
Innovation for a Green Recovery: Business and Government in Partnership

A Business Perspective on Public Policy and Governance of Green Innovation

The UCL Green Innovation Policy Commission

Innovation for a Green Recovery: Business and Government in Partnership

A Business Perspective on Public Policy and Governance of Green Innovation

The UCL Green Innovation Policy Commission
January 2021

This report should be cited as: Miedzinski, M., Dibb, G., McDowall, W. and Ekins, P. 2020. 'Innovation for a Green Recovery: Business and Government in Partnership', UCL, London, www.ucl.ac.uk/bartlett/sustainable/research/project-directory/green-innovation-policy-commission/about-green-innovation-policy

Table of contents

Preface	3
On the Green Innovation Policy Commission	4
Members of the Green Innovation Policy Commission (GIPC)	4
The GIPC's recommendations to government and business	6
Executive summary	10
Introduction	21
1 Why green innovation?	24
2 What is green innovation?	27
3 A glance at the UK's green innovation performance	38
4 GIPC's sectoral insights	46
4.1 Sectoral transformations for a net-zero future	47
4.2 A spotlight on the resources and waste sector	48
4.3 A spotlight on the construction sector	54
4.4 A spotlight on the water sector	59
4.5 A spotlight on the food sector	65
4.6 A spotlight on the transport of goods by road	73
5 Policy and governance for transformative green innovation	80
5.1 Political momentum and social contract for green recovery	81
5.2 Policy mix for green innovation	83
5.2.1 Create and shape demand for green innovation: from niches to global markets	84
5.2.2 Boost green innovation investments: from R&D to innovation diffusion	86
5.2.3 Change the rules of the game: progressive and agile regulation	89
5.2.4 Nurture innovation partnerships: cross-sectoral collaboration and place-based experimentation	92
5.2.5 Lay the foundations for a greener economy: innovative infrastructure	96
5.2.6 Working together to foster green recovery: innovative government and governance	99
6 Business leadership for transformative green innovation	102
References	109
Annex I. GIPC Sector Roundtables	115

Preface

As the world struggles with Covid-19, the challenges of climate change and wider environmental problems loom large. It is clear that the economic response to the impact of Covid-19 must benefit the environment, while plans to address climate change and environmental issues must benefit the economy and society. The only way these twin imperatives can be met is through green innovation - the subject of this report.

The report is the fruit of two years of deliberations of the Green Innovation Policy Commission (GIPC), a business-led Commission set up and supported by University College London (UCL) – specifically the UCL Institute for Sustainable Resources and UCL Public Policy team – and Green Alliance.

A majority of the Commissioners are business people, who are committed to both the success of their businesses and addressing the world's environmental problems, particularly the climate crisis, through contributing to the UK target of net-zero emissions in 2050 and to similar targets in other countries where they operate. All the Commissioners are convinced of the importance of green innovation to their businesses' performance and to the UK's future, and have contributed to this report.

While all Commissioners have made a pro bono contribution, this report and the associated policy brief would not have been possible without generous financial support from the SUN Foundation in Germany and the Tellus Mater Foundation, which we acknowledge with grateful thanks.

We would also like to thank those who took part in and contributed so many useful ideas to the GIPC sectoral roundtables, the participants in which are listed in Annex 1.

We believe that green innovation has never been more urgent, but also that the opportunities for it and the benefits to be derived from it, have never been greater. We very much hope that this report will help more of it to be realised in practice.

John Cridland CBE, Chairman, Green Innovation Policy Commission, Visiting Professor, University College London

Professor Paul Ekins OBE, Director, Green Innovation Policy Commission, Director, UCL Institute for Sustainable Resources

On the Green Innovation Policy Commission

The Green Innovation Policy Commission (GIPC) brings together progressive businesses and leading academics to identify how policy can best support green innovation across the UK economy and reward the innovators, entrepreneurs and investors who generate value from the solutions to the global environmental challenges.

Over its two-year programme, the GIPC set out to:

- Identify green innovation priorities across the UK economy, with a particular focus on hard-to-reach sectors, including road freight, buildings, heavy industry and food;
- Inject new thinking on how policy can most effectively promote and support green innovation;
- Create a new public dialogue between policymakers, academics, and business leaders on the challenges and opportunities around economic growth directed at green innovation.

Members of the Green Innovation Policy Commission

The GIPC comprised the following members (affiliations as at September 2020):

John Cridland (Chair), Chairman, Home Group

Paul Ekins (Director), Professor of Resources and Environmental Policy, University College London

Angela Francis, Chief Advisor, Economics and Economic Development, WWF

Ian Gardner, Director & Arup Fellow, Global Energy Leader, UKIMEA Board, Arup

Peter Harris, Vice President, International Sustainability, UPS

Richard Kirkman, Chief Technology and Innovation Officer, Veolia

Mariana Mazzucato, Professor in the Economics of Innovation & Public Value, University College London

Nick Molho, Executive Director, Aldersgate Group

Benet Northcote, Sustainability Strategy Adviser, BSI Group (until April 2020 Director, Corporate Responsibility, John Lewis Partnership)

Jeremy Oppenheim, Founder and Senior Partner, SYSTEMIQ

Graham Southall, Group Commercial Director, Northumbrian Water

The commissioners took part in the GIPC proceedings in their personal capacities.

For further information and profiles of the commissioners please visit <https://www.ucl.ac.uk/bartlett/sustainable/research/project-directory/green-innovation-policy-commission/about-green-innovation-policy>

Acknowledgements

The GIPC gratefully acknowledges financial support from the SUN Foundation in Germany, the Tellus Mater Foundation, UCL's EPSRC Impact Acceleration Account (IAA) and UCL Public Policy.

We would like to thank Tim Lord, Director, Clean Growth, BEIS, for his insightful feedback at early formative meetings of the GIPC and support throughout the proceedings of the Commission.

The research underpinning the final report was led by Prof. Paul Ekins and a team of UCL academics, including Dr Michal Miedzinski, Dr Will McDowall and Dr George Dibb. The UCL team was supported by Caterina Brandmayr from Green Alliance.

The GIPC team would like to thank Sarah Chaytor, Dr Olivia Stevenson and Dr Isabel Bennett from UCL Public Policy for supporting the GIPC proceedings and providing helpful comments on the final report.

Harry Barton (UCL) created the GIPC website. Cathy Bridge (UCL) supported the organisation of the GIPC meetings held at UCL.

The GIPC's recommendations to government and business

Policy recommendations

The Green Innovation Policy Commission (GIPC) identified six priority areas the UK Government needs to address to deliver on its environmental goals.

Create demand for green innovation: from niches to global markets

Government should use demand-side instruments to create and scale up market pull for innovative green products and services.	Use fiscal instruments including a strengthened carbon price to foster and reward green innovation
	Scale up green public procurement
	Bolster pre-commercial procurement of green innovation
	Incentivise people to make sustainable consumption choices

Boost green innovation investments: from R&D to innovation diffusion

Public investment in R&D and innovation should prioritise innovations with a potential to foster and accelerate green transformation across Britain.	Establish a well-resourced National Green Investment Fund within the new National Infrastructure Bank to provide patient, long-term finance for green innovation
	Prioritise, streamline and scale up public innovation investments which create public value
	Rebalance public investments in green innovation from R&D to experimentation and commercialisation

Change the rules of the game: progressive and agile regulation

Government should align regulations with environmental targets to enforce consistent binding targets, norms and standards across Britain.	Mandate the Regulatory Horizons Council to report specifically on market redesign and regulatory reforms for green innovation
	Introduce performance-oriented standards to foster green innovation
	Use regulatory sandboxes for green innovation

Nurture green innovation ecosystems: cross-sectoral collaboration and experimentation

Government should support cross-sectoral collaborations and balance R&D and innovation investments to foster green transformation across Britain.	Actively encourage and fund challenge-driven innovation collaborations that span sectors and make full use of the opportunities offered by digitalisation and artificial intelligence
	Foster and nurture local and regional innovation ecosystems
	Level up regional capabilities and skills for green innovation

Make infrastructure work for a greener economy: innovative infrastructure

Government should invest in infrastructure to enable and accelerate the transition to a greener and fairer economy.	Make infrastructure planning and investment consistent with environmental objectives
	Consider natural assets and green infrastructure a transformational opportunity
	Harness the potential of digital and space infrastructure to accelerate green innovation

Working together to foster green recovery: challenge-led policies and governance

Government should build new capabilities and governance mechanisms to become a catalyst of transformative green innovation partnerships.	Establish a Green Innovation and Sustainability Transformation Council
	Produce a Green Innovation Policy Roadmap
	Work closer with regional and local actors
	Provide leadership for global green innovation cooperation
	Strengthen monitoring, evaluation and policy learning on green transformation across government.

Business recommendations

The innovation-led transition to a greener economy will require a new settlement between the public and private sector to work out innovative ways of collaboration and new forms of strategic partnerships.

To unlock the full potential of green innovation, UK businesses need not only a clear direction and coherent policy from government, but also shifts in their own corporate culture, leadership, and binding targets on the part of businesses of all sizes.

GIPC identified **eight areas in which business should take leadership for green innovation.**

Board-level responsibility and corporate culture

Every FTSE 350 company should report on sustainability in its Annual Reports and Accounts, with a nominated Director responsible for sustainability.

Net-zero commitments

By 2023 FTSE 350 companies should have a commitment to net zero and a plan of how they will deliver it.

Sustainability plans should be promoted by a national business leadership initiative similarly to the Hampton Alexander's initiative "Women on Boards".

Monitoring and measuring progress towards net zero

Business should collaborate within and across sectors and with government to agree on a set of indicators to measure progress on the pathway to agreed targets and milestones. Government should move to make this form of reporting mandatory and transparent.

Co-creation and compliance with regulation

Businesses and their lobbyists need to engage constructively with new environmental standards and regulations in the post-Brexit environment.

Sectoral leadership for transformative innovation

Sectors should be able to articulate what their contribution to net zero will be, and how they will achieve it by setting out the major steps that they will take together to drive green innovation.

As BEIS engages with sectors and trade associations in the process of developing sector deals, it should be mandatory that these address net zero and related issues. Companies should not expect to be able to receive government support without net-zero plans in place.

New forms of innovation collaboration

We recommend that trade associations and sectoral leadership should develop plans to establish a collaboration platform relevant to the nature of their sector for sharing best practice towards net zero and environmental targets

Experimentation of transformative system innovation

Businesses should raise funding and develop plans to establish pilot initiatives by 2022, and in return it is fair for them to expect that government will make available match funding. Such match-funding could be made available from an innovateUK Industrial Strategy Challenge Fund.

Financial sector

The finance sector should lead by example by providing comprehensive climate risk disclosures in line with the Taskforce on Climate-related Financial Disclosures (TCFD) recommendations, showing support for the UK Government to make these reporting requirements mandatory, and reallocating capital to take full advantage of the new opportunities opened up by green innovation.

Executive summary

The UK, and wider world, face two huge challenges: recovering from the recession inflicted by the global pandemic; and addressing climate change and wider environmental challenges that threaten far greater economic and social disruption in the future.

This report is about one of the major solutions to these problems: green innovation.

The GIPC defines green innovation as the creation and adoption of new ideas, inventions, practices, processes, products and organisational forms that create value for society and the economy while giving better environmental outcomes and helping meet environmental objectives in line with science-based targets.

The UK has had a number of successes in driving innovation to decarbonise the power sector and reduce waste, but the scale and urgency of the environmental challenge now require us to accelerate these efforts. The GIPC arose out of the shared interest in businesses, academia and environmental advocates to reflect on what is driving green innovation - and what is holding it back - across Britain so we can act now, in the next decade of transition.

The role of businesses in this conversation is crucial, so often the objects of policy, but rarely its co-creators. The GIPC is unique in being led and informed by the challenges faced on the ground by businesses that are on a decarbonisation journey. The findings and recommendations in this report are the result of joint work and deliberation by the Commissioners and wider business stakeholders.

The need for green innovation

The world faces many environmental challenges – climate change, biodiversity loss, air pollution and water stress to name a few. Green innovation will be important in addressing all of these challenges. However, the main focus of this report is responding to climate change, and specifically how the UK is going to meet its target of net-zero emissions of greenhouse gas (GHG) emissions, to which the UK government committed in June 2019. Other environmental issues will be touched on where they are relevant.

The challenge of net zero is wide ranging. Businesses, buildings, transport, industry and agriculture –the whole of production and consumption – will all be profoundly affected. The required transformation is also a huge economic opportunity. Industry after industry offers great opportunities for investment for growth and jobs: renewable electricity, with the UK already leading the world in offshore wind; electric vehicles, and associated battery opportunities, where the UK has some catching up to do; low-carbon heating technologies, such as heat pumps and district heating, where the UK can learn a great deal from experience elsewhere; and sustainable farming, with the UK already having some of the highest standards in the world. As the recent experience of the UK with renewable energy has shown, green innovation can dramatically bring down the costs of low-carbon technologies.

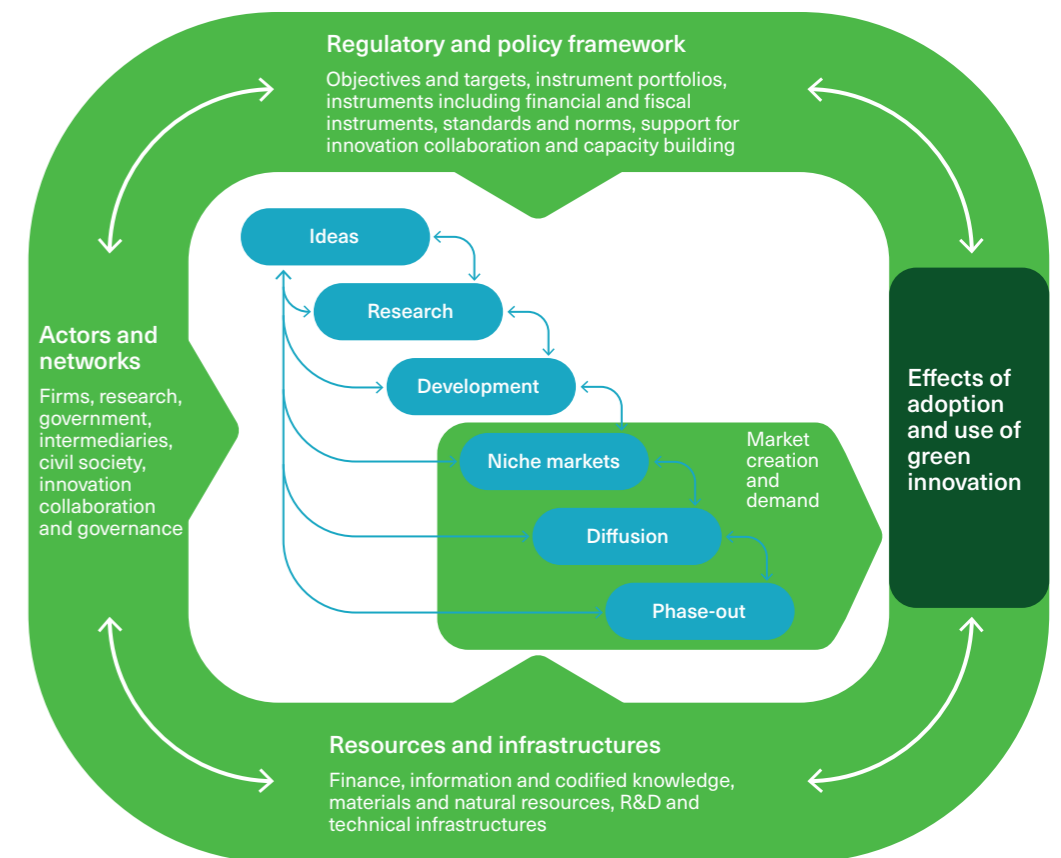
The UK Government has recognised these opportunities and has committed to a significant increase in R&D investment over the coming years. This is a welcome opportunity to super-charge the UK's innovation system, and much of that investment must be channelled towards innovations to foster green recovery. However, the GIPC perceives that, while R&D is important, green innovation policy requires a stronger emphasis on the deployment and

diffusion of already close-to-market green innovations. Innovation policy is much more than R&D policy and needs to focus also on market formation and redesign. To follow through on the vision of the Clean Growth Strategy and meet the net-zero target, the policy needs to support innovation of the kind described in this report.

The nature of green innovation

Innovation as envisaged here encompasses innovations in processes, products and services, organisations, marketing, business models, social arrangements, lifestyles and relations with the natural world. All these are involved as technologies, goods and services move from the research institute or laboratory through to markets and societal deployment at scale, as shown in Figure ES1. When this occurs through all major social systems, as is required for decarbonisation, the outcome is systemic transformation, comparable to the industrial revolution or the emergence of the motor car.

