020) highlight how consistent policies and incentives on both the demand and supply side can help the UK benefit from the economic opportunities associated with zero-carbon passenger vehicles, for example.

Encouragingly, LSE research indicates that innovation spillovers are larger for low-carbon than for high-carbon technologies. Analysis of more than 1 million innovations using patent data and 3 million citations worldwide suggests that spillovers from low-carbon innovation in the energy production and transport sectors are over 40 per cent greater than in conventional technologies (Dechezleprêtre et al., 2013). Furthermore, the innovation spillovers from low-carbon innovations are comparable to those in other important fields such as IT and biotechnologies.

There are well documented skills gaps in the UK, in particular with respect to STEM [science, technology, engineering, maths] and mid-level technical skills, both of which are key to the invention and diffusion of low-carbon technologies. For instance, National Grid estimates that 260,000 new roles will need to be created up to 2050 in the energy sector across R&D, manufacturing, logistics and engineering, to form part of a 'net-zero energy workforce'. Tasks for this workforce will include building new low-carbon infrastructure, upgrading existing low-carbon infrastructure, complete retrofits of existing infrastructure and decommissioning outdated high-carbon assets (National Grid, 2020). To supply this workforce, and to make it resilient to rising automation and other technological change, initiatives to improve educational outcomes – in particular for those from disadvantaged backgrounds – and work-based skills programmes will be needed. Rapid technological innovation and big data can provide analytical insights regarding current workforce skills in relation to in-demand jobs, enabling institutions such as further education colleges to anticipate demand. However, for such systems to work effectively they need to be locally relevant and forward-looking, adapting efficiently and quickly to the changing needs of workers and firms (Escobari et al., 2019).

Well-designed programmes of public investment with consistent policy frameworks can provide an opportunity to rebalance the economy from consumption towards investment. Furthermore, they can build strong and sustainable foundations for raising productivity as the country moves into a new phase after Brexit. Alongside labour productivity, it will be important to catalyse improved performance in related areas including resource productivity and efficiency. Doing so can shift the UK towards a new circular economy model: an economy that is restorative and regenerative through its utilisation of outputs as inputs in a continual cycle.

iii) The benefits of regionally-balanced growth are increasingly being recognised

The UK suffers from large and persistent regional disparities in productivity and related opportunities (Overman, 2019). There is now broad recognition from government and renewed policy focus on achieving growth that is more balanced across the country (see, for example, UK Government, 2019). Strengthening and building innovation capacity across the UK's regions will be key to achieving this (Jones, 2019). LSE analysis of regional productivity and innovation spillovers (as mentioned above, an indicator of innovative strength, measured via citations in patents) has found that regions in the top decile for productivity, which include parts of inner London, areas around Oxford, and Edinburgh, are nearly 40 per cent more productive than those in the bottom decile, which includes Cornwall and large parts of Wales. While there is some overlap between regions with high innovation spillovers and high productivity – e.g. Northeast Scotland, Cheshire – there are considerably more areas with low productivity but above-average amounts of national spillovers and hence potential growth opportunities; these areas include the Scottish Highlands and Islands, Kent, Essex and Greater Manchester (Rydge et al., 2018).

Evidence-based, targeted and long-term programmes, national and local, can raise the innovation performance in regions with underlying strengths or where new opportunities can be identified. This will simultaneously increase national growth and reduce regional disparities. More broadly, sustainable investments in infrastructure accompanied by improvements in local skills and institutional capacity will generate economic opportunities and improve labour market resilience.

The co-benefits of sustainable growth are also increasingly recognised by citizens, benefits that include cleaner, more efficient and liveable cities where there is improved health and wellbeing. For instance, results of a recent poll of 4,000 adults in the UK found 71 per cent were concerned about the health impacts of dirty air (Holder, 2019). Coordinated programmes of sustainable investment have been shown to deliver a wide range of local development co-benefits alongside progress on national decarbonisation (Corfee-Morlot et al., 2012). Changes of this nature would raise productivity, improve living standards and help build communities' sense of identity and pride across the UK.