Figure ES1. Innovation chain perspective



Source: Adapted by the GIPC from Wilson et al (2012)

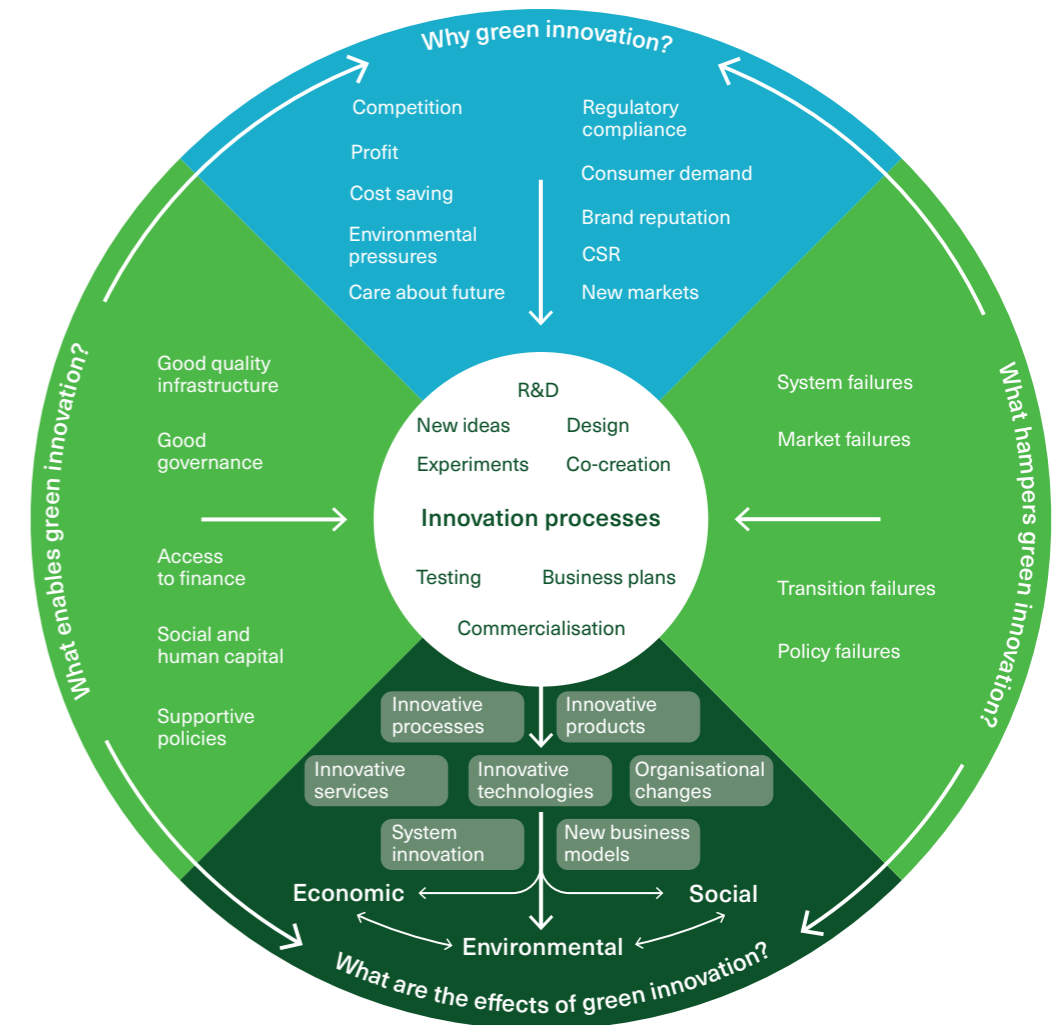
Facilitating green innovation

Most technological breakthroughs and innovations have in the past largely occurred driven by the opportunities offered by new or expanding markets, although governments have not hesitated to intervene and make large investments in the process when it seemed to them necessary or appropriate. But low-carbon innovation is different. While it offers many market opportunities, the pervasiveness of high-carbon infrastructures and the social norms and activities they have fostered throughout society mean that governments have a crucial role to play in providing low-carbon infrastructures and redesigning markets, along with regulatory drivers and other incentives, to tilt the economic playing field in a way that takes full account of the need to decarbonise at an unprecedented rate.

Businesses certainly have an important role to play but the private and public sectors need to work together to overcome the barriers to green innovation to generate the system changes and their associated economic, social and environmental benefits.

Figure ES2 illustrates that innovation can be helped or hampered by regulatory and policy frameworks, institutions and governance, the finance system, entrepreneurial and corporate culture, human capital and skills, enabling technologies, and technical and R&D infrastructures. The role of public policy is crucial in ensuring that regulatory frameworks and incentives, fiscal frameworks and investments, infrastructures and governance arrangements encourage those companies with a corporate appetite for green innovation to develop the human capital, skills and technologies to deploy them profitably at scale.

Figure ES2. The dynamics of green innovation



Source: GIPC

The UK record in green innovation

The UK is a strong performer in respect of research and innovation in general. The country has a world leading university and research sector. The country has a globally competitive position in strategic clean technology areas such as offshore wind, marine energy and efficient aviation. This potential does not fully translate into performance in green innovation. Despite a stable and relatively rapid growth of the UK's low-carbon and renewable energy sectors, Britain has underinvested in R&D for energy and environment and has a patchy record in innovation in areas driving transition to net zero.

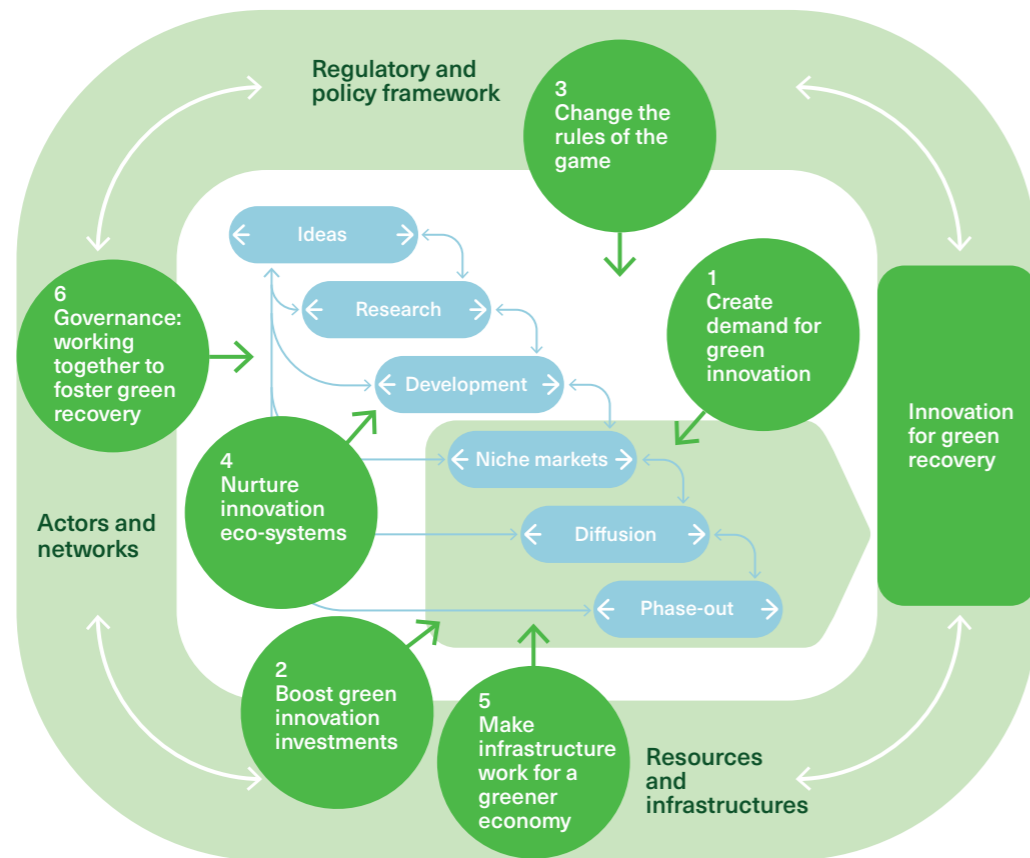
Making green innovation happen

Battered by Covid-19, there is real momentum in the UK for a green recovery, but this requires political will, institutional change and a broad policy portfolio.

The impetus for a green recovery needs to command strong cross-party support across the four nations and a new social contract for a green recovery and transformation towards a green, fair and resilient society. With a political consensus and social mandate, the government should make innovation central in the green recovery process and use its tools to foster and scale up green innovation across Britain.

The Green Innovation Policy Commission (GIPC) has identified **six priority areas the UK Government needs to address to deliver on its environmental goals** (see Figure ES3).

Figure ES3. Policy priorities for green innovation



Source: Adapted by the GIPC from Wilson et al (2012)

Create demand for green innovation: from niches to global markets

In order to foster the transition to net zero, government needs to use its demand-side instruments to create and scale up market pull for innovative green products and services.

- Use fiscal instruments including a strengthened carbon price to foster and reward green innovation
- Scale up green public procurement
- Bolster pre-commercial procurement of green innovation
- Incentivise people to make sustainable consumption choices, including lowering VAT on green products and services.

Boost green innovation investments: from R&D to innovation diffusion

Public investment in R&D and innovation should prioritise green innovations with a potential to foster and accelerate green transformation across Britain. Government should create financial instruments to provide patient finance for green innovations through public investment and leverage, and “crowd-in” private investment.

- Establish a well-resourced National Green Investment Fund within the new National Infrastructure Bank to provide patient, long-term finance for green innovation
- Prioritise, streamline and scale up public innovation investments which create public value
- Rebalance public investments in green innovation from R&D to experimentation and commercialisation.

Change the rules of the game: progressive and agile regulation

There is a need to align the regulatory framework with the UK’s climate and environmental goals adopted by government and redesign core markets that will enable these to be achieved. Regulations need to foster a shared direction of transformation by enforcing consistent binding targets, norms and standards across Britain while ensuring that the regulatory framework is agile and adaptable to the changing context and new evidence. Trade policy and trade agreements must be consistent with this framework.

- Mandate the Regulatory Horizons Council to report specifically on market redesign and regulatory reforms for green innovation
- Introduce performance-oriented standards to foster green innovation
- Use regulatory sandboxes for green innovation.

Nurture green innovation ecosystems: cross-sectoral collaboration and experimentation

Support cross-sectoral innovation collaborations to foster the low-carbon transition. Balance R&D and innovation investments to strengthen regional innovation ecosystems and foster transition to net zero across Britain.

- Actively encourage and fund challenge-driven innovation collaborations that span sectors and make full use of the opportunities offered by digitalisation and artificial intelligence
- Foster and nurture local and regional innovation ecosystems
- Level up regional capabilities and skills for green innovation.

Make infrastructure work for a greener economy: innovative infrastructure

Use government investments in infrastructure to enable and accelerate the transition to a greener and fairer economy. Ensure that all government's infrastructure investments, including in digital connectivity, consider a variety of alternative solutions and unlock opportunities for green innovation.

- Make infrastructure planning and investment consistent with environmental objectives
- Consider natural assets and green infrastructure a transformational opportunity
- Harness the potential of digital and space infrastructure to accelerate green innovation.

Working together to foster green recovery: challenge-led policies and governance

Government needs to build new capabilities, institutions and governance mechanisms to strengthen its capacity to design and implement better policies and to become a catalyst and driver of transformative green innovation partnerships.

- Establish a Green Innovation and Sustainability Transformation Council
- Produce a Green Innovation Policy Roadmap
- Work closer with regional and local actors
- Provide leadership for global green innovation cooperation
- Strengthen monitoring, evaluation and policy learning on green transformation across government.

Business leadership for green innovation

Businesses in Britain are already driving green innovation but the innovation-led transition to a greener economy requires a new settlement between the public and private sectors. Businesses themselves can do, and need to do, much more. Unlocking green innovation in business needs not only a clear direction and coherent policy from government, but also shifts in corporate culture, sectoral leadership, and binding targets on the part of businesses of all sizes. Business should foster transformative green innovation in the following areas.

Board-level responsibility and corporate culture

Every FTSE 350 company should report on sustainability in its Annual Reports and Accounts, with a nominated Director responsible for sustainability.

Net-zero commitments

By 2023 FTSE 350 companies should have a commitment to net zero and a plan of how they will deliver it.

Sustainability plans should be promoted by a national business leadership initiative similarly to the Hampton Alexander's initiative "Women on Boards".

Monitoring and measuring progress towards net zero

Business should collaborate within and across sectors and with government to agree on a set of indicators to measure progress on the pathway to agreed targets and milestones. Government should move to make this form of reporting mandatory and transparent.

Co-creation and compliance with regulation

Businesses and their lobbyists need to engage constructively with new environmental standards and regulations in the post-Brexit environment.

Sectoral leadership for transformative innovation

Sectors should be able to articulate what their contribution to net zero will be, and how they will achieve it by setting out the major steps that they will take together to drive green innovation.

As BEIS engages with sectors and trade associations in the process of developing sector deals, it should be mandatory that these address net zero and related issues. Companies should not expect to be able to receive government support without net-zero plans in place.

New forms of innovation collaboration

We recommend that trade associations and sectoral leadership should develop plans to establish a collaboration platform relevant to the nature of their sector for sharing best practice towards net zero and environmental targets

Experimentation of transformative system innovation

Businesses should raise funding and develop plans to establish pilot initiatives by 2022, and in return it is fair for them to expect that government will make available match funding. Such match-funding could be made available from an innovateUK Industrial Strategy Challenge Fund.

Financial sector

The finance sector should lead by example by providing comprehensive climate risk disclosures in line with the Taskforce on Climate-related Financial Disclosures (TCFD) recommendations, showing support for the UK Government to make these reporting requirements mandatory, and reallocating capital to take full advantage of the new opportunities opened up by green innovation.

Digging deeper into sectoral green innovation

This report explores in some detail the imperatives for green innovation in five sectors: resources and waste, buildings, water, food, and transport of goods. For all these sectors decarbonisation is a significant innovation challenge. For all of them, too, digitalisation and artificial intelligence (AI) offer multiple and pervasive opportunities for carbon reduction and increased resource efficiency.

Resources and waste

The challenge here may be summarised as reducing material use and waste by moving towards a circular economy. The UK has strong waste management companies and many good practices, but the resources and waste sector overall is fragmented. It urgently needs unifying through policy that includes a bolstered approach to green public procurement, product standards for durable design and measures against planned obsolescence, fiscal and advisory support to professional repairers, and transparent information on product reparability.

There is much to be built on in the UK Resources and Waste Strategy and strategic partnerships, such as the Plastics Pact, but they need to be followed up by a strong policy action. Fiscal measures, including strengthened carbon pricing, should level the playing field between less and more carbon-intensive and resource-efficient products and processes, and so drive demand for green innovation. Extended Producer Responsibility frameworks should incentivise green design and move markets towards greater circularity. Networks of businesses and other stakeholders need to be established to encourage the exchange of resources through industrial symbiosis and a robust digital information base of material flows round the economy needs to be created to support investment in their circular management.

Construction

Construction has two formidable challenges in the context of the net-zero target: creating zero-emission new buildings that are healthy and pleasant to live in, and reducing and decarbonising the energy use of the existing building stock, the majority of which will be still standing in 2050.

Meeting these challenges will require a number of simultaneous systemic changes including delivering low-carbon heating to buildings, retrofitting and construction of new buildings, developing new approaches to managing complex projects, and managing complex global value chains. Attention needs to be paid to site wastage, re-use of demolition waste, the digitalisation of building information, and the culture of the sector, in terms of client demands, procurement, and sectoral leadership.

Government has a huge role to play in driving this shift through public procurement, investment in innovation and experimentation, fiscal incentives, ambitious and dynamic regulation, and mandating whole-life carbon assessments. The sector needs to take a strategic view of the skills it will require to meet sustainability challenges, collaborating at national and city levels to ensure that it has the capacity to deliver net zero in the required timescale.

Water

Given the sector's relationship to the natural environment, for the water sector especially, green innovation must mean more than carbon reduction. Ensuring enough water for society and economy, particularly in drier parts of the country and in a context of climate change, will mean managing society's water demands, reducing leakage and increasing the use of grey water. Moreover, changes in weather as a consequence of climate change will require investment in aging infrastructure. Upstream catchment management could help reduce the discharge of agricultural chemicals into water, reducing both energy use and treatment costs as well as reducing the reliance on material-

intensive end-of-pipe solutions. The water sector needs to find ways of improving energy efficiency and reducing leakage while tackling the longer-term, more ambitious agenda of finding ways to use the waste heat from wastewater treatment, and boosting anaerobic digestion.

The policy challenge for green innovation in water is to find ways of encouraging the sector to move in these directions while maintaining its delivery of this vital resource at an affordable cost, within what can be a constraining regulatory environment. Institutional changes in this fragmented sector may be part of the answer, learning from the good and bad experiences of the water sector's different regulatory and institutional models in the UK's four nations. Policy should create synergies with the food sector by incentivising sustainable land management in agriculture through the system that will replace the Common Agricultural Policy (CAP).

Food

How food is produced has a profound effect on nature, water, GHG emissions and the landscape. While there is certainly some good practice in all these areas, as a whole the UK's food system needs substantial reform for green innovation to thrive. Part of the reform needs to come from consumer demand. While there are some encouraging trends of people moving to healthier, less meat-intensive diets, government needs to use its instruments to enable and reward behavioural changes which contribute to the net-zero target.

A key element will be finding an appropriate role for trade, growing enough of the food that the UK can grow to be resilient, while taking advantage of trade to enhance that resilience and vary diets. UK plans to decarbonise the food and farming sectors have to be developed with a trade policy that supports low-carbon food choices whether they are produced at home or overseas. High standards of food production – animal welfare, food safety, environmental impact – are hard to maintain, and impossible to improve, if they are undercut by low standards of foreign production allowed to compete on the same terms. Progress on food production at home will be worthless if it is accompanied by an increased food footprint from poor agricultural practices and deforestation overseas.

There is a long list of potential innovations for more sustainable food production, food processing, diets and food waste reduction, but policy needs to get behind them to reward sustainability, track and maintain standards through the supply chain, provide information for healthy eating and support consumer organisations that support nutritious diets and food waste reduction. A large part of the answer will be the system of agricultural support that replaces the CAP.

Road freight

Road freight is often overlooked not just as a source of GHG emissions, but also as a major contributor to other air pollution and congestion. The key drivers are appropriate infrastructure, institutions, regulatory frameworks and economic incentives to encourage take up of the many technical opportunities for green innovation in road freight. These relate to fuel or other energy sources (biomethane, hydrogen, batteries), infrastructure (charging points, electric roads), logistics improvements (through digitalisation) and last-mile delivery e.g. using e-bikes.

There is progress in all these areas, but it is slow, and the economics of many of them remain challenging if the public benefits are not taken into account. Fiscal measures to improve the economics, regulations such as clean air zones with common standards to give value to healthy air, and investment in clean road and fuel infrastructures, with national governments working in close partnership with local authorities to facilitate planning arrangements, would all help road freight achieve the step change in environmental improvement that green innovation could achieve.

Introduction

Innovation – doing things differently – will be crucial in achieving the UK's goal of net-zero greenhouse gas (GHG) emissions by 2050 and meeting its wider environmental objectives.

There is no shortage of innovation in economies today, and the UK is no exception. Indeed, in many ways this is the age of innovation, with technologies, economies and societies changing at unprecedented rates. But what is needed to resolve today's environmental issues is not any old innovation. It is green innovation, the subject of this report.

Section 1 of this report spells out in more detail just why green innovation is essential, and the enormous economic as well as environmental opportunities that it represents. Section 2 discusses in more detail what this term means in the context of this report, and sets the stage for the later analysis as to how it might be achieved. Here it is important to stress that innovation encompasses much more than just research and development (R&D), important though this is. It includes all the changes and new initiatives, in infrastructure, public institutions, and businesses that are required for new technologies and practices to be widely diffused and adopted in society, once they have been developed.

Innovation is driven by a variety of different motives. In the private sector an important motive is profit – doing things differently (e.g. more efficiently), or putting new goods and services on the market, to benefit the bottom line. But this is not the only motive for innovation, especially green innovation, as this report makes clear. Long-term sustainability, reputation, attractiveness to employees, are some of the other reasons businesses introduce green innovations.

In the public sector the reasons for promoting innovation are even broader, with governments providing support for innovation for general reasons of increasing social welfare, as well as supporting the economy and making businesses more competitive.

Section 3 shows that the UK has a world leading position in research and innovation. The country has rapid growth in rather narrowly defined environmental goods and services (EGS) sector. This is an important sector for green innovation, but this report envisages green innovation much more broadly. It will have to become pervasive through the entire economy for today's environmental challenges to be effectively addressed and, most particularly, for the net-zero GHG target to be achieved.

Green innovation happens because people, and private and public institutions, including businesses and governments, consider it to be in their individual or collective interests. At present these interests are nothing like strong enough to bring about green innovation at the required rate. Across a wide range of issues, environmental problems are getting worse, not better, and the UK is not on track to achieve its net-zero target.

The good news is that, as shown in Section 4, a lot of businesses want to do much more green innovation. There are some inspiring examples of what they have achieved. But there is also much frustration that it is not possible for them to achieve more. Sometimes this is because green innovation raises short-term costs, and the environmental benefits it generates do not get factored into markets or business benefits. Sometimes the necessary infrastructure to support the green innovation is missing. Sometimes there are regulations or other institutional barriers that make the green innovation unviable.

Businesses very often cannot resolve these problems by themselves. They need to work collaboratively with the public sector, at national or local level. Policy recommendations along these lines, based on the analysis and business experiences recounted in Section 4, are the subject of Section 5.

Many of these recommendations are directed at public policy makers. But this is also intended to be a report by business for business. Section 6 contains recommendations for businesses themselves. By this time it will be clear that green innovation will be most effectively promoted by business and the public sector in partnership. But there is a lot that business itself can do, as this section shows. And it is fitting that these recommendations should act as the conclusion to this report.

1.

Why green innovation?

The UK Government's net-zero target and 25-year Environment Plan has firmly positioned decarbonisation and environmental sustainability as key challenges to be addressed to ensure the future prosperity of the UK's society and economy.

Achieving net zero will require emissions to be cut across all sectors and parts of the country. Transport, homes, businesses and land use all make a significant contribution to the UK's greenhouse gas emissions. They are also responsible for an unsustainable rate of resource extraction, loss in biodiversity and ecosystem resilience, and pollution that damages both people and nature.

Reducing their climate and wider environmental footprint requires an unprecedented scale of change. This will include innovation in products, processes and services to develop cleaner, resource-efficient alternatives, novel ways of planning and managing infrastructure to support people and businesses in moving towards low-carbon activity, and new approaches to land that enhance its productivity and resilience while supporting biodiversity and climate mitigation.

While the scale of change may seem daunting, the UK should double down on this agenda, because it is the right thing to do, but also because it is in its wider self-interest.

It is right for the UK to lead on decarbonisation, because it was the first country to industrialise and ranks fifth among countries with the largest cumulative CO2 emissions since 1750.¹ If the UK is to account for its historical responsibility and be true to the commitment made by signing the Paris Agreement, it needs to play its part in tackling the climate challenge by ending its contribution to damaging climate impacts worldwide.

But the low-carbon transition also represents a huge industrial opportunity.² Growth in low-carbon industries has outpaced overall economic growth in the UK (CCC, 2019). And low-carbon solutions will be increasingly in demand, with global markets for clean vehicles and related services expected to increase at an annual rate of 25-30% to 2030, and those for low-carbon financial services and electricity at 10% and 7%, respectively.³

Building on its research excellence the UK is well placed to benefit from the transition. Promoting innovation and growth in low-carbon and resource-efficient supply chains will ensure UK businesses will remain competitive as global economies decarbonize. Furthermore, by supporting new green industries across the country, from zero-emission vehicles to smart energy, from whole building retrofit to nature-enriching food production, it can also help rebalance the economy north to south and support future-proof, green jobs.

The UK Government has in part recognized this opportunity. It set clean growth as one of the four grand challenges that should drive delivery of its industrial strategy and has started to introduce policy to promote innovation and investment in key low-carbon industries such as electric vehicles, offsite construction and carbon capture and storage.

1 See <https://www.carbonbrief.org/in-depth-qa-the-uk-becomes-first-major-economy-to-set-net-zero-climate-goal>
2 See <http://www.lse.ac.uk/GranthamInstitute/news/why-the-chancellors-statement-on-the-cost-of-a-net-zero-transition-in-the-uk-could-imperil-the-countrys-climate-ambitions/>; <https://www.theccc.org.uk/wp-content/uploads/2019/05/Advisory-Group-on-Costs-and-Benefits-of-Net-Zero.pdf>
3 See <https://www.theccc.org.uk/wp-content/uploads/2017/03/ED10039-CCC-UK-Bus-Opportunities-Draft-Final-Report-V7.pdf>

Yet, while the foundations are in place in many of the areas needed to reach net zero, the Committee on Climate Change (CCC) pointed out⁴ that policy should be ramped up significantly across all sectors in order to deliver the emissions reduction needed and maximise the economic and societal benefits of the low-carbon transition. Failing to take action at the pace and scale needed will not only expose communities across the world to the damaging impacts of climate change, but also make the UK's transition to net zero more costly and limit the opportunity for UK businesses to be at the forefront of emerging low-carbon industries.⁵

It can be done. Well designed and appropriately funded policies for low-carbon energy over the past decade have turned UK research excellence into world-leading renewable industries. The remarkable fall in the cost of renewables and their rapid deployment has vastly exceeded expectations. And, crucially, it led the CCC to estimate that net-zero emissions by 2050 could be achieved with the same level of investment originally estimated for only an 80 per cent emissions reduction, thanks to cost reductions achieved through innovation and economies of scale.

The case for action is clear, and so is the role of innovation in achieving a net-zero world. What is less clear is what concrete steps government and businesses should take in order to replicate across other UK sectors the success achieved in renewable energy, and to accelerate the innovative low-carbon solutions that could provide the foundation for a green economic recovery from Covid-19.

In this work, the Green Innovation Policy Commission sets out its view on what is needed to unlock low-carbon innovation across the UK and urges the government and businesses to take immediate and ambitious action in this direction.

4 See <https://www.theccc.org.uk/2019/07/10/uk-credibility-on-climate-change-rests-on-government-action-over-next-18-months/>

5 See <http://www.lse.ac.uk/GranthamInstitute/news/why-the-chancellors-statement-on-the-cost-of-a-net-zero-transition-in-the-uk-could-imperil-the-countrys-climate-ambitions/>

2.

What is green innovation?

Climate change, depletion of natural resources, pollution of air, water and soils or biodiversity losses are challenges with acute and localised impacts increasingly felt across the UK society and economy. There is a growing acceptance that the environmental crises have been driven by the economic system relying on unsustainable production and consumption patterns. What follows is that innovations aiming to effectively tackle these crises ought to start from treating their economic and social roots rather than mostly addressing environmental damage already done.

Recognising the social nature of environmental challenges, **the GIPC defines green innovation as the creation and adoption of new ideas, inventions, practices, processes, products and organisational forms that create value for society and the economy while giving better environmental outcomes and helping meet environmental objectives in line with science-based targets.**

Green innovation: from incremental improvements to system-level changes

There is no single mode or locus of innovation which can respond to environmental challenges facing the UK and the world. Green innovation is diverse, ranging from incremental improvements to radical innovation of entire production and consumption systems (see Box 1). It needs to be situated in a specific context.

Traditionally, the focus of green innovation was on solutions minimising negative environmental impacts from production and consumption activities. These so-called “end-of-pipe” solutions proved effective in limiting negative impacts of harmful emissions (e.g. pollution control technologies, catalytic converters in cars). Thanks to their measurable benefits, they became a tangible symbol of environmental modernisation. They will continue to play an important role in reaching environmental targets. Traditional environmental technologies alone, however, are not sufficient to tackle most of the global sustainability challenges.

More recently the focus shifted to green innovations with demonstrable benefits for business, including cost savings (e.g. by improving efficiency of the use of materials and energy) and new markets (e.g. green products and service-based business models). Cost savings through material and energy efficiency are often considered low-hanging-fruit opportunities of green innovation, but it needs to be recognised that productivity improvements may lead to rebound effects that reduce environmental gains.

The challenge of transition towards a net-zero future requires a systemic approach to innovation. The scale and urgency of societal challenges suggest that there is a need for combinations of various innovations, including wider and faster deployment of tested green technologies as well as new forms of more transformative system innovations, such as circular economy business models or integrated mobility approaches. System innovations include a range of functionally connected changes including product, organisational and process innovations that, enacted together, can transform socio-technical systems (e.g. mobility, agri-food). They are collaborative processes building on synergies emerging between sectors, disciplines, and value chains.

Box 1

Types and selected examples of green innovation

Process innovation

- Pollution control and pollution treatment technologies
 - _ Air, water and soil pollution control technologies
 - _ Cleaning technologies that treat pollution released into the environment
 - _ Noise and vibration control
 - _ Environmental monitoring technologies (meters)
- Waste prevention and waste management
 - _ Waste management processes and equipment
 - _ Integration of secondary materials in the production
- Resource-efficient processes
 - _ Material, energy and water efficient production processes
 - _ Renewable energy uses in manufacturing

Product and service innovation

- Innovative technologies, including renewable energy technologies
- Innovative products
 - _ Novel competitive products with a reduced lifecycle-wide environmental impact (e.g. durable, repairable, re-usable, recyclable, compostable products)
 - _ Novel eco-innovative materials with a reduced lifecycle-wide environmental impact and a capacity to substitute existing alternatives
 - _ Frugal innovation with a reduced lifecycle-wide environmental impact due to a reduced complexity of products (re)designed or remanufactured to deliver core functions.
- Innovative services
 - _ B2B: Provision of services aimed at improving processes of clients (e.g. waste management, environmental consulting, eco-design)
 - _ B2C: Provision of services that are less resource intensive and reduce emissions (e.g. extended warranties and repair services)

Organizational innovation

- Environmental management and auditing systems (such as EMAS, ISO 14001)
- Introduction of Total Quality Management to the organization
- Introduction of Extended Producer's Responsibility solutions (CSR)

Marketing innovation

- Informing customer choices (e.g. independently verified eco-labels)
- Science-based campaigns and awareness raising on sustainable consumption

Business model innovation (single-actor models)

- Radical changes in value proposition and product-service systems of companies (e.g. circular economy business models, including product sharing and functional sales)

Social innovation

- New social arrangements with environmental benefits (e.g. energy cooperatives, repair cafés, eco-villages)

Nature-based solutions

- Innovative approaches to afforestation, soil remediation; re-introduction of mangroves for flood protection.

System innovation (multi-actor models)

- Product-service systems engaging a group of functionally connected organizations:
 - Multi-actor product-service systems (e.g. product sharing platforms and infrastructure)
 - Industrial ecology
 - Waste management systems (integrated approaches to collection, sorting, processing and disposal)
 - Integrated mobility systems with a reduced use of cars
 - Smart buildings and smart cities.

Enabling, pervasive and transversal innovation

- Digitalisation and Artificial Intelligence (AI)
- Hydrogen as a major new energy carrier

Source: Miedzinski et al (2017)

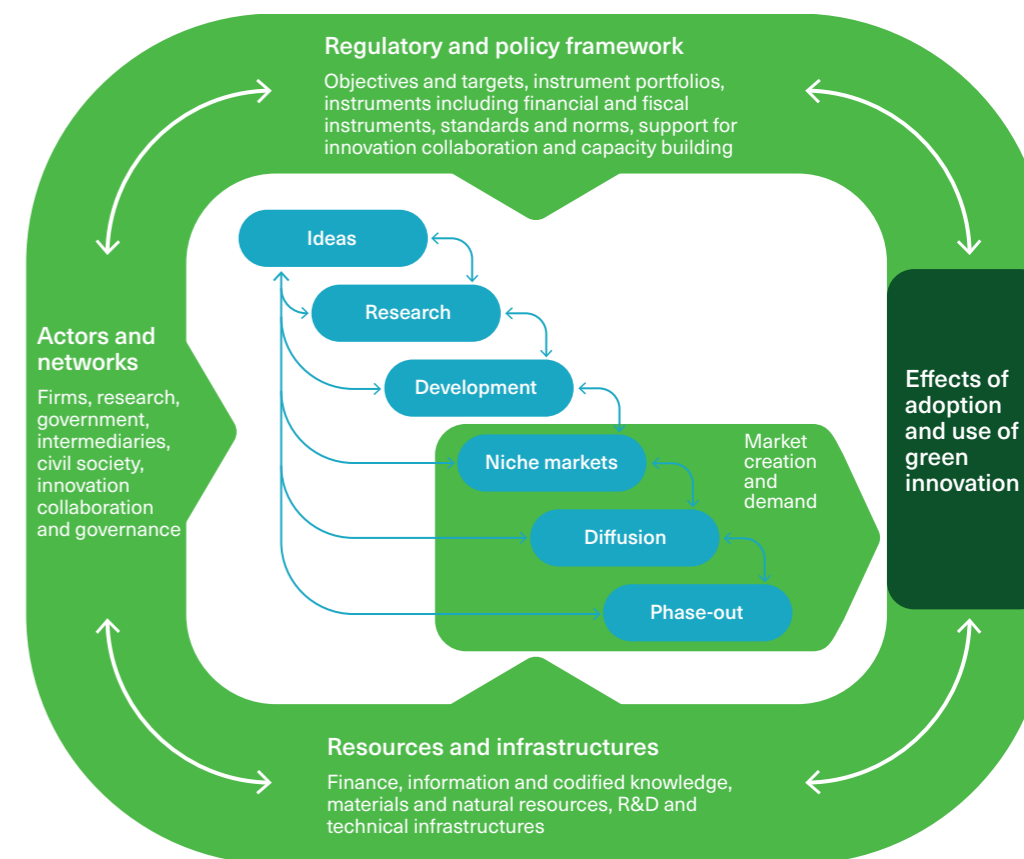
Systemic view of the innovation process

Innovations are most often introduced on the market by firms. The capabilities of firms to learn and transform old and new ideas and knowledge into innovation are therefore crucial for green innovation. Firms are, however, not alone in the innovation process. Others directly or indirectly involved in the innovation process include knowledge organizations, such as universities and research institutes, government on all levels, civil society as well as consumers. All these actors have a role in the innovation process, and need to collaborate to learn, co-design and jointly develop and deploy green innovation in the UK and globally.

Innovation is often perceived as a result of advanced research and development (R&D) activities which directly lead to designing and implementing new products and services on the market. While R&D is important for some firms, successful innovations rarely, if ever, result from a linear science-driven process. The commercial success of innovations is based on the combination of different types of knowledge and expertise, resources and capacities.

The innovation process involves multiple iterations and interactions within and between firms and other actors whose activities are enabled or hampered by the wider socio-economic, technical and institutional environment. The innovation process seen from this perspective is a learning process involving many actors and significant risk (see Figure 1).

Figure 1. Innovation chain perspective



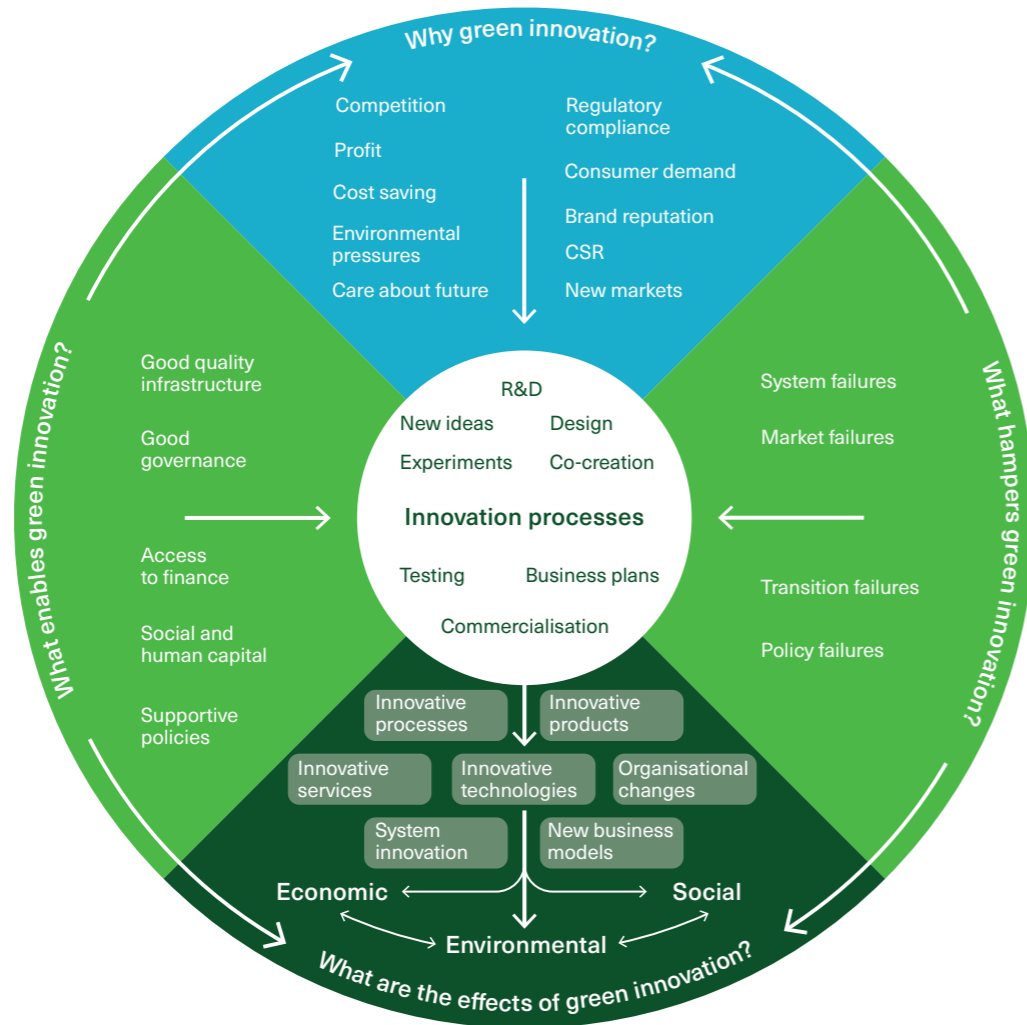
Source: Adapted by the GIPC from Wilson et al (2012)

“**The Commission adopted a business perspective on green innovation exploring why businesses engage in green innovation and what are the key factors, including public policy, which enable or foster green innovation in various sectors**”

This perspective on innovation is at the core of the concept of an innovation system. Innovation systems are most often analysed on the level of countries, hence the national systems of innovation framing (Lundvall, 1985, 2010; Freeman, 1987). The focus on countries is based on recognising the fundamental role of states as actors with the mandate and capacity to design and implement regulatory, policy and institutional frameworks which are important elements of an innovation system. Innovation ecosystems, however, are multi-faceted and open. They are interconnected with international value chains and collaborations and co-evolve with international and global trends. Innovation scholars investigate innovation systems also on the global (e.g. global innovation networks), sectoral (Malerba, 2004), technological (Hekkert et al., 2007; Bergek et al., 2008) as well as the regional level (Cooke and Morgan, 1998; Cooke et al., 2004).