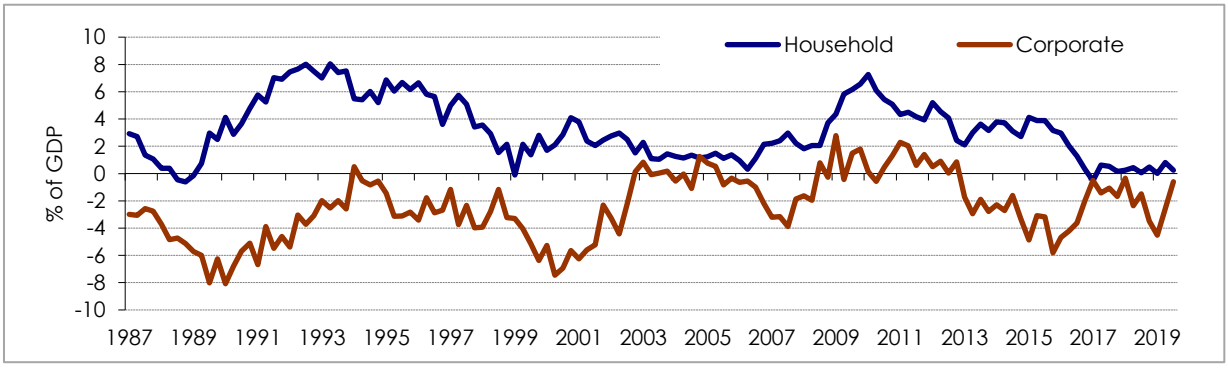
iv) The economic climate is right for investment

Interest rates have been low in the UK for some years, offering attractive cost/benefit ratios in additional output and income relative to upfront investment. Empirical evidence indicates that low interest rates coupled with an enabling policy framework create a conducive environment for green investment (Eyraud et al., 2013).

Increasing public infrastructure investment offers private investors such as pension, insurance and sovereign wealth funds a reliable source of long-term income from sustainable assets (via gilts, for example). Green bonds – bonds designated for climate-related projects – are one such area of opportunity in the current economic climate. Bond yields indicate that the markets are signalling an opportunity for more, and not less, public investment. The global green bond market ended 2019 on a high, with a record US$231 billion in issuance. New UK-focused green bond products, supporting activities aligned with delivering a 'just transition' for instance, could raise well-priced funding for zero-carbon, resilient and socially inclusive investments (including in skills and places with below-average productivity) at a time of ultra-low interest rates (Robins, 2020).

Despite the positives presented by low interest rates, investment has remained low in the UK in comparison with its international competitors, primarily because of the current behaviours of UK households and businesses. In a steady state economy companies are expected to have a deficit resulting from borrowing from household savers to invest in production. Conversely, households are expected to have a surplus from savings through their pensions, insurance and banks (funding company deficits). However, as Figure 2 shows, in the last three years corporate financial balances have remained relatively high compared with the significant average deficits in the late 1990s and early 2000s. This indicates weak company confidence, perhaps reflecting uncertainty over Brexit. Conversely, in the same period, household balances have hovered around zero, indicating increasing indebtedness following years of surplus. This builds the case for the public sector to step in and help leverage private sector investment. The UK needs to shift the balance of investment, taking advantage of low rates to expand future supply and generate revenues.

Figure 2. Private sector financial balances in the UK, split between households and companies, % of GDP, 1987–2019



Source: Authors' analysis of Office for National Statistics data

3. Immediate actions can catalyse a step-change in innovation and investment

The UK is facing deep-rooted challenges in the broad areas of infrastructure, innovation and skills. A strategic approach is required to understand these challenges and how they are interlinked, at both a national and regional level. The economic and climate challenges faced by the UK require *long-term* policies that are also dynamic in the face of technological change, the advance of climate science and emerging evidence on the relative success of different policies. However, there are a number of measures that can be implemented at this critical moment. These would strengthen the UK as an international leader, directly impact investment rates in the UK and create both a short-term boost to growth and improved growth prospects for the medium to long term. The Cabinet Office and HM Treasury have overall responsibility for ensuring implementation.

Recommendations for the UK Government

a) Establish a National Investment Bank, with a focus on managing and reducing risk in infrastructure projects, to leverage private finance.

The Bank should have an explicit sustainability mandate, seeking out net-zero-aligned projects for which risk levels need to be reduced. A combination of the right financial instruments that lower the cost of capital and operating under a shareholder structure can make these projects viable investment propositions, enabling and fostering the participation of the private sector. Ultimately, establishing such a Bank will facilitate the movement of capital at scale towards net-zero-aligned projects that cannot currently be financed by the market. The Bank could act as part of a net-zero institutional framework that can operate transparently and independently of political changes, making it a major positive legacy project for the current government. The Bank could be a major tool for encouraging flagship foreign investment into the UK in zero-carbon goods and services. For instance, the Bank could help to make the UK a more attractive location for companies to set up gigafactories for battery cell production by offering targeted lending or guaranteeing products or equity (Unsworth et al., 2020).

Initially the Bank should have a targeted focus on managing and reducing risk in infrastructure projects. Its mandate could be broadened over time to become a full service investment bank, although this would need to be carefully coordinated to avoid replication of existing concessional banking provision in the UK such as that provided by the British Business Bank. The National Investment Bank's focus should be flexible and responsive to where there are gaps in the availability of finance products at any point in time. Project origination and appraisal processes should be rooted in regional development plans and infrastructure needs.

Action lead: *HM Treasury should work in close consultation with the Select Committees, other government departments and local government to understand financing needs at the sectoral and regional level and inform the design of the Bank.*

b) Harness the UK's green finance capabilities to deliver on innovation and investment demands across all regions.

The UK has been world-leading in greening the global finance system and spurring innovation but has been less effective in delivering domestic green investment. Investment flows to date suggest that the UK's financial services sector may need assistance in directing capital towards UK assets. There are a number of tools that the Government can employ to facilitate this redirection of capital, which include advocacy coalitions with private financiers (Polzin, 2017). Building on the UK's leadership in implementing the Task Force on Climate-related Financial Disclosures (TCFD) and establishing the Green Finance Institute, the Government should move to the next phase and set out a roadmap for bringing the financial system into alignment with the goals of a resilient, net-zero economy. This can build on the growing desire by both UK financial institutions and individual savers to deploy capital at scale for the transition. Fundamentally, green finance must become more clearly rooted in the bottom-up needs for innovative investments in communities, cities and regions across the country. UK-based investors following the recommendations of the TCFD now have a clear mandate to seek out transition-aligned investments, providing an opportunity to match supply of finance with demand from net-zero-aligned, resilient domestic projects.

Action lead: *The Green Finance Institute should work in close consultation with HM Treasury, other government departments and local government to understand financing needs at the sectoral and regional level.*

c) Set out a global agenda of investment in zero-carbon infrastructure and innovation in the lead-up to the COP26 UN conference.

In order to be credible as a leader on sustainable investment, the UK needs to get started in the months leading up to the COP26 UN conference that will take place in Glasgow in November 2020. The UK can then utilise COP26 as a platform to encourage other economies to follow its example. Gaining commitments at COP26 from other countries to join a coordinated global programme of net-zero-aligned, resilient investment could be a high-profile success for both the UK and the planet. The scope could also potentially be broadened to direct investment towards developing countries, in order to close the remainder of the gap to reach the UNFCCC's 2020 target of raising US$100 billion a year of public and private climate finance.

Action lead: *The COP26 team within the Cabinet Office should work in close consultation with a wide variety of government departments including the Department for Business, Energy and Industrial Strategy (BEIS), Foreign and Commonwealth Office, the Department for International Development and the Department for International Trade, as well as engaging with HM Treasury regarding the UK's investment plans.*

d) Overhaul technical and governance processes to ensure public investment is net-zero-aligned and resilient.

The planned revisions to the Treasury's Green Book policies should properly appraise alignment with a net-zero, resilient pathway. Choosing discount rates and carbon price projections that fully reflect the net-zero target will be vital (Burke et al., 2019). Furthermore, the system-wide, macroeconomic impacts of large-scale investments (e.g. on wages and prices) must be considered in project appraisal processes; they will depend on macroeconomic circumstances (e.g. unemployment) and might be missed in microeconomic analysis. Standards and regulations, and the regulatory bodies responsible for them, must also be anchored around net zero and resilience. This also applies to R&D spending. The Treasury's Net Zero Review team should seek to track short- to medium-term government spend, through the Budget process, to ensure alignment with longer-term goals such as the Fourth, Fifth and Sixth Carbon Budgets and ultimately reaching net-zero greenhouse gas emissions. For instance, the team could track net-zero-aligned public investment and private sector-leveraged investment into different sectors (such as road transport), relative to sectors' emissions, over the longer term.