The GIPC has investigated the fitness for purpose of the UK innovation system to enable development and deployment of transformative green innovation in the UK and globally. The Commission adopted a business perspective on green innovation exploring why businesses engage in green innovation and what are the key factors, including public policy, which enable or foster green innovation in various sectors (see Figure 2).

Figure 2. GIPC's understanding of green innovation



Source: GIPC

Why green innovation?

Businesses are motivated to invest and develop green innovation by many factors. These motivations can be internal (e.g. improvement of a company's image, quest for new markets) or external to the organisation (e.g. regulatory compliance or competitive pressure).

Once companies embark on green innovation, their journey is enabled or hampered by many internal and external factors. These barriers and drivers can include:

- Regulatory and policy frameworks (e.g. stringency of environmental policy);
- Institutions and governance (e.g. cooperation culture and trust);
- Finance system (e.g. access to green finance);
- Entrepreneurial and corporate culture (e.g. sustainability values);
- Human capital and skills (e.g. new skills);
- Enabling and emerging technologies (see Box 2 and 3);
- Technical and R&D infrastructures (e.g. quality and access to infrastructures).

Innovation systems are considered mature if they provide an enabling environment for companies and other actors to engage in innovation activities. But what is a mature innovation system from the perspective of sustainability

“Public policy needs to build and nurture innovation ecosystems which prioritise and enable green innovation in a comprehensive and systemic manner.”

challenges? GIPC explores key enablers and barriers for green innovation across the UK economy, with a focus on some key sectors.

What is the role of innovation policy?

With its focus on policy, the particular focus of the Commission is on the role of government and governance mechanisms in enabling and stimulating supply and demand for green innovation. The traditional rationale of policy support for innovation is based on market failure. A market failure manifests itself in an insufficient allocation of capital for risky and long-term innovative projects despite the promise of future societal benefits.

Green innovations suffer from an additional market failure manifested by the failure of prices to reflect the social and environmental costs of unsustainable products and services. In the absence of mechanisms that internalise these costs in prices, green innovators struggle to access funds for their projects and to attract customers. As a result, society remains exposed to unsustainable processes and products contributing to climate change, toxic pollution and resource depletion.

The market failure perspective, however, does not reflect the systemic nature of innovation. The systemic view on innovation came with the evidence of system failures which influence innovation performance. System failures include shortcomings in the key elements of innovation systems, notably capabilities of actors, linkages (collaborations and networks) and framework conditions. Importantly, understanding the relevance of systemic bottlenecks significantly changes the rationale for policy intervention. Building an effective enabling environment for green innovators requires consideration of market and system failures.

The perspectives of market and system failures are important for green innovation policy but even so they do not fully capture the challenge of enabling a systemic change. Green innovation suffers also from transformational failures that manifest themselves in the limited capability to foster transformation towards a desired future because of, for example, failure to influence the direction of growth towards a sustainable future (e.g. directionality) and to create markets for green products and services (Weber and Rohracher, 2012).

GIPC argues that in order to scale up green innovation and fully harness its benefits, public policy needs to build and nurture innovation ecosystems which prioritise and enable green innovation in a comprehensive and systemic manner. One key role of government is, to ensure the long-term aspirational vision and stakeholder alignment around key transition pathways. This is not only about addressing failures but more about orchestrating innovation efforts towards a desired direction, a sustainable future.

Box 2

Green innovation through digitalisation and system change

The opportunities for green innovation are shaped by wider technological trends which cut across all economic sectors and revolutionise production and consumption patterns. Digitalisation, for example, offers many opportunities for green innovation. Digitalisation is a wide-scale process of diffusion and adoption of digital technologies and business models enabled by them (e.g. platforms) across economy and society. Mobile phones, Big Data, artificial intelligence (AI), the internet of things (IoT) or blockchain technology all have transformative impact on business operations in all sectors and in virtually every aspect of everyday lives. Digital technologies allow to scale up business models and open up new opportunities for new cross-sectoral collaborations.

Digital technologies and automation can substantially improve resource and energy productivity and help reduce emissions in manufacturing processes. Access to better data on production processes and other company operations help companies to improve their overall environmental footprint. The use of digital technologies in product design can improve product resource and energy efficiency. Access to data on product performance during the use phase (e.g. via sensors) allows companies to further improve their performance. Information and communication technologies (ICTs) are increasingly applied to the level of complex products and systems, e.g. buildings, cities (e.g. smart city) or functional systems (e.g. mobility, energy, waste). Advanced ICTs aided by applications of machine learning can create synergies and further improve system inter-operability (e.g. multi-modal transport systems).

Digital transformation does not come without challenges for environmental and social sustainability. Automation may lead to losses of jobs in manufacturing. It can create challenges for privacy and creates space for cybercrime. From the environmental footprint point of view, there is little evidence that digitalisation and new business models based on digital platforms (e.g. online shops, car sharing platforms) lead to the overall decrease in consumption. The platforms make it easier than ever to purchase any product anytime anywhere. There is also a growing concern about the carbon and material footprint of digital technologies themselves (e.g. resource and energy use of data centres and daily use of ICTs, challenges of recycling electronic equipment).

Renewable energy technologies foster the transition towards low-carbon, clean and fair energy systems and create innovation opportunities across the economy and society. Some new energy carriers, such as hydrogen, have the potential to enable deep and systemic decarbonisation. The transition requires innovations not only within the energy system itself, including in power generation (mainly by promoting renewable energy technologies and shifting away from fossil fuels), energy storage (environmental friendly batteries) and the transmission grid (e.g. smart grid technologies), but also has an impact on all economic sectors by improving their energy efficiency and access to clean electricity and enabling new business models. For example, when endowed with small-scale solar energy generation capacity buildings can become energy producers rather than mere users. With the overall trend towards electric urban mobility, buildings (including public utilities such as schools, hospitals or public administration buildings) can offer charging points and effectively become part of urban mobility systems.

Box 3

Sustainable energy and hydrogen

Hydrogen is emerging as an important innovation option for achieving deep decarbonisation. Hydrogen can be produced from a wide range of energy sources, and then stored, transported, and used (with zero emissions) in a wide range of energy applications such as a combustion fuel in industrial or domestic heating, or in a fuel cell to power vehicles and other electric loads.

Because of the wide array of possible applications of hydrogen, there are wide cross-sectoral collaborations already underway. Power and gas utilities, automotive companies, electronics manufacturers, boiler manufacturers and many others are all involved. Hydrogen has the potential to play a significant role in worldwide energy systems, and thus there is a strong potential market for the firms that ultimately dominate hydrogen and fuel cell (H2FC) technologies. There are also smaller near-term benefits to adopting hydrogen energy systems, including niche or localised applications (e.g. remote power systems, hydrogen buses in cities).

While much activity has focused on the prospects for hydrogen passenger vehicles, more recently it has become clear that hydrogen may be an attractive option for decarbonising a range of 'hard-to-abate' sectors: long-distance HGVs, trains where electrification is uneconomic, industrial processes and heating, and potentially residential heating using existing gas network infrastructure.

The key innovation challenges are related to the development and commercialisation of hydrogen technologies and systems across a wide range of markets. For the UK, the key challenges are to support the existing UK H2FC sector to enable the UK to benefit from future growth in both UK and international markets. A particular interest in the UK has been around the potential for hydrogen to decarbonise residential heat through re-purposing of the gas distribution grid and gas boilers. The UK is a leader in exploring this option. There is a major need for technological innovation: both to develop new H2FC products and applications (e.g. hydrogen-fired kilns in industry, hydrogen use in low-carbon steelmaking) and for process and manufacturing innovation to drive down unit costs (this is particularly true in fuel cell assembly).

A key area for innovation is around cost effective production of clean hydrogen. Hydrogen can be produced from fossil fuels, and from renewable energy (e.g. through gasification of biomass, or through electrolysis of water using renewable electricity). Currently, almost all hydrogen produced commercially is produced from natural gas, and hydrogen's role in future energy systems is contingent on innovation in clean hydrogen production. The world market for electrolysis is projected to be between 0.5-2bn by 2030, with European firms (including UK firms) enjoying a globally strong position.

Interest in hydrogen is growing internationally, with a recent International Energy Agency report highlighting strong expected global growth in hydrogen energy systems worldwide. The UK has several leading companies that are internationally competitive in H2FC technologies: ITM Power make electrolyzers (which produce hydrogen from electricity); Johnson Matthey produce components for fuel cells; Ceres Power and Intelligent Energy produce fuel cells. Despite these leading firms, the UK is not among the top countries in terms of hydrogen fuel cell capabilities, and is behind Germany, Japan and the US. This is a common picture in clean energy technology, in part owing to the UK's lack of serious public energy R&D expenditure during the 1990s and early 2000s.

“The government has unique competences and capabilities to provide positive and negative incentives to catalyse and steer innovation efforts into a desired direction.”

The government has unique competences and capabilities to provide positive and negative incentives to catalyse and steer innovation efforts into a desired direction. Policy makers can deploy a range of policy instruments to directly support the innovation process and to create a better environment for innovations addressing sustainability challenges. This instrument mix can include direct funding, new financial arrangements to leverage private investment, adjusting fiscal frameworks (including through the introduction of carbon pricing), public procurement, building green innovation capabilities and skills, and – to the extent possible – working towards adjusting wider international framework conditions (e.g. via trade agreements and international collaborations).

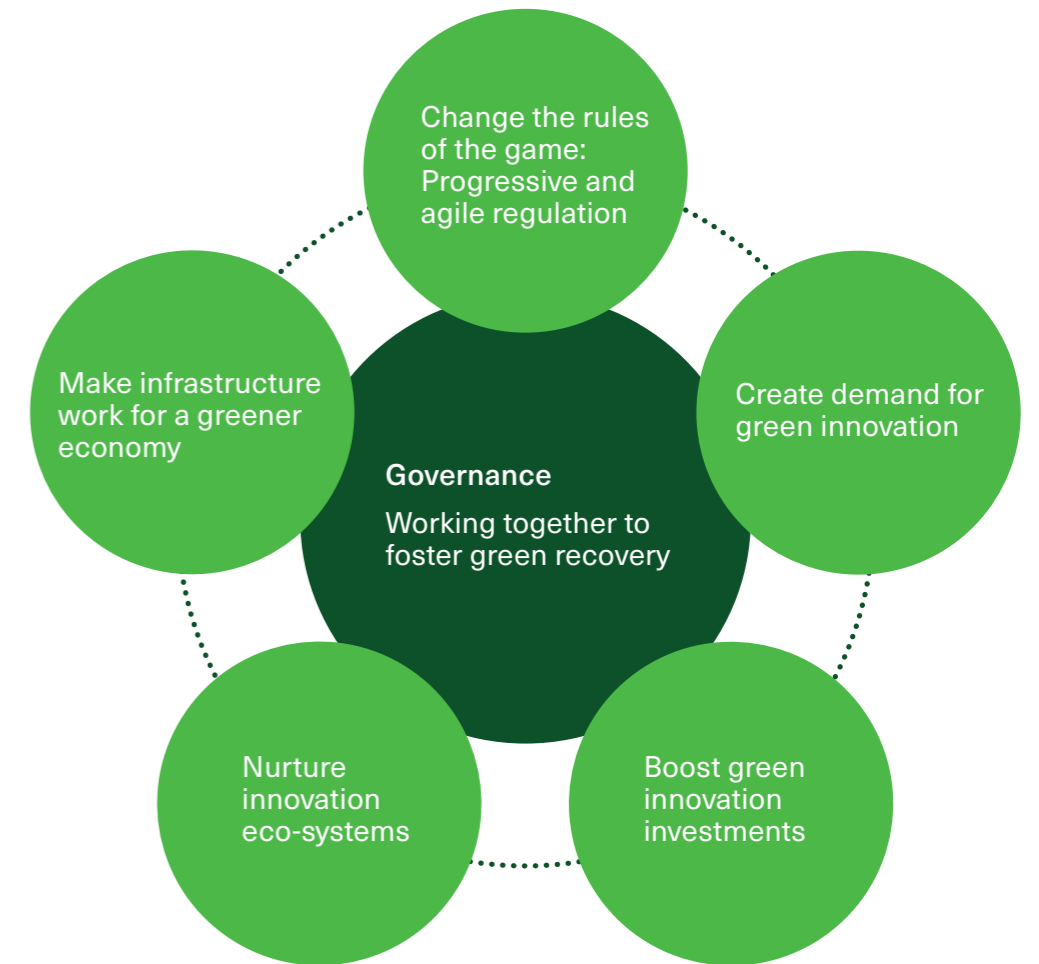
This is also a governance challenge with implications for the way policy is designed, implemented, monitored and evaluated, and how government works with its partners in business, science and civil society.

Policy makers have a task to strive for a comprehensive, consistent and coherent ‘policy mix’ comprising mutually supporting strategic goals, instruments and processes. At the same time, supporting transformative green innovations invites experimentation and disruptive innovation from both business and policy makers but it comes with a responsibility to consider how to ensure that the risks and benefits of innovation are borne in a fair way.

To address the role of public policy and governance in a systemic way, this report adopts a comprehensive approach and focuses on six areas in which government can strengthen its policy to accelerate green innovation:

- Create and shape demand for green innovation: from niches to global markets;
- Boost green innovation investments: from R&D to innovation diffusion;
- Change the rules of the game: progressive and agile regulation;
- Nurture green innovation ecosystems: cross-sectoral collaboration and experimentation;
- Make infrastructure work for a greener economy: innovative infrastructure;
- Working together to foster green recovery: challenge-led policies and governance.

Figure 3. GIPC's approach to policy for green innovation



3.

A glance at the UK's green innovation performance

“**Without a strategic re-orientation of its research and innovation system Britain will miss a chance to fully exploit its green innovation potential and could lose its globally competitive position in a longer term.**”

This chapter is a snapshot of the UK's green innovation performance and its position in the world. We conclude that the UK is a research and innovation power house with a major potential and real opportunity to foster green transformation at home and globally. Without a strategic re-orientation of its research and innovation system, however, Britain will miss a chance to fully exploit its green innovation potential and could lose its globally competitive position in a longer term.

Here we draw on global indicators to paint a picture of the UK's performance, including Britain's position in international innovation indices and a look at key metrics in the areas of green innovation, notably R&D investments, patents and economic developments in the environmental goods and services (EGS) sector.

Box 4

Challenges of measuring green innovation

Measuring the full potential and benefits of green innovation is notoriously difficult. The pervasive nature of green innovation, spanning all economic sectors, the complex nature of innovation adoption and diffusion processes, and limited access to company-level innovation data, all mean that its measurement poses a challenge to researchers. There is no a single method or indicator that can serve as a sufficient metric of green innovation (Arundel and Kemp, 2009; Miedzinski et al. 2017; Kemp et al., 2019).

Metrics currently used to measure green innovation performance across countries use baskets of indicators, many of them proxies. Probably the most challenging area is measuring the economic impacts of green innovation due to the lack of data on green innovation for all sectors and difficulties to attribute economic benefits to implementation or adaption of a specific innovation. As a result, researchers use proxies which means they capture the potential of green innovation only partially.

This is the case of, for example, using indicators for environmental goods and services (EGS) as a proxy for measuring economic outcomes of green innovation. EGS has a focus on goods and services with the main purpose to prevent, decrease or repair environmental damage of human activity. While EGS cover important areas, its scope does not capture innovative products in sectors which are not covered by EGS but which are crucial for reaching net zero and other environmental goals (e.g. manufacturing, construction or transport).

The UK is among the most innovative countries in the world...

The UK is an innovation super-power. The Global Innovation Index (GII) compares 130 economies in the world based on 80 indicators (Cornell University et al., 2020). Britain is ranked fourth in the most recent GII 2020. The country hosts four S&T clusters ranked in the top 100: London (15th), Cambridge (57th), Oxford (71st) and Manchester (93rd). Cambridge and Oxford are the world's most S&T-intensive clusters (ibid.).