Action lead: *HM Treasury should work in close consultation with other government departments on technical aspects and local government on governance aspects. The Treasury Select Committee and the Net Zero Review team formed in November 2019 can play a key role in ensuring HM Treasury delivers on this action.*

e) Give clearer recognition to the roles of anchor institutions such as universities and further education colleges as drivers of place-based, sustainable growth.

As anchor institutions making strategic contributions to local economies, and as hubs of innovation, universities create enormous potential when working in partnership with industry and ambitious local leaders. Such interactions should be strengthened in order to maximise positive spillovers. The recent underfunding of further education (FE) colleges needs to be reversed, as they play crucial roles in improving labour market outcomes for the large share of young people who do not attend university, in building resilience in the existing workforce via lifelong learning, and in improving the technical skills that will aid the diffusion of new innovations into the economy. Higher and further education institutions must be given key roles in national and regional strategies for sustainable innovation and its diffusion. Developing an effective 'hub-and-spoke' diffusion model, where the top-ranked research universities are the hubs and other universities across the UK are the spokes could help diffuse innovation more broadly across sectors and regions (Haldane, 2018). Regional networks such as the recently formed Place-based Climate Action Network (PCAN), led by academics, can facilitate knowledge-sharing between cities, towns and regions on decarbonisation and sustainable growth.

Action lead: *The Department for Education should work with BEIS and UK Research and Innovation, in close consultation with local government, businesses and education institutions,*

to understand the partnerships that could be fostered or strengthened in different parts of the UK.

f) Ensure that policies for investment across innovation, education, training and infrastructure consistently align with sustainable and inclusive growth.

Achieving this alignment will necessitate choices to be made – for example, investments in public infrastructure projects in one area may be at the expense of another priority area. Decisions should be based on evidence of systemic impacts, taking into account complementarities between different forms of capital and utilising the latest innovations in public participation to ensure that new policies are fair for all and therefore receive public support. It is important that decision-making powers are devolved where appropriate, based on the capacity in regional or local governments. Consideration should also be given to the most appropriate spatial economic unit to make an intervention and the market failures or barriers to sustainable growth in different contexts. Further, it is crucial that there are governance processes in place to enable the public to contribute to these decision-making processes, particularly in the early stages of large infrastructure projects.

Increases in public infrastructure investment must be coordinated with skills and innovation investment. In some instances, investment in skills and innovation may need to precede public infrastructure investment. For instance, the UK's workforce is likely to require reskilling before it can deliver housing energy efficiency upgrades and zero-carbon heat supply installations at the scale required.

Action leads: *The drivers of this action should come from both communities and central government. HM Treasury should seek to engage with local government and, by extension, communities. Participatory processes to inform policy decisions will likely unfold differently across the UK, according to local circumstances.*

g) Utilise public sector procurement to pilot sustainable technologies.

The public sector directly accounted for 4 per cent of total energy consumption in the UK in 2018, and it indirectly consumes considerable additional amounts of energy (such as the petrol consumption of government vehicles) (BEIS, 2019a). Furthermore, the UK spends an estimated 13.7 per cent of UK GDP on public procurement of goods and services, acting as a major demand-side stimulus (IIPP, 2019); aligning this entire procurement spend with the UK's sustainable and inclusive growth plans will be essential. There is huge potential to both deliver material emissions reductions and create demand for zero-emission goods and services by redesigning public sector procurement rules. Public sector procurement should seek to promote innovation and creative solutions in areas where the Government is a large buyer. Successful procurement strategies can trial, and create demand for, products or services that can then be adopted by the private sector in the UK and overseas. This can also cement the UK government's position as pushing the boundaries of decarbonisation. However, to do this, material changes will be required to procurement evaluation processes to prioritise other metrics alongside short-term cost-effectiveness (IIPP, 2019).

Action leads: *HM Treasury and the Crown Commercial Service.*

h) Set out a timetable with key funding commitments into the medium term to deliver net-zero emissions, with lines of accountability for delivery.

While a significant step-change in investment is urgently needed, immediate measures need to be designed as part of a broader strategy to address the complex underlying challenges detailed in this report. The actions needed to set the UK on a sustainable and inclusive growth trajectory include both targeted investments now and forward-looking policy and funding programmes to strategically mobilise further investment. For instance, in the case of carbon capture and storage, immediate investment is needed (see Section 4 below), supported by a long term roadmap of funding and policy changes to make it a viable investment proposition in industry as well as power generation. While a level of flexibility must be maintained, setting out timetables of funding with clearly demarcated responsibility across the economy can ensure investments are made that pave the way towards net-zero emissions in 2050.

Action lead: *HM Treasury*

4. The 2020 Budget provides an opportunity to set out specific investment measures

The Committee on Climate Change (CCC) has set out, sector by sector, how the UK can achieve net-zero greenhouse gas emissions by 2050. HM Treasury will soon publish its National Infrastructure Strategy, describing how government can respond to the National Infrastructure Commission (NIC)'s National Infrastructure Assessment and the recommendations of the CCC. Three indicative examples are provided below to demonstrate possible measures for the Budget (due on 11 March 2020), aligned with the CCC's and NIC's positions. These could catalyse innovation and investment and direct it towards three critical sectors that require further, deeper decarbonisation: **buildings**, **transport** and **industry**. Projects are also urgently needed to begin addressing emissions from land use and land use change, with key actions set out in the CCC's recent report on reaching net zero in the land use sector (CCC, 2020).

These investment measures would result in major changes to workforces in terms of the skills required. For instance, more than 130,000 people work in installing, maintaining and servicing home heating systems (UKERC, 2019) and the measures would mean a significant change to livelihoods and working practices in jobs like these. Efforts should be made to ensure workers have the right skills and equipment to deliver high quality projects under decent working conditions. Employer associations should be carefully consulted to ensure workforces are prepared to respond to the increased demand for work that the measures below could stimulate.

- **Heat for buildings – demand and supply:** Buildings are responsible for 17 per cent of the UK's greenhouse gas emissions. Improving the energy efficiency of buildings by installing insulation to reduce demand for energy is emphasised as a national infrastructure priority by the NIC, which in 2018 recommended a target of 21,000 energy efficiency installations a week by 2020 (NIC, 2018). However, there has been little progress in installing insulation. The limited impact of past policies, such as the Green Deal, which relied on energy bill savings to finance efficiency improvements, indicate that public investment is needed to spur action and leverage private finance. The Budget could use the £6.3bn committed for energy efficiency in the Conservatives' 2019 election manifesto for one or more concessional debt products, disbursed by the National Investment Bank we propose above. In terms of supply, a clear roadmap to decarbonise heat supplied to buildings must be established. This should include building standards reform, R&D targeted at future heat supply solutions and demonstration projects at scale for hydrogen and heat pumps. These actions can direct innovation and investment towards supplying zero-carbon heat and lowering demand.
- **Electric vehicle charging infrastructure:** Transport accounts for 23 per cent of the UK's greenhouse gas emissions, with road transport the largest single contributor. The currently insufficient size and geographic coverage of charging infrastructure for electric vehicles is a major barrier to their large-scale adoption in the UK. Significant investment is required, without crowding out the private sector. The £1bn committed for charging infrastructure in the 2019 election manifesto should be focused on developing infrastructure in parts of the UK with lower traffic and population densities relative to congested areas. The £28bn committed for roads in the manifesto must be disbursed in line with sustainability objectives, ensuring it leverages private investment in charging infrastructure. Consulting UK businesses to gradually develop the Autonomous and Electric Vehicles Act into a clear regulatory framework for charging infrastructure – but taking care not to impede innovation – could help to strengthen the case for private investment (Unsworth et al., 2020).
- **Carbon capture and storage (CCS) for industry:** Industry accounts for 21 per cent of the UK's greenhouse gas emissions. CCS forms a critical component of the Committee on Climate Change's net-zero scenario. It is likely to be needed both for zero-carbon hydrogen production in the short to medium term and to secure UK jobs in heavy industry that are aligned with net zero. The £800m for new CCS infrastructure reaffirmed in the Conservative Party manifesto – which we welcome – should be invested carefully to ensure that it leverages private capital and that job creation is accompanied by regional skills