Figure 4. Global Innovation Index 2020: Britain is among top global innovators

Country/Economy	Score (0-100)	Rank	Median 30.94
Switzerland	66.08	1	
Sweden	62.47	2	
United States of America	60.56	3	
United Kingdom	59.78	4	
Netherlands	58.76	5	
Denmark	57.53	6	
Finland	57.02	7	
Singapore	56.61	8	
Germany	56.55	9	
Republic of Korea	56.11	10	
Hong Kong, China	54.24	11	
France	53.66	12	
Israel	53.55	13	
China	53.28	14	
Ireland	53.05	15	
Japan	52.70	16	
Canada	52.26	17	
Luxembourg	50.84	18	
Austria	50.13	19	
Norway	49.29	20	

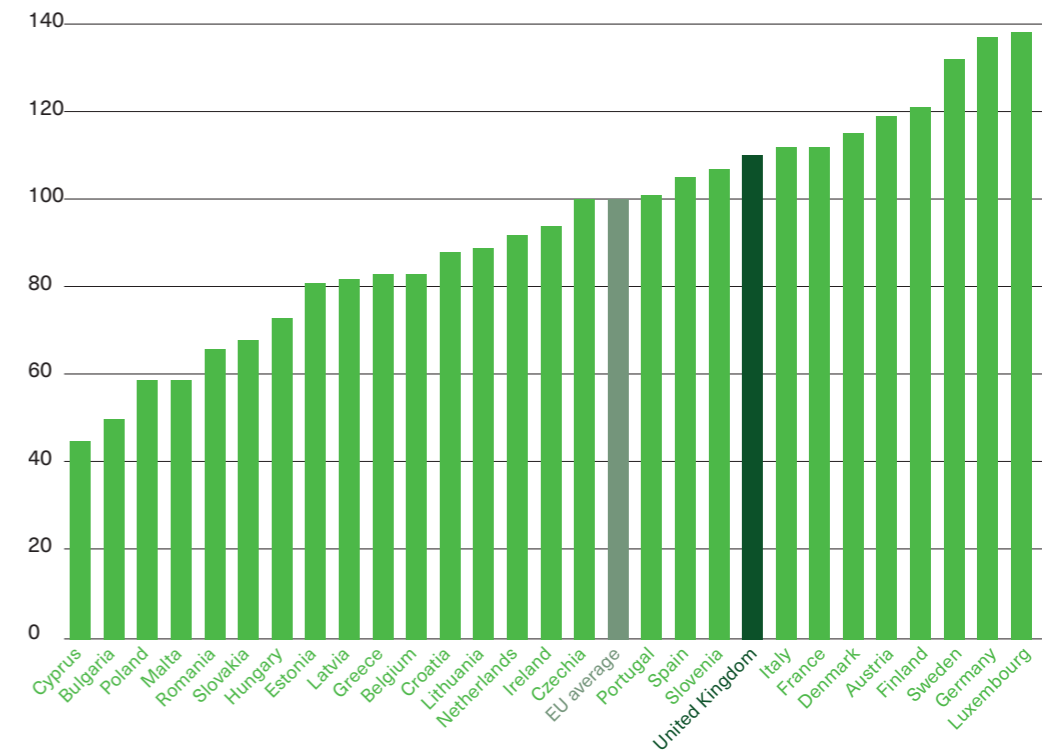
Source: Top 20 countries in the Global Innovation Index (GII) 2020 (Cornell University et al., 2020)

...but does not perform as well in green innovation

Britain's world leading position in science, technology and innovation (STI) does not fully translate in its green innovation performance. The Eco-Innovation Index (Eco-IS)⁶, focusing on measuring green innovation in the EU member states since 2010, ranks the UK among above-average European countries, but the UK has never made it to the top three EU performers. In the 2018 Eco-IS the UK ranked ninth (see Figure 5).

6 The EU Eco-Innovation Index covers only EU Member States. See https://ec.europa.eu/environment/ecoap/indicators/index_en

Figure 5. European Eco-Innovation Index 2018: Britain is a solid green innovation performer in Europe



Source: Eurostat

While the UK compares favourably to EU member states in several areas (e.g. early stage investments in clean technology, exports of products from eco-industries), it falls behind the leaders in government R&D spending and employment and turnover in eco-industries. A closer look at selected indicators reveals areas where the UK lags behind and fails to exploit its potential.

UK underinvests in green R&D and innovation

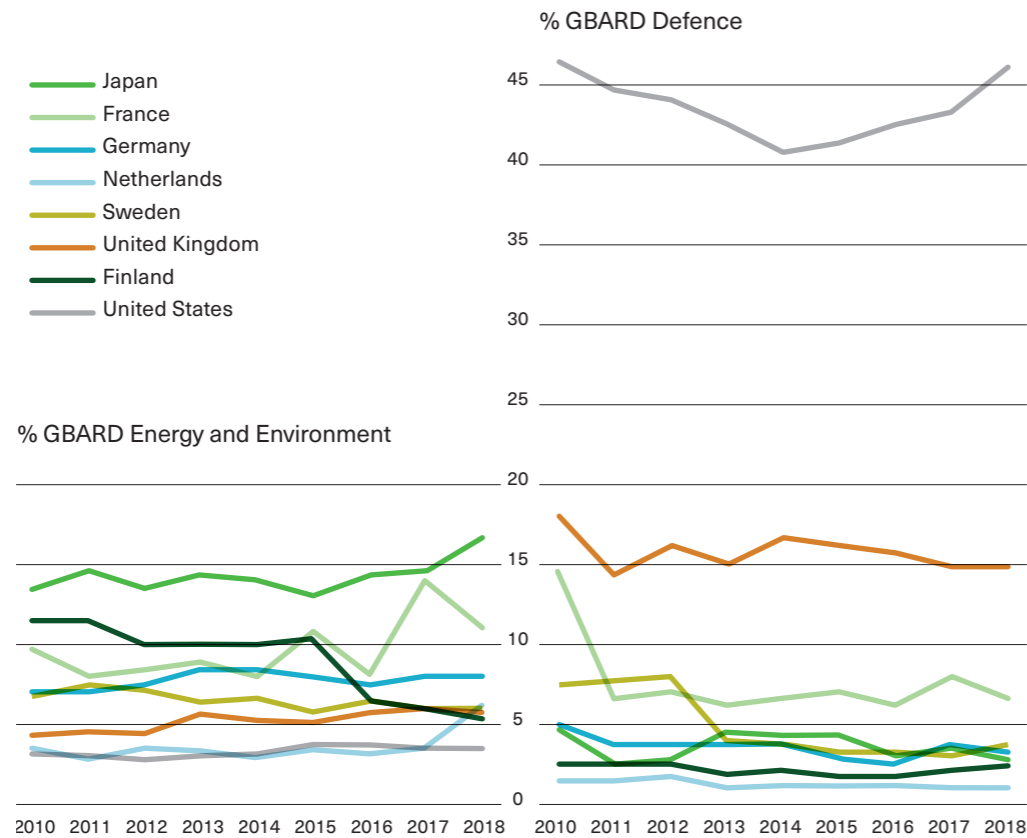
The UK is weak on investment in R&D. Although the UK performs relatively well in terms of early-stage private investment in clean technologies when compared to many European countries⁷, it lags behind leading European and global economies in terms of government's R&D expenditure (1.7% of GDP in 2018) and, more specifically, R&D investments related to environment and energy (see Figure 6).

It is particularly striking that in relative terms the UK invests nearly three times more of its government R&D budget in defence (15% of GBARD⁸) than in energy and environment (5.5%). The country stands out in this regard compared to its European partners.

7 According to Cleantech Group data as reported in the Eco-Innovation Index.

8 GBARD stands for Government budget allocations for R&D.

Figure 6. Comparison of energy and environment and defence related R&D as a share of GBARD



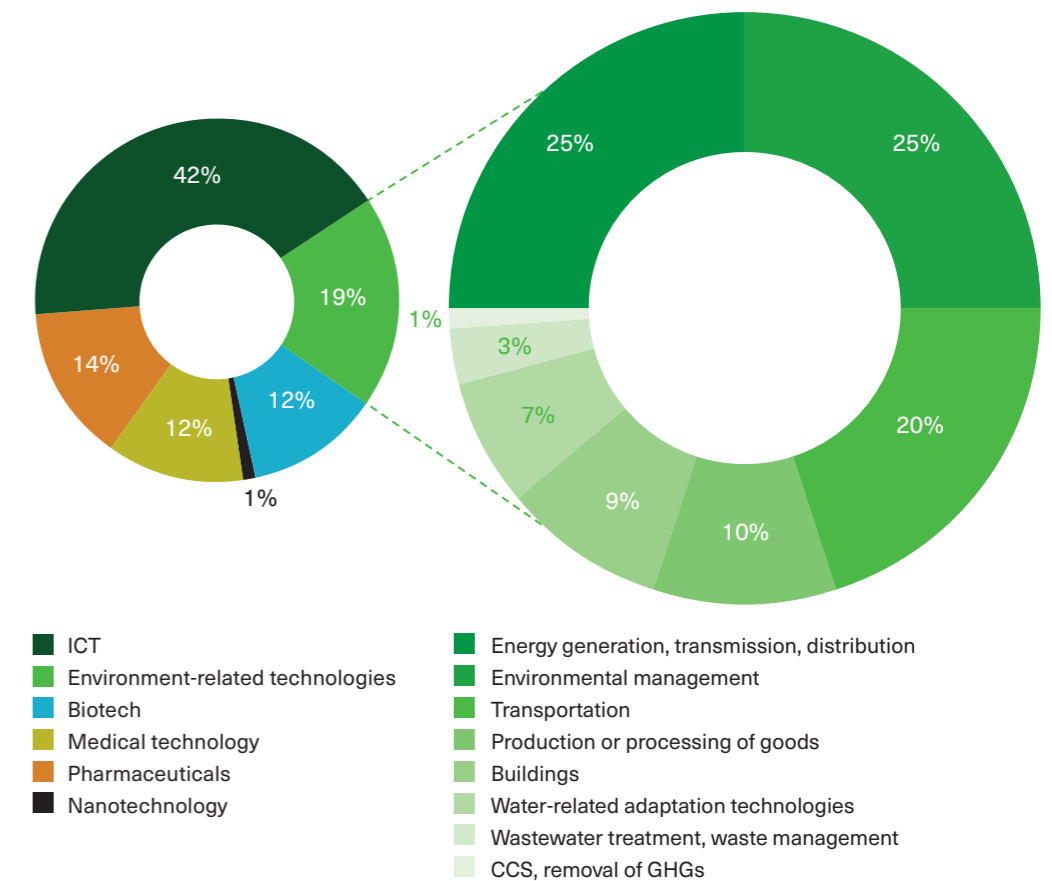
Source: EUROSTAT

UK falls short in capitalising on its knowledge creation potential

The UK is globally renowned for its knowledge sector. The country ranked first in the quality of its scientific publications and second in the quality of its universities in GII 2020 (Cornell University et al., 2020).

Patent applications are often used by innovation researchers as a proxy for measuring innovative potential of countries. The UK's patent output has been dominated by ICT-related applications. The environment-related technologies are the second area in terms of the number of applications; the applications in the area focused mostly on clean energy and transportation and environmental management, followed by improvements in the production or processing of goods and buildings (see Figure 7).

Figure 7. UK patents in environment related technologies (2007-2016)

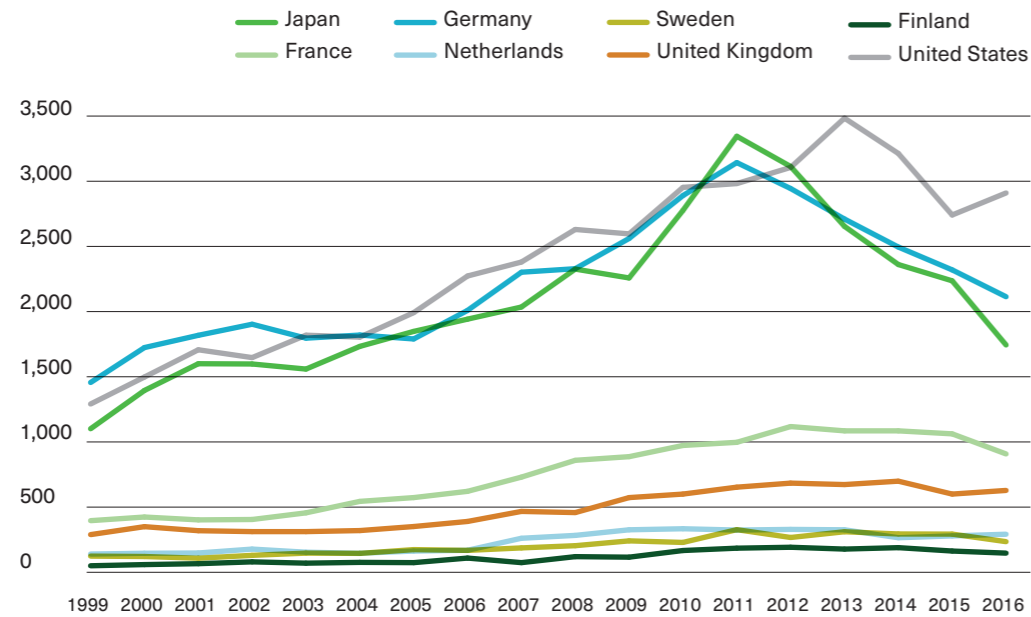


Legend: Total patent applications to the European Patent Office (EPO) 2007-2016 (total UK patent applications: 31,120; total UK environment-related patents: 7,338). Source: Authors based on OECD STAT

Patent analysis conducted for the LSE Growth Commission (Rydge et al, 2018) suggests that UK businesses are among the global leaders in clean energy technologies. The overall share of clean energy patents in total UK patents was 11% which was on average higher than in other G7 countries (7%). The UK has a comparative advantage relative to other advanced economies in the areas of efficient aviation, marine energy and wind but appears to be disadvantaged in solar energy (ibid.).

The absolute number of environment-related EPO patent applications submitted by UK entities has gradually risen since the early 2000s, but it remains below its main global (USA and Japan) and European (Germany and France) partners and competitors (see Figure 8).

Figure 8. Patent application to the EPO in selected environment related technologies



Source: Authors based on OECD STAT

Green innovation promises the growth of the environmental goods and services sector

Measuring the contribution of green innovation to the whole economy is challenging. There is no single indicator or approach that captures the aggregate benefits of green innovation to the whole economy. The growth of turnover and employment in economic sectors contributing to the green economy can be seen as a proxy indicator of successfully adopted green innovation. These estimates have to be interpreted with caution as they neither capture the full potential of green innovation nor they can be directly attributed to specific innovation activities.

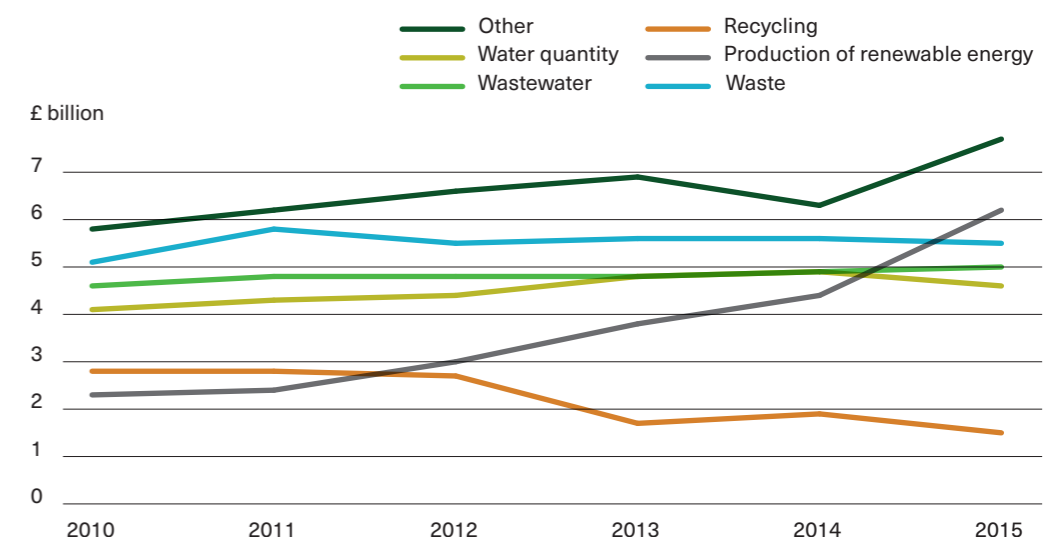
ONS estimated the turnover in the UK low-carbon and renewable energy economy to be £46.7 billion and 224,800 full-time equivalent (FTE) in 2018.⁹ 'Energy efficient products' was by far the biggest sector with £16.7 billion turnover and 114,400 employees. Other important areas included low-emission vehicles and infrastructure, bioenergy, nuclear energy and off-shore and on-shore wind. Previously ONS has made estimates of the direct and indirect turnover generated by business in the UK low-carbon and renewable energy economy.¹⁰ It estimated that in 2017 about £79.6 billion was generated compared with £73.6 billion turnover in 2016 and £71.8 billion turnover in 2015. Low-carbon businesses accounted for a total of 396,200 employees in 2017, compared with 390,600 in 2016 and 377,300 in 2015.

Another proxy indicator used to estimate the economic performance of the green economy is the environmental goods and services (EGS) sector. The EGS sector has grown significantly over the recent years. The sector contributed £42.2 billion to the UK economy in terms of gross value added (GVA) in 2018, growing by 70% since 2010. This was the second highest value generated from EGS in the EU, second only to Germany. In 2010-2015 the GVA from activities producing renewable energy nearly trebled from £2.3 billion to £6.2 billion. EGS sector represents around 1.6% of UK GDP.