programmes so that local workforces match job supply. The National Investment Bank we propose could make long-dated concessional debt available for CCS infrastructure in the planned zero-carbon industrial clusters (via the industrial clusters mission (BEIS, 2019b) in the Industrial Strategy Challenge Fund), particularly for pipelines and storage, which have received comparatively less funding than carbon capture facilities. This should be accompanied by long-term policy frameworks – most crucially carbon pricing (see Burke et al., 2019) – that make innovation and investment in CCS a compelling proposition for UK business.

5. Increasing investment could deliver a range of benefits including additional GDP growth

The potential benefits of green incentives packages in the US has been analysed empirically by Mundaca and Richter (2015), summarised in Box 1 – and while the contexts differ, the US case provides lessons for the UK by showing the responsiveness of the real economy to these types of measures. Mundaca and Richter study the packages of measures introduced from 2009–12, focused on the renewable energy sector. They find the measures to have had a positive effect on the sector. The UK should seek to deliver a similarly comprehensive package of measures, covering investment in innovation and infrastructure and with a strong focus on leveraging private finance. The UK should also consider how investment is likely to impact the country's participation in global markets (via imports and exports and by participating in global value chains). Finally, the design of a UK innovation and investment programme should be sensitive to how it might be perceived. For instance, Mundaca and Richter highlight the multiple and sometimes conflicting goals of the 1705 Loan Program in the US, which led to criticism. While there were fewer bankruptcies in the programme than initially anticipated, these received substantial media coverage despite the loan portfolio as a whole being deemed to have an acceptable level of risk.

Coordinated action to channel public sector investment into productive and sustainable assets, provided that the appropriate institutions and policies are in place too, will provide long-term and stable direction for the private sector. This will help to crowd in further private sector investment. In this way, a shift to clear, stable policies and institutional frameworks on infrastructure and other investments can raise the investment rate. An incremental capital output ratio of around 4 (that is, assuming that £4 of additional net investment will generate £1 of extra GDP) implies that around 0.25 percentage points could be added to the GDP growth rate for every 1 pp by which this package of policies increases the net investment rate. Further gains are to be expected from improving skills alongside increased innovation and its diffusion.

Box 1. Sustainable public investment to spur production and jobs: lessons from the United States

Measures targeted at the US renewables sector included: research funding for early-stage clean energy innovation, establishment of research centres, extension of production and investment tax credits, cash grants, clean energy manufacturing tax credits, targeted loan guarantees, training grants and more effective green patenting. The US government invested in renewable energy to leverage private investment, such as the 1705 Loan Program, which guaranteed more than US$16bn and attracted another US$9.3bn in private equity. A clean energy manufacturing tax credit was awarded to 183 projects, leveraging US$5.4bn in private investment.

Impacts of the measures: Domestic production of goods such as wind turbine components increased significantly while imports began to fall through the period 2009–12, after previously increasing. Emissions fell substantially during the period, although the authors emphasise that the economic crisis and coal-to-gas switching were significant to this trend. The measures led to substantial job creation related to large wind and solar PV projects. However, the majority of this was in construction (52,000–75,000 jobs per year over the period 2009–11) as opposed to permanent jobs for the lifetime of the assets constructed under the packages (around 5,000 jobs per year were created for the lifetime of the system). While not specific to these jobs, there is evidence to suggest that 'green jobs' (those that are involved in producing goods and services with an environmental benefit) in the US are linked to better career opportunities than those afforded by other jobs, and that average salaries in the green economy are higher than in the economy as a whole (around US$44,000 p.a. compared with US$38,600; see Muro et al., 2011).

Source: Mundaca and Richter (2015)

Taken together, these actionable policies and commitments can increase investment, productivity and economic and societal wellbeing in the UK. The country will stand a realistic chance of achieving its commitment to bringing greenhouse gas emission to net zero by 2050, while strengthening its global position in the zero-carbon economy of the future.

References

Burke J (2019) *How to price carbon to reach net-zero emissions in the UK*. London: Grantham Research Institute on Climate Change and the Environment. http://www.lse.ac.uk/GranthamInstitute/publication/how-to-price-carbon-to-reach-net-zero-emissions-in-the-uk/

Burke J, Fankhauser S, Kazaglis A, Kessler L, Khandelwal N, Bolk J and O'Boyle P (2020a, forthcoming) *Distributional Impacts of a UK carbon tax: Report 1 – Analysis by household type.* London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science, and Vivid Economics.

Burke J, Fankhauser S, Kazaglis A, Kessler L, Khandelwal N, Bolk J, O'Boyle P and Owen A (2020b, forthcoming) *Distributional impacts of a carbon tax in the UK: Report 2 – Analysis by income decile.* London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science, and Vivid Economics.

Cable V (2016) *Why Governments Won't Invest*. Centre for Economic Performance Special Paper No. 33. http://cep.lse.ac.uk/pubs/download/special/cepsp33.pdf

Committee on Climate Change [CCC] (2019*) Summary Report: 2019 Progress Report to Parliament*. London: CCC. https://www.theccc.org.uk/wp-content/uploads/2019/07/2019-Progress-Report-Summary.pdf

Committee on Climate Change [CCC] (2020) *Land use: Policies for a Net Zero UK.* London: CCC. https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

Dechezleprêtre A, Martin R, Mohnen M (2013) *Knowledge spillovers from clean and dirty technologies: A patent citation analysis,* Centre for Climate Change Economics and Policy Working Paper No. 151 Grantham Research Institute on Climate Change and the Environment Working Paper No. 135. http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2013/10/WP135-Knowledge-spillovers-from-clean-anddirty-technologies.pdf

Department for Business, Energy & Industrial Strategy [BEISa] (2019) *Digest of UK Energy Statistics 2019*. London: BEIS. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820277/DUKES_2019_Press_Notice_GOV.UK.pdf

Department for Business, Energy & Industrial Strategy [BEISb] (2019) *What is the Industrial Clusters mission?* London: BEIS. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803086/industrial-clusters-mission-infographic-2019.pdf

Department for Business, Innovation and Skills [BEIS] (2015) *The Dowling Review of Business-University Research Collaborations.* London: BEIS. https://www.raeng.org.uk/publications/reports/the-dowling-review-of-business-university-research

Escobari M, Seyal I and Meaney M (2019) *Realism About Reskilling Upgrading the career prospects of America's low-wage workers.* Washington DC: The Brookings Institution. https://www.brookings.edu/wp-content/uploads/2019/11/Realism-About-Reskilling-Final-Report.pdf

Eyraud L, Clements B and Wane A (2013) Green investment: Trends and determinants. *Energy Policy* 60: 852-865. https://www.sciencedirect.com/science/article/pii/S0301421513002929

Gibson J (2017) *Built to Last: Challenges and Opportunities for Climate-Smart Infrastructure in California.* Cambridge: Union of Concerned Scientists. https://www.ucsusa.org/sites/default/files/attach/2017/11/gw-whitepaper-smart-infrastructure.pdf

Haldane A (2018) *The UK's Productivity Problem: Hub No Spokes.* Speech by Andy Haldane given at the Academy of Social Sciences Annual Lecture, London, 28 June. https://www.bankofengland.co.uk/speech/2018/andy-haldane-academy-of-social-sciences-annual-lecture-2018

Holder M (2019) Air pollution: Could a fuel duty hike and EV tax breaks help clean up our air? *Business Green,* 13 August. https://www.businessgreen.com/news-analysis/3080384/air-pollution-hike-fuelduty-and-make-evs-tax-exempt-government-urged

Institute for Innovation and Public Purpose [IIPP] (2019) *A Mission-Oriented UK Industrial Strategy*. London: IIPP. Available at https://www.ucl.ac.uk/bartlett/public-purpose/sites/public-purpose/files/190515_iipp_report_moiis_final_artwork_digital_export.pdf

Jan Corfee-Morlot J, Marchal V, Kauffmann C, Kennedy C, Stewart F, Kaminker C and Ang G (2012) *Towards a Green Investment Policy Framework: The Case of Low-Carbon, Climate Resilient Infrastructure*. Paris: Organisation for Economic Co-operation and Development [OECD]. https://www.oecd-ilibrary.org/content/paper/5k8zth7s6s6d-en