⁹ See <https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/finalestimates/2018>

¹⁰ See <https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/finalestimates/2017>

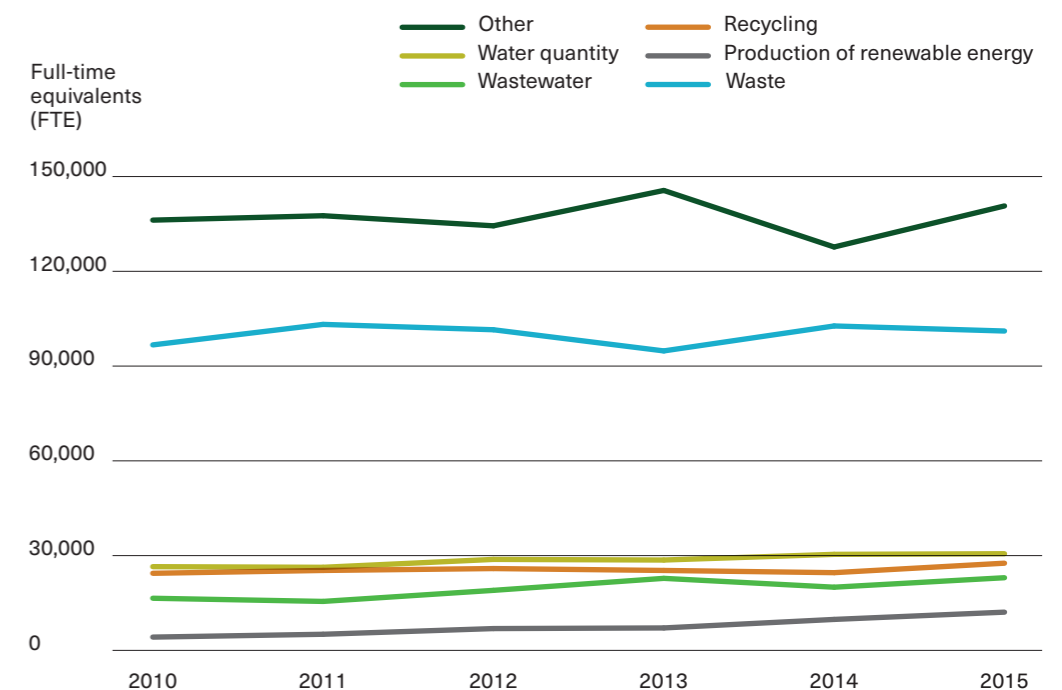
Figure 9. GVA from the environmental goods and services by sector activity in the UK (2010-2015)¹¹



Source: ONS. Available online at <https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/ukenvironmentalaccounts/2010to2015>

The EGS sector contributed around 335,000 full-time equivalent jobs to the economy in 2015. This was an increase of 10% from 2010 to 2015. The EGS sectors represents about 1% of total employment in the UK.

Figure 10. Employment in the environmental goods and services sector in the UK (2010-2015)



Source: ONS. Available online at <https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/ukenvironmentalaccounts/2010to2015>

¹¹ The "other" category comprises 12 EGSS activities: Environmental charities, Managerial activities of government bodies, Management of forest ecosystems, Insulation activities, In-house environmental activities, Organic agriculture, Environmental related education, Energy saving and sustainable energy systems, Environmental consultancy and engineering services, Environment related construction activities, Environmental inspection and control and Production of industrial environmental equipment.

4.

GIPC's sectoral insights

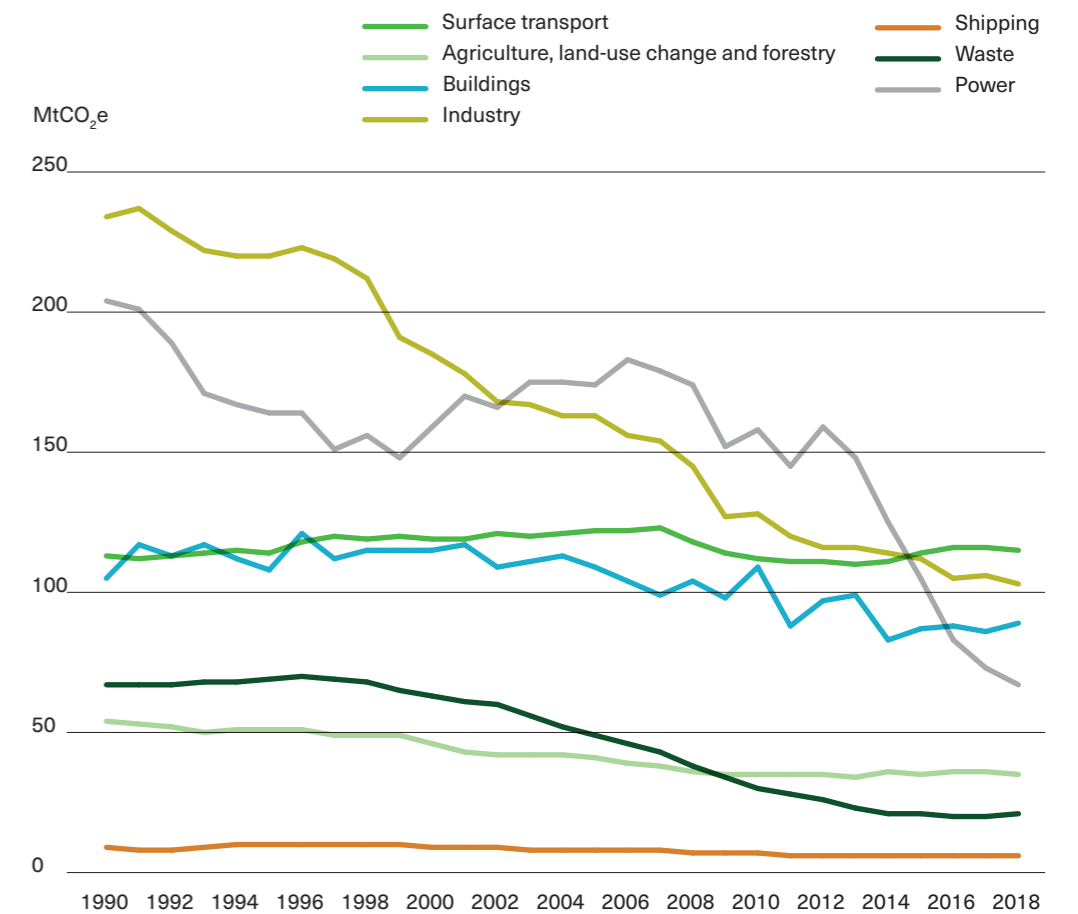
4.1 Sectoral transformations for a net-zero future

GIPC brings together companies representing a number of sectors essential in driving green innovation in the UK. The Commission includes representatives of five sectors:

- Resources and waste (Veolia);
- Construction (Arup);
- Water (Northumbria Water);
- Food (John Lewis Partnership);
- Transport of goods (UPS).

Sectors represented in the GIPC are responsible for a majority of the UK's CO2 emissions, with transport (33.6% of total UK CO2 emissions in 2018) and buildings (20.3% from residential and public sectors) being the largest contributors. Greater investment in green innovation will be essential to further reduce the GHG emissions as well as to reduce other environmental pressures caused by unsustainable business activities, including related to the use of resources and land, pollution, and excessive consumption.

Figure 11. Sectoral trends in GHG emissions in the UK



Source: CCC 2019

The following sections discuss key challenges in each of these sectors and set out six areas in which government needs to act to accelerate green innovation towards net zero:

- Create demand for green innovation: from niches to global markets;
- Boost green innovation investments: from R&D to innovation diffusion;
- Change the rules of the game: progressive and agile regulation;
- Nurture green innovation ecosystems: cross-sectoral collaboration and experimentation;
- Make infrastructure work for a greener economy: innovative infrastructure;
- Working together to foster green recovery: challenge-led policies and governance.

While the following sections are presented through sectoral lenses, the evidence gathered by the GIPC suggests that green innovation opportunities often emerge at the interface between many sectors, and require collaborations between sectors and along value chains. Examples of such collaborative innovations are introduced in the following sections.

4.2 A spotlight on the resources and waste sector

“The key innovation challenge for the resources and waste sector is to work with other sectors and across entire supply chains to design and implement system-wide solutions.”

The UK waste sector has considerably improved its performance over the last decades. The emissions from the waste sector have decreased by 73% since 1990. Household recycling rates increased from 11% to 45.7% between 2000/1 and 2017 (HM Government 2017, DEFRA 2019). The sector now contributes 14% of UK renewable electricity. This progress, although significant, falls short of the broader challenge to overhaul current unsustainable production and consumption systems. The sector has the potential and an opportunity to make a stronger contribution to the transition to a net-zero and more circular economy.

Key challenges for transformative green innovation

The UK has many good practices in place in the traditional waste management sector, notably waste sorting including applications of advanced automation and digital technologies (e.g. machine learning). There is, however, ample space for improvement in waste management. One important challenge inhibiting systemic transformation of current resource flows is the limited consideration of consumer behaviour and consumption practices in designing product-service systems, and related waste and resources systems. Specific challenges still remain in ensuring separate collection and recycling of food waste and effective collection, re-use and recycling of bulky products (e.g. mattresses, furniture), construction waste and batteries.

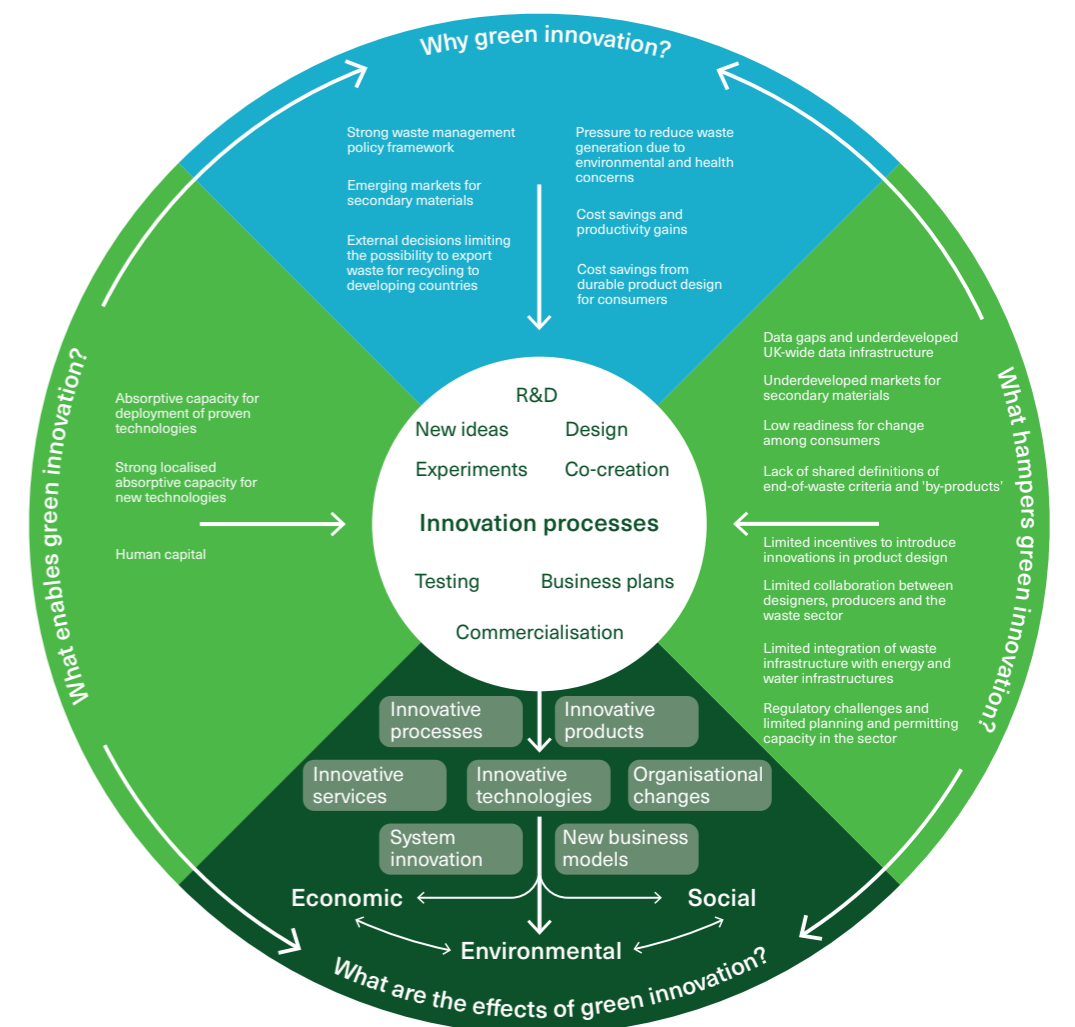
The key innovation challenge for the resources and waste sector is to work with other sectors and across entire supply chains to design and implement system-wide solutions, including upstream innovation (e.g. material and product design), systemic innovations overcoming fragmentation of the waste system, and innovative business models involving businesses (B2B) and consumers.

A circular economy offers a massive opportunity for the UK economy. One study estimated the benefits of a circular economy in the UK at £29bn (1.8%) of

GDP per year (Voulvoulis, 2015). The prospect of a circular economy is an opportunity for companies in the resources and waste sector to rethink and innovate the way they run their business. Circular economy business models ensure that resources are used efficiently, and that end-of-life products and materials are recovered and put to another productive use. In the times when businesses are increasingly responsible through Extended Producer Responsibility (EPR) arrangements for the waste and environmental impacts generated by their products, re-use, repurposing, remanufacturing or recycling models offer opportunities to turn waste from being a cost and potential liability into a valuable resource and new revenue stream.

New business models need to be based on evidence and observations of real-life consumer practices (e.g. focus on access to potable water where and when it is needed rather than on better materials for disposable bottles). Application of digital technologies, including Artificial Intelligence (AI), has a potential to improve our understanding of resource and waste flows through enabling data collection and interpretation on an unprecedented scale. This has implications for consumer behaviour as well as production processes (e.g. better design and resource efficiency).

Figure 12. Incentives, barriers, and enablers of green innovation in the resources and waste sector



“**The policy attention should focus more on upstream innovations and new product-service systems rather than mostly on infrastructures and technologies made to sort and recycle increasingly complex waste streams.**”

Policy portfolio for green innovation

Towards transformative innovation policy for resources and waste

There is a need for a stronger directionality and ambition in public policy supporting innovation aiming at the transformation of current production and consumption systems. Policy should aim at changing the current production and consumption system rather than on making the existing system more efficient.

The policy attention should focus more on upstream innovations and new product-service systems rather than mostly on infrastructures and technologies made to sort and recycle increasingly complex waste streams. As one consulted expert put it “we shouldn’t be sorting more but we should be designing out more”. One way to reframe innovation policy for a circular economy would be to focus on improved performance of infrastructures, products and services rather than on specific technology or material substitution. For example, instead of asking “how do we remove plastic food packaging?” policy makers could ask “how to get food from the farm to fork with the least environmental impact?”.

Box 5

Examples of green innovations in the sector

The resources and waste sector offers plenty of green innovation opportunities along material flows ranging from improving product design, through more efficient re-use and recycling to re-imagining material flows in product-service systems. Some illustrative examples are featured below.

Design for durability

In the framework of the Sustainable Clothing Action Plan (SCAP), WRAP has been working with the clothing industry to reduce the environmental impact of clothes. Design for extending the life of products is one of SCAP’s key areas. The initiative developed open-access knowledge resource (the Clothing Knowledge Hub), guidance for approaches and techniques for extending the life of clothes and ran a series of trials with industry partners to test them in real life.

More information: <https://www.wrap.org.uk/sustainable-textiles/scap>

Re-use

There are many successful re-use platforms in the UK. The Reuse Network has about 200 member organisations across the UK and works closely with many commercial partners, including major retailers such as John Lewis and Partners, Dixons Carphone and IKEA. The Network has been running the John Lewis Sofa Reuse Scheme across all UK since 2014. The commercial retail partnerships allowed the Network to supply furniture and electrical items to 69,000 households in the UK in 2019 which saved them £9.1m and prevented 3,500 tonnes of products from being wasted.

More information: <https://reuse-network.org.uk/>

Recycling

Veolia treats over 400,000 metric tonnes of green household waste in the UK very year. To give the green waste new life, the company uses it to produce a peat-free compost meeting industry’s highest quality standards. Pro-Grow™ consists of 80% organic matter and 20% nutrients, and is suitable for all plants, particularly in horticulture.

More information: <https://www.planet.veolia.com/en/pro-growtm-united-kingdom-has-natural-peat-free-fertilizer>

“**The fiscal system should reward sustainable activities and products and disincentivise those leading to negative environmental and social impacts.**”

Knauf Insulation and Veolia formed a partnership to create a facility producing high-performance glass mineral wool insulation from used glass bottles and jars collected from households. The facility, located in St. Helens, Merseyside, processes over 60,000 tonnes of used glass very year.

More information: <https://www.knaufinsulation.co.uk/why-knauf-insulation/veolia-partnership-knauf-insulation>

Examples of innovations that prevent waste arising include sustainable design (e.g. durable product design), resource-efficient manufacturing as well as service-based business models based on product sharing. In the area of sustainable design, government should promote product durability and reparability in a more systemic way. This could include:

- Support for durable design and measures against planned obsolescence (e.g. as in Italy)
- Fiscal and advisory support to professional repairers (e.g. reducing VAT on repair as in Sweden);
- Ensuring access to either new or 3D-printed spare parts (e.g. France);
- Extending the right to repair to consumers for simple products; as well as
- Transparent information on product reparability for consumers (e.g. reparability index in France).

A systemic approach to green innovation in the resource and waste sector requires considering the waste management system as a nationwide network of resource flows including primary and secondary materials and waste streams. This perspective will enable better prioritisation of areas for intervention considering specific features of resource flows and their spatial implications.

Create and shape demand for green innovation

Fiscal policy and environmental (including carbon) taxes should become key government instruments in fostering the change. At the moment green innovators are facing unfair competition from large well-funded industries relying on fossil fuels and often benefit from lenient regulatory frameworks. The fiscal system should reward sustainable activities and products and disincentivise those leading to negative environmental and social impacts.

Government can introduce strong incentives to encourage or discourage the use of specific materials. A plastics tax, for example, can discourage the use of single-use plastics. Public procurement, on the other hand, can be used to create markets and stimulate demand for secondary materials, and ensure their high quality by introducing binding standards. Such instruments introducing positive and negative incentives need to be designed taking a systems perspective; their design needs to consider, for example, how they influence the cost of running a business and take account of the intricacies of materials, the availability of substitutes and the dynamics of supply chains. Badly designed incentives may lead to undesired effects and rebounds resulting in higher environmental impacts.

There is a need to design stronger incentives for consumers to change their consumption practices (e.g. re-use and recycling). Labelling, for example, can assist consumers in making better decisions but it needs to be based on a set of agreed mechanisms and metrics (e.g. independently verifiable Life Cycle Assessment (LCA) done to the right ISO standard) as well as considering insights from behavioural science. Providing clear information to consumers is important but it is not enough to change their behaviour.

Among key shortcomings of current policy is that it was not designed to enable and reward consumers for making healthier and greener consumption choices. Government can enable behavioural change with positive and negative incentives (e.g. taxes) and by improving infrastructures facilitating sustainable practices (e.g. access to recycling or re-use centres).

Boost green innovation investments

Government should scale up its investments in transformative green innovation in the area of circular economy by providing direct innovation funding (e.g. via innovation deals in the area of circular economy, dedicated innovation programmes (or through a new National Green Investment Fund) as well as indirect support (e.g. prioritising circular economy investments in the UK guarantee scheme to help access debt finance for innovative circular economy projects).

Change the rules of the game

Eco-design and Extended Producer Responsibility (EPR) have a potential to become game-changing policies. Eco-design can promote longer lasting, repairable products and remove from the market wasteful ones. Government should continue its work to design and implement binding EPR schemes covering the most impactful products and material streams, as well as mandate common waste collection systems, to increase the quality of recycle streams. This should be done in a close collaboration with industry and consumers.

If designed to reward resource-efficient design (e.g. through bonus/malus systems) and make producers fully responsible for whole life costs of products, EPR can directly influence business practices and create strong incentives to shift away from environmentally harmful product designs. It pushes the companies to charge the whole life cycle cost of products. The shift in waste systems from “pay as you throw” to “pay as you buy” is likely to have a systemic impact on product design and the value proposition at the heart of their business models. The effective implementation of EPR will require, however, strong enforcement mechanisms.

A consideration for new measures, such as the nationally mandated restriction on residual waste, needs to consider lessons learned on how to design these measures to encourage waste avoidance, re-use and recycling. Government should also consider exercising the right to ban selected environmentally harmful products and materials, especially for non-essential products and where substitute materials are available.

Nurture dynamic innovation ecosystems

There is a need to bring a greater focus on supporting national, regional and local innovation ecosystems to create environments enabling design and implementation of innovation in the area of circular economy. Government should actively encourage collaborations between many stakeholders, including small and larger businesses, entrepreneurs, regulators, local authorities, researchers and local communities. Innovation policy could invest more in challenge-driven collaborative innovation projects addressing specific circular economy challenges. This support should include not only focus on developing and testing new technologies but also a possibility to trial novel standards and other regulatory arrangements in practice (e.g. as in regulatory sandboxes).

The regional and local dimension is essential for co-creating and demonstrating alternative innovative solutions to specific challenges which require a close collaboration between actors (e.g. industrial symbiosis, food waste avoidance).

“**The regional and local dimension is essential for co-creating and demonstrating alternative innovative solutions.**”

Lay the foundations for a greener economy

There are important infrastructural needs in the area of waste and resources. Government should review the quality of infrastructure and investment needs to repurpose waste infrastructure to move towards a circular economy as well as invest in data infrastructure to enable more efficient and effective coordination and management of material flows in Britain (e.g. establishing a consolidated material flow database, improving data on infrastructure).

Rethinking policy processes and governance for green innovation

The Resources and Waste Strategy (RWS) provides an ambitious policy framework for the waste and resources sector, including economic incentives, eco-design, Extended Producer Responsibility (EPR) and labelling. To be transformative the policy mix needs to be more comprehensive and coherent. Strong vetting of any policy proposals against the key government targets, including net zero, would ensure a greater policy coherence in this area.

To be successful the RWS requires robust government action and implementation based on cross-departmental collaboration and coordination, especially involving DEFRA and BEIS, and a close partnership with industry and finance. The systemic approach requires a more pro-active engagement of partners along supply and value chains to exploit cross-sectoral synergies and tap into resource productivity opportunities. There are good examples of such collaborations such as the UK Plastics Pact (see Box 5). Government should enable such partnerships and support them through dedicated challenge-driven innovation deals as well as ensuring that sufficient consideration of resource efficiency opportunities is given in existing and future Sector Deals.

There is an opportunity to tap into the potential of the regions and municipalities for experimenting with system innovations and better implementation of circular economy policies. Municipalities, cities and regions have an important role to play, especially in encouraging industrial and urban symbiosis, re-use, and repair. The policy needs to engage with local levels of governance, including LEPs, to co-design and implement policy support schemes and build local partnerships.

Box 6

The Plastics Pact – A Roadmap to 2025

WRAP launched The UK Plastics Pact in April 2018, working in partnership with the Ellen MacArthur Foundation (EMF), to create the first national implementation of the vision for a New Plastics Economy. The UK Plastics Pact has 85 business members, representing retail, manufacturing, hospitality, the plastics supply sector, plastics recycling and resource management. The Pact groups companies responsible for over 80% of the plastic packaging on products sold through UK supermarkets, and 50% of the total plastic packaging placed on the UK market. The UK Plastics Pact aims to achieve three main objectives by 2025:

- 100% of plastic packaging shall be reusable, recyclable or compostable (eco-design);
- 70% of plastic packaging shall be effectively recycled or composted (repurposing);
- 30% of recycled content across all plastic packaging;
- Take actions to eliminate problematic or unnecessary single-use packaging items through redesign, innovation or alternative (reuse) models.

Source: <https://www.wrap.org.uk/content/the-uk-plastics-pact>

The policies need to recognize the international dimension of waste and resources policy as much project design, production and waste management takes place outside the UK. Government could consider taking a leading role in tackling selected global challenges by initiating and facilitating international science, technology and innovation collaborations bringing together various stakeholders across global value chains (e.g. based on the commitment to work on marine plastics pollution).

4.3 A spotlight on the construction sector

The built environment is currently responsible for more than 40% of UK CO₂ emissions (Green Construction Board, 2013), and the imperative to act fast in the construction sector is great given the long life of its products. Construction is one of the largest sectors in the UK economy with a turnover of £370bn, value added of £138bn and employment of 3.1 million (HM Government 2017). The sector is central to the UK Industrial Strategy and will be supported by the Sector Deal introduced by the strategy.

The construction sector is complicated by being a composite of new build, refurbishment, and infrastructure and utilities. The construction sector in the UK is fragmented and delivery is broken down across a complex supply chain ranging from significant organisations of international standing, to very small self-employed traders and a multiplicity of materials vendors and suppliers.

The need for a rapid behaviour change in light of the UK's 2050 net-zero commitment is more important and stark in the construction sector due to the lifetime of buildings and other constructed assets. Most things built today will likely still be standing in 2050, and if major changes are not made in construction by 2030 then the country as a whole will likely not meet its commitments in 2050. The construction sector requires action on an equal scale to banning internal combustion engine cars if sufficient progress towards decarbonisation is to be made by 2030.

The construction sector faces many systemic challenges including, for example, delivering low-carbon heating to buildings, retrofitting aging infrastructure in the UK, applying circular economy models to design, retrofitting and construction of new buildings, developing new approaches to managing complex projects, as well as overcoming "lock-ins" and managing complex global value chains.

Key challenges for transformative green innovation

As in many sectors of the economy, the innovation challenge in construction is not solely new inventions and research, but bringing the technologies that already exist to market, scaling them, and deploying at a competitive price.

Materials

- Low-carbon Building Materials - Major materials such as cement, concrete, steel, aluminium, bricks and glass are all energy-intensive in their manufacture.
- Reduced site wastage - Construction activities tend to include a relatively high proportion of material wastage particularly in wet trades (i.e. concrete, brickwork, and plastering).
- Modular construction - Off-site manufacturing of large construction components can be cleaner and more efficient than on-site, yet there are still clear innovation challenges. Modular construction needs an effective market.

Energy, recycling, and waste

- Reduction in final energy demand - The energy demand of buildings must be reduced. This means both reducing energy usage (through heating insulation, for example) and in terms of reducing the energy demand of the building on the electricity grid (i.e. installation of photovoltaics and other renewable energy generation technologies).
- Material recycling, reuse, circular economy - Innovation is required across a range of technologies to support more extensive building refurbishment, material reuse and waste collection and recycling.
- Building retrofit – There is a substantial challenge in finding retrofit solutions that are scalable and that can be deployed at reasonable cost. There is also a skills challenge to develop the workforce with the required skills to retrofit the approximately 28 million existing buildings in the UK.

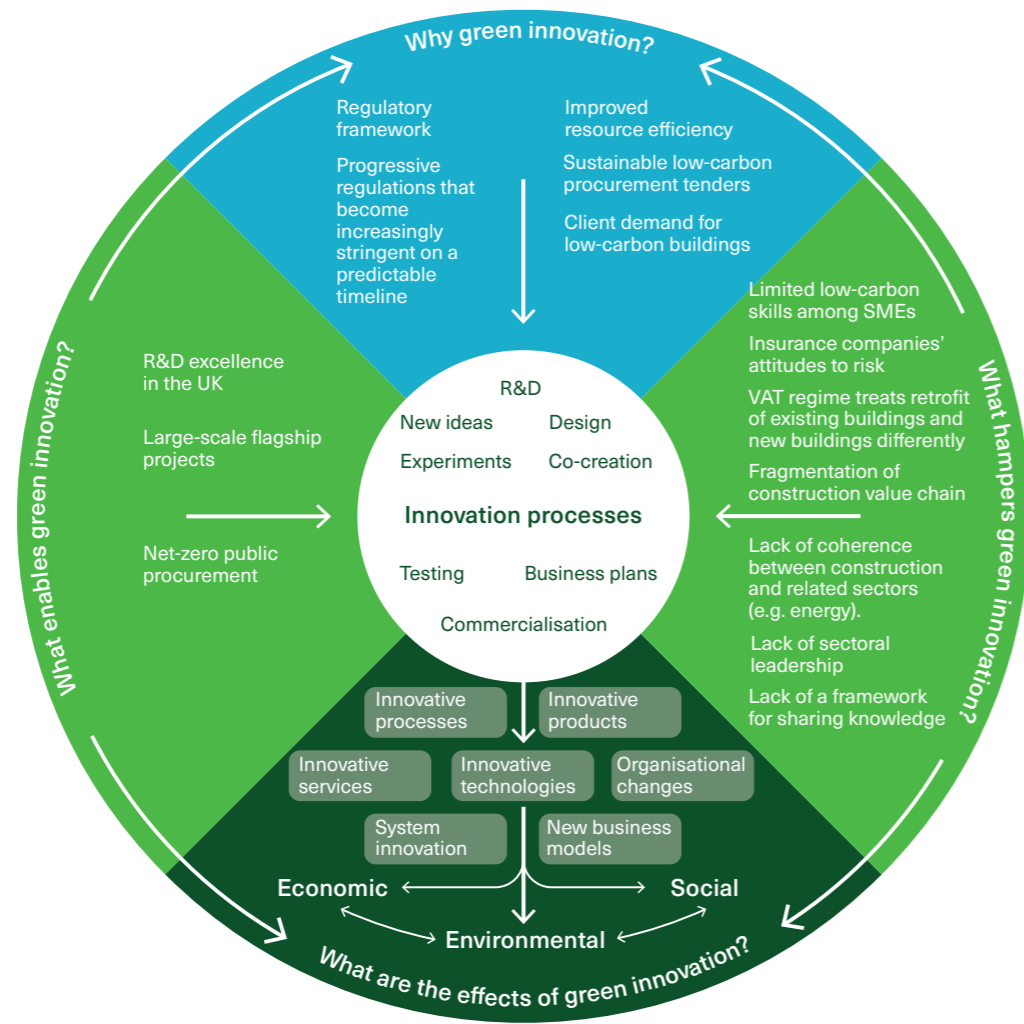
Digitalisation

- Building Information Modelling - Digitalisation could assist in both retrofit and new build while also driving the better utilisation and ultimate reuse of constructed assets. Mature technologies in this space need to be scaled across the sector to improve efficiency of construction and manufacturing processes.
- Data on emissions associated with the production of building materials - Innovation is needed in this area in both the collection and sharing of data to allow for effective life-cycle analysis of construction materials and buildings.

Culture

- There is a need for a cultural shift if the construction sector is to meet the needs for net zero by 2050. Equivalent culture shifts have been achieved before – the whole industry attitude to health and safety (H&S) was such an example.
- Sectoral leadership - The construction sector needs better sectoral leadership, so that the long, under-performing tail of the sector will be "pulled" round by a culture across the industry and its clients in which poor environmental standards will not be acceptable.
- Clients and procurement - Clients have a key role to play in setting expectations and a commitment to 'whole life' carbon reduction by including capital expenditure and supply chain carbon, operational and maintenance carbon, and the possible consequential user carbon.
- Sustainability through procurement - The ways in which construction projects are tendered, frequently including a 'score' for sustainability, is a massive influence on the prevailing culture. Procurement by a progressive client who values sustainability can drive action by a constructor, whilst tender criteria that ignore these values can put green innovation at a competitive disadvantage.

Figure 13. Incentives, barriers, and enablers of green innovation in construction



Box 7

Examples of green innovations in the sector

The city of Oslo chairs C40's Clean Construction Group and has been exploring fossil-fuel free construction sites, having found on-site fuel use a not-insignificant contributor to their overall footprint. This proportion has increased as Oslo has seen a very significant increase in the use of EVs in place of internal combustion engine vehicles across both private and public sector transport.

More information: https://www.c40knowledgehub.org/s/article/How-Oslo-is-driving-a-transition-to-clean-construction?language=en_US

Steel presents a major challenge for decarbonisation. ResponsibleSteel has developed a sustainability standard for ore-based and scrap-based steel production incorporating ambitious carbon targets.

More information: <https://www.responsiblesteel.org/about>

Arup has developed an in-house software decision-making tool for sustainable building design. The software – "SPeAR" – lends support by measuring sustainability against a wide range of parameters, and graphically showing before and after scenarios for proposed projects. This assists in meaningful discussions between designers and clients about the sustainability options available to meet national, regional, and client goals.

More information: <https://www.arup.com/projects/spear>

Policy portfolio for green innovation in the sector

Create and shape demand for green innovation

Government should lead the way to use public procurement to stimulate demand for sustainable materials in construction by introducing clear and binding standards. Procurement policy should be leveraged towards net zero, both in the public and private sectors. Government should consider setting a performance standard for carbon emissions or sustainability for private sector tenders.

Boost green innovation investments

Government should invest and facilitate strategic experimentation and demonstration construction projects at scale (e.g. whole-house retrofits, circular economy design, including urban symbiosis).

Government can introduce strong fiscal incentives, including through carbon pricing, to encourage or discourage the use of specific materials in construction. Government should review the VAT regime to ensure that it doesn't present undue barriers to the retrofit of existing building stock. An important signpost and enabler for this would be to scrap the VAT differential on refurbishment when compared to new build (20% as opposed to 0%).

Government should scale up its investments in green innovation in construction by providing innovation funding as well as by establishing dedicated guarantee schemes. The investments should be based on transparent criteria and parameters (e.g. in-use performance, materials, embodied carbon).

“ Procurement policy should be leveraged towards net zero, both in the public and private sectors.”

“**Government should introduce more ambitious (dynamic and progressive) building regulations and standards for residential and non-residential buildings.**”

Change the rules of the game

Government should introduce more ambitious (dynamic and progressive) building regulations and standards for residential and non-residential buildings. These should ensure that buildings' energy efficiency is rated and rewarded based on their actual rather than modelled performance (see e.g. Australia's NABERS programme¹²). Government has promised to consult on in-use ratings in 2020 but the process is slow. Regulations and standards should be “progressive” in the sense that they become increasingly stringent on a predictable timescale to allow business to respond whilst driving best practice.

A system of regulations on the whole-life carbon impact of construction is urgently needed. This regulatory regime should be consistent with net-zero obligations, it should apply fairly to both existing and new construction, and it should be backed up with robust enforcement and the possibility of criminal sanctions.

Government should mandate whole-life carbon assessments to ensure that the sector addresses carbon from supply chains, promoting resource efficiency and low-carbon materials. London has included this as a requirement for projects referable to the Mayor but this needs to happen at national level to really take off.

Nurture dynamic innovation ecosystems

The construction sector and the government should work together to develop clear sectoral leadership. This should also include setting three big steps the sector will take to reach net zero, and a sector-developed roadmap to 2050. Government should enforce this through future Industrial Strategy Sector Deals.

Policy drivers in construction should encourage a ‘whole-enterprise’ approach, above the level of individual firms or individual projects. This would involve a series of priority themes to make the significant transition needed to achieve net-zero carbon by 2050. The insurance sector, construction sector, and government should work together to review attitudes and approaches to risk measurement and management in light of the low-carbon transition to net zero.

A coherent approach to the construction sector should also include a strategic view of what skills will be needed in the sector to achieve net zero. The challenge of retrofitting the vast number of existing buildings and the development of the specialist skills needed to do this is great and should be prioritised in this approach.

Rethinking policy processes and governance for green innovation

Government could raise the ambition of existing targets on energy use and GHG emissions. These should reflect the net-zero commitment, especially by applying stricter targets to new buildings. New targets could also include air quality inside buildings. Construction and buildings should be prioritised for action to reach net zero due to the long lifetimes of buildings and the long lead times of construction projects. This action must be on a similar scale to banning internal combustion engines if sufficient progress is to be made by 2030.

Government should improve collaboration across governance levels by supporting and engaging in partnerships with cities. It could also facilitate collaboration between councils to build institutional capacity for integrated planning. London, for example, is able to align housing, transport and employment planning because it has the power and institutions to do so, but this doesn't apply to the rest of the country.

¹² See <https://www.nabers.gov.au/>

4.4 A spotlight on the water sector

The water sector is a foundational sector and, therefore, an important sector for the Industrial Strategy. Every day, over 50 million household and non-household consumers in England and Wales receive good quality water, sanitation, and drainage services. These services are provided by 32 privately-owned companies in England and Wales. Among these providers there is a huge variation of scale from companies with a turnover of £1 billion and millions of customers such as Thames Water, through to very small companies such as Independent Water Networks providing the final connection to hundreds of localised customers.