Jones R (2019) *A Resurgence of the Regions: rebuilding innovation capacity across the whole UK*. Sheffield: University of Sheffield. http://www.softmachines.org/wordpress/wp content/uploads/2019/05/ResurgenceRegionsRALJv22_5_19.pdf

London School of Economics (2020) *Investing in a just transition – global project*. Webpage. http://www.lse.ac.uk/GranthamInstitute/investing-in-a-just-transition-global-project/

Mazzucato M (2018) Mission-oriented innovation policies: challenges and opportunities. *Industrial and Corporate Change* 27(5): 803–815. https://academic.oup.com/icc/article/27/5/803/5127692

Ministry of Housing, Communities & Local Government [MHCLG] (2019) *Next generation of new towns and economic growth opportunities to be developed, levelling up every region.* Press release, 26 October. London: MHCLG. https://www.gov.uk/government/news/next-generation-of-new-towns-and-economic-growth-opportunities-to-be-developed-levelling-up-every-region

Mundaca L and Richter J (2015) Assessing 'green energy economy' stimulus packages: Evidence from the U.S. programs targeting renewable energy. *Renewable and Sustainable Energy Reviews*, 42: 1174-1186. https://www.sciencedirect.com/science/article/pii/S1364032114008855

Muro M, Rothwell J and Saha D (2011) *Sizing the clean economy: a national and regional green jobs assessment.* Brookings Institution, Washington DC https://www.sciencedirect.com/science/article/pii/S1364032114008855

National Grid (2020) *Building the net zero energy workforce*. Warwick: National Grid. https://www.nationalgrid.com/document/126256/download

National Infrastructure Commission (2018) *National Infrastructure Assessment*. London. https://www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf

Office for National Statistics (2020) *UK economic activity covering production, distribution, consumption and trade of goods and services. Individuals, businesses, organisations and governments all affect the development of the economy*. Webpage. https://www.ons.gov.uk/economy

Office for National Statistics [ONS] (2019) *Gross domestic expenditure on research and development, UK: 2017.* Webpage. https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2017

Organisation for Economic Co-operation and Development [OECD] (2019) OECD Stat. https://stats.oecd.org/

Overman H (2019) *People, Places and Politics*. London: Centre for Economic Performance, London School of Economics and Political Science. http://cep.lse.ac.uk/pubs/download/ea047.pdf

Polzin F (2017) Mobilizing private finance for low-carbon innovation – A systematic review of barriers and solutions. *Renewable and Sustainable Energy Reviews* 77: 525-535. https://www.sciencedirect.com/science/article/pii/S1364032117305099

Robins N (2020) Why governments need to issue just transition sovereign bonds and how they could do it. *Responsible Investor*, 13 January. https://www.responsible-investor.com/articles/financing-fast-and-fair-climate-action-why-governments-need-to-issue-just-transition-sovereign-bonds-and-how-they-could-do-it

Rydge J, Martin R, Valero A (2018) *Sustainable Growth in the UK: Seizing opportunities from technology and the transition to a low-carbon economy*. London: Grantham Research Institute on Climate Change and the Environment. http://www.lse.ac.uk/GranthamInstitute/wpcontent/uploads/2018/12/Sustainable-Growth-in-the-UK_Full-Report_78pp.pdf

UK Energy Research Centre (2019*) Heating engineers, skills and heat decarbonisation*. Blog post, 5 September. London: UKERC. http://www.ukerc.ac.uk/news/heating-engineers-skills-and-heat-decarbonisation.html

Unsworth S, Valero A, Martin R and Verhoeven D (2020) *Seizing sustainable growth opportunities from zero emission passenger vehicles in the UK*. London: Grantham Research Institute on Climate Change and the Environment. http://www.lse.ac.uk/GranthamInstitute/publication/seizing-sustainable-growth-opportunities-from-zero-emission-passenger-vehicles-in-the-uk/

Valero A and Van Reenen J (2019) *The UK Economy*. London: Centre for Economic Performance, London School of Economics and Political Science. http://cep.lse.ac.uk/pubs/download/ea049.pdf