A regulatory framework is in place to ensure that consumers receive high standards of service at a fair price. Since privatisation in 1989 the water industry has invested on average about £4.9 billion per year - more than £140 billion in total in 1989-2018 – in improving water supply and wastewater infrastructure (House of Commons Library, 2019).

In 2020 the Water industry in the UK became the first sector to commit to net-zero CO₂ emissions by 2030¹³ which will involve great steps forward across activities within British water suppliers. Yet for the water sector green Innovation means more than just carbon reduction; the water industry exists in a proximity to the environment that is very different to many other industries. Water companies rely upon the natural environment, and therefore have a closer relationship between their business models and important sustainability considerations such as biodiversity and conservation, in addition to CO₂ emissions. The environment is the day-to-day business of a water utility, and changes to weather and rainfall due to climate change will affect water companies in a way they will affect likely no other.

The water sector also faces trends shaping developments in the sector including population growth and per capita demand, stricter environmental standards, increased focus on resilience of water and wastewater infrastructure, and more extreme weather events.

Key challenges for transformative green innovation

Green innovation in the water sector can be split into the incremental changes that companies need support to get on with as soon as possible and the bigger transformational changes that will require long-term systemic solutions. In the former category are efficiency savings, reducing consumption and leakage, and a low-carbon fleet of vehicles. In the transformational category are changes such as new approaches to land use, the hydrogen economy, circular economy, and partnerships and catchment management.

Encouraging sustainable consumption and enabling customers to make sustainable choices

A key challenge to reducing water consumption and wastage is the general disregard of the value of water. Per capita consumption of water has been steadily rising in the UK. This is driven by many factors including low cost and unmetered usage; very few people ever have to worry about where their water is coming from.

Water companies must find a legitimate voice to ask consumers and customers to manage demand. Companies have had success with customer-facing

¹³ See <https://www.water.org.uk/news-item/water-industry-plans-to-reach-net-zero-carbon-by-2030/>

campaigns to reduce water use. Some of the areas of the UK with the highest pressures on water supply also have some of the highest rates of per capita consumption. This requires innovation in approach to communicate this to the customer, especially on a wide basis that doesn't just target customers who are "natural environmentalists" but across the entire customer base.

With regards to water metering, the current regulations do not allow for mandatory metering for billing processes. Rates vary across the country and there is little to no appetite for universal metering. This lack of interest in mandatory metering is both in the customer base and among policy makers and politicians. With this opportunity for consumption management removed, innovation solutions must be found. Thames Water and other utilities are piloting a "smart meter" program that is about both demand reduction but also identifying leakage in the system. Other providers are engaging in new ways with communities and stakeholders to raise the issue of an individual's "water footprint". Innovation in behavioural approaches is essential to encouraging the consumer to make responsible choices.

Leakage and repairs to aging infrastructure in the UK

Whilst leakage often receives a large amount of press coverage it does not represent a significant proportion of customers' bills. However, as part of a general drive to reduce consumption, reducing leakage is essential. Perceptions of leakage also impact on customer behaviour, as customers are less likely to look to reduce their consumption if they perceive there to be a significant level of leakage across the system. This is all the more important considering the high standards of cleanliness achieved in drinking water as described below. Driving down the cost of locating and fixing leaks is therefore a major innovation challenge. This includes the use of satellite technology to identify leaks and remotely operated devices, remote and "no dig" methods for fixing leaks, and self-fixing pipes as key innovation projects.

Water usage and inefficiency

100% of the water provided by water companies in the UK is of high drinking water standard, yet only 4% of this water is used for drinking. Water treatment to achieve this standard is costly in terms of energy and chemical usage. Given the low proportion of drinking water that is actually drunk, using the necessary chemicals and processes to achieve that degree of purity across the whole water supply may be regarded as wasteful.

An innovation challenge is to develop alternative methods of water delivery and re-use to reduce this inefficiency recognising that introducing a dual network of potable and non-potable water would be prohibitively complex. It would require new regulation to ensure no cross connections and to mitigate health risks where non-potable water is used.

Some solutions under development include "under-counter" purification units that allow the supply of water to the home to be of lower quality for general usage, but which allow a higher degree of purification solely for the purpose of drinking. At a domestic level this is currently cost prohibitive, bar some major new technology.

Alternatively, innovation may enable increases in usage of "grey" water. In specific cases with large industrial or business customers, utilities have come to specific arrangements, but these are the exception, often implemented on a small scale, rather than the rule. Examples of the use of wastewater include cooling in industrial processes or providing a golf course with treated effluent straight from a sewage treatment works. For domestic customers the use of rainwater harvesting or reuse of water for toilet flushing and for gardens are examples.

Ensuring resilient infrastructure and sustainable drainage

Ensuring there is enough capacity in the sewerage and drainage network is a major innovation challenge. This needs to cope with changing weather patterns, such as increased intensity of rainfall which require increased network capacity. The water going into sewers also needs consideration: more chemicals (such as fertilizers or pharmaceuticals) going into sewers increases the chemicals and energy needed to treat the wastewater when it arrives at a wastewater treatment works. Moreover, solid objects or other matter such as fat, oil and grease going into sewers leads to blockages and pollution events.

However, options are available to minimise the water going into the sewer. Education of what should - or more relevantly should not - go into sewers reduces chances of blockages and pollution events. The use of rainwater or bathwater in the home for watering gardens or flushing toilets further reduces the capacity requirement in the sewer. More widely in respect of land management, no single land-owner owns enough land to make a difference so a new approach will rely upon partnerships to avoid a piecemeal approach. Upstream catchment management solutions are options to reduce rainwater flows and prevent chemicals going into sewers, which would both reduce the capacity need in the sewer and the end-of-pipe treatment required.

Adapting to droughts and a changing climate

Long-term solutions to sourcing water sustainably require careful planning. Climate change has two key impacts; less water is available (in some areas) due to lower rainfall and when available it is harder to capture due to the intensity of rainfall and flooding.

Sustainable solutions exist around greater capture and storage, when water is available. This can be both at a large scale (reservoirs) as well as small-scale domestic property with tanks for rainwater capture. Leakage reduction also plays a part in reducing the demand for treated water. Innovation could also perhaps reduce the cost and energy intensity of desalination.

Reducing energy usage, improving anaerobic digestion, and utilising waste-heat

The use of waste heat and the discharge from water treatment for heating is often seen as the "holy grail" of environmental efficiency and a major transformational innovation opportunity. The innovation challenge is to take low-grade, easily-obtainable heat and find an easy way of using it.

Some testbeds and experimental schemes have experimented with using waste heat from water treatment and using this heat in greenhouses for growing commercial crops. This sort of scheme captures the benefits of a circular economy approach – the farming itself becomes low-carbon, it doesn't incur high levels of transport, and doesn't involve "importing" water from other areas where these crops would normally be grown. There are enormous benefits to be had in this area, but these schemes must move from experiments to commercial deployment.

Another area of innovation is around home heating. In a world where we will not be installing any new gas boilers in homes beyond the 2030s, the challenge is to find a way to replace some of these boilers with heat recaptured from wastewater treatment processes. What could be the regulatory frameworks to foster this innovation?

Anaerobic digestion is an existing green process for treating sewage sludge. There is further scope to roll this out so that a greater proportion of sewage is treated this way. However, it is also an area that lends itself to greater innovation to increase the gas production and hence energy recovery from the process.

Box 8

Examples of green innovations in the sector

Smart Water Catchments deployed by Thames Water help understand the specific catchment area needs and how local stakeholders can address multiple environmental challenges simultaneously. It aims to build better functioning river catchments, that, in turn, can help deliver water and wastewater services more effectively. The programme will deliver pilot projects in the Evenlode, Chess and Crane catchments with 10-year improvement plans in partnership with local stakeholders to reduce pesticide and nitrate levels.

More information: <https://www.thameswater.co.uk/about-us/responsibility/smarter-water-catchments>

Yorkshire Water have introduced a Sustainable Finance Framework (Kelda Group) which is now used for virtually all their debt, with £850m of Sustainability Bonds (or similar) raised so far.

More information: <https://www.keldagroup.com/investors/sustainable-finance/>

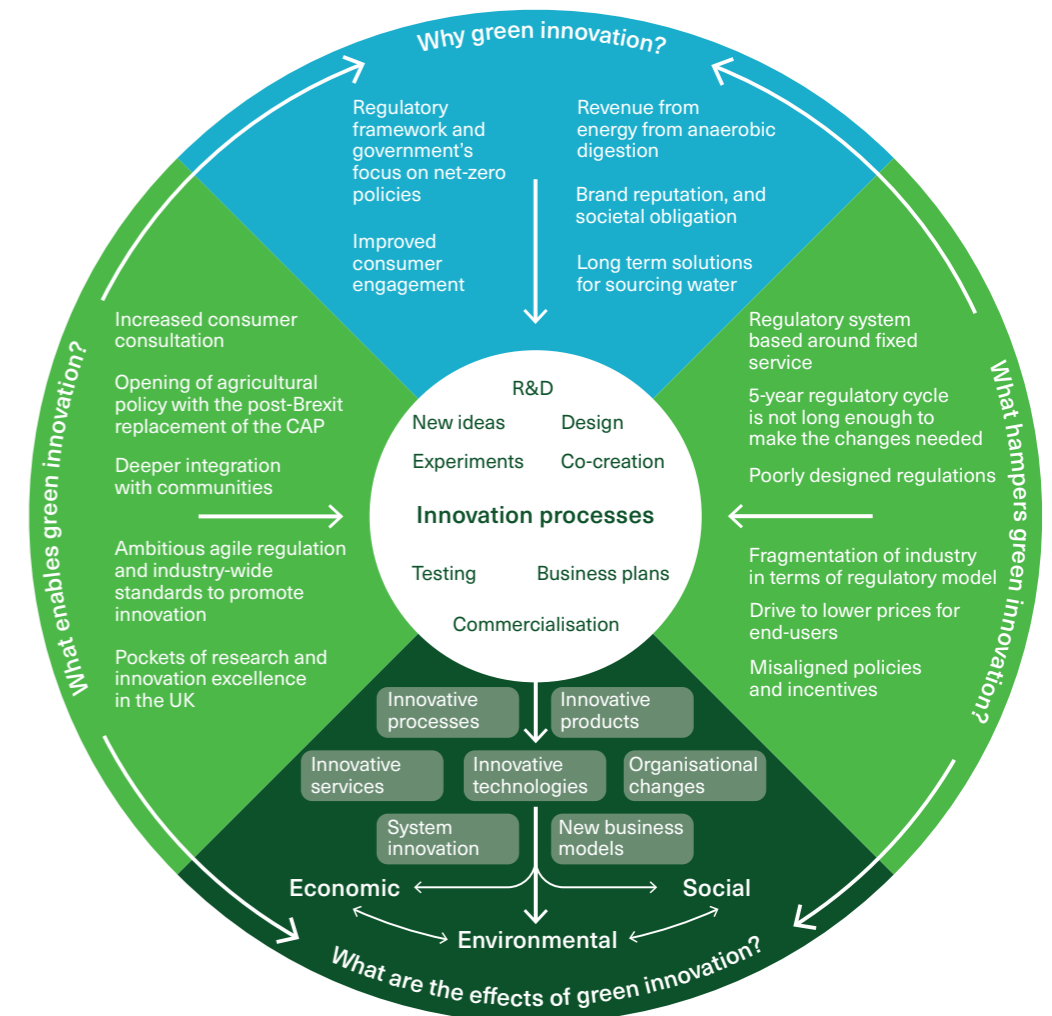
The Counters Creek Flood Alleviation Scheme (CCFAS) was developed following widespread basement flooding caused by intense rainfall in the Royal Borough of Kensington and Chelsea and the London Borough of Hammersmith and Fulham. The Thames Water scheme included: Provision of pumping or FLIP devices, local flood alleviation schemes, installation of Sustainable Drainage Systems (SuDS). It is one of the first projects of its kind, where a package of local solutions has proved much more fit for purpose than a large capital scheme.

More information: <https://www.thameswater.co.uk/help-and-advice/drains-and-sewers/counters-creek>

Yorkshire Water are part of an innovative partnership, along with Arup and the Rockefeller Foundation, in the city of Hull responding to water resilience challenges. Hull is one of five cities globally to be working with on developing a global water resilience framework.

More information: <https://livingwithwater.co.uk/>

Figure 14. Incentives, barriers, and enablers of green innovation in the water sector



Policy portfolio for green innovation

Towards transformative innovation policy for water

Policy makers should set a big-picture vision with a strategic agenda to address water system challenges. Drawing on the innovation challenge of 21st century drainage, there is a need for a coherent approach that includes decision and regulatory frameworks that allow the water industry to have a different approach to partnerships to drive better behaviour.

Boost green innovation investments

Strategic investment should be made available to successful demonstrator projects. Given the existence of strong demonstrator-scale innovations in areas such as waste-heat recovery and effluent discharge heating of greenhouses, strategic innovation support and investment should be deployed by government to scale these on a national basis. Without support across the fragmented water sector these are unlikely to see necessary scale.

The Industrial Strategy 'mission' for decarbonisation of industrial clusters¹⁴ could connect water industries generating waste heat with industries and farmers who could use that heat, towards a more circular economy model, for example.

14 See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803086/industrial-clusters-mission-infographic-2019.pdf

“**The major policy challenge in this space is finding a way of adjusting the regulatory structure to maintain the high standards whilst also making sure it is fit for purpose for the transformation.**”

Change the rules of the game

The major policy challenge in this space is finding a way of adjusting the regulatory structure to maintain the high standards of improvement that the sector has seen over recent decades, whilst also making sure it is fit for purpose for the transformation that is to come.

In the UK there are currently different regulatory frameworks in place in England, Scotland, Wales and Northern Ireland, and we can look to those to see examples of how different regulatory and institutional settlements can enable different kinds of conversations between the providers and the regulators. Making sure that the regulatory structure can allow transformation for a sustainable future means also considering innovation and sustainability as considerations for regulators when considering approval for each regulatory cycle.

Ofwat's current regulatory system of water planning and price control with five-yearly cycles¹⁵ creates a short-term attitude that doesn't match long-term transformation, innovation and investment. A key challenge is to balance moving away from short-termism with the need for flexibility. One way of doing this is to require the regulator to consider the needs of future consumers as well as the consumers of today. In recent years, Ofgem have been through a very similar process in the regulation of the energy sector, but of course zero carbon is a straightforward metric in electricity and the water sector is different and more complex. Regulators should explore a broad range of metrics against which they can assess the sustainability of a water provider.

In Scotland, the conversations between the regulator and water suppliers are less constrained by price and tight metrics on cleanliness and taste, etc., and are more structured around a strategic conversation that entails asking “what do you want to achieve in this regulatory period?”. This allows a longer-term conversation to occur and one more open to sustainable and green innovation.

There is a need for a system-wide approach to regulation so that the water industry is seen as a part of a system that includes farming, forestry, mining and industry. These regulatory systems must be brought into alignment so that incentives and pressures on different actors all drive towards the most sustainable outcomes, in terms of pollution but also in terms of sustainability.

In UK agricultural pollution is currently a chronic problem. The EU's Common Agricultural Policy (CAP) is still in place but will soon be replaced by domestic policy set by DEFRA. The implementation of the CAP's Green Pillar in UK currently does little to bring about measurable environmental improvement. The new agricultural policy must prompt a shift in the way land is managed onto a more sustainable and less polluting footing. This is an example of an area where policy cannot look at the water sector alone; progress cannot just be achieved with sectoral incentives, it requires a holistic view that includes other sectors. Any agricultural regulation that replaces the CAP should consider the UK's net-zero carbon emissions targets, and take a systemic approach. The framing of future agricultural support in terms of 'public money for public goods' has much to recommend it, but care and attention to detail will be required in its implementation if it is to be effective.

Lay the physical foundations for a greener economy

There is a gap in responsibility for watercourses, particularly those in cities, as it is not a responsibility of either DEFRA or Natural England (unless it is a specifically designated watercourse). Some watercourses have enhanced protections if they are part of a Site of Special Scientific Interest. Often such responsibility is simply left to local interest groups. This should be addressed by policy to ensure that a system-wide approach to water drainage and watercourses are considered.

¹⁵ Except for Scotland where there is a six-year regulatory cycle.

This connects into the innovation challenge described above of an urban drainage system fit for the 21st century, as in urban environments there is a policy gap of who should speak with developers and when. This applies in particular to SuDS (Sustainable Drainage Systems). In England, the National Planning Policy Framework laid out by the Ministry of Housing, Communities and Local Government recommends that “major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate” (HM Government, 2019b). Developers are also advised to give early consideration to the use of SuDS, but this is not mandated, as it is in Wales and Scotland.

However, there are few structures or policies in place to ensure that water drainage, use and treatment are considered at the earliest stage of development. Instead the default in development is sending wastewater down the sewers and there are currently few incentives not to do so. Consideration of the usage of SuDS at the earliest possible stage should become mandatory for all developments in England, as it is currently in Wales and Scotland.

4.5 A spotlight on the food sector

Key challenges for transformative green innovation

The UK's food system is unsustainable, fragmented and heavily dependent on imports (Lang, 2020a). Britain produces only 53% of food consumed in the UK. The system needs to be fundamentally transformed to become resilient and better prepared to face challenges such as climate change, ecosystem deterioration, health crisis and social inequality.

The current global food system is a major driver of environmental and social challenges, for example, by contributing to GHG emissions and causing deforestation and biodiversity loss. Green innovation can foster the shift towards more sustainable and resilient global and local food systems. In order to be transformative, however, green innovations should be designed and implemented with the awareness of the complexity, interconnectedness and multi-level nature of the food system. They need to go beyond a narrow focus on food supply and should promote embedding and normalising sustainable food production and consumption practices in local communities across the UK.

The COVID-19 pandemic is stress-testing the resilience of the UK's food system (Moran et al., 2020; Lang, 2020b). The ongoing crisis demonstrates the importance of strengthening local food supply-chains as well as ensuring well-functioning trade links, especially at the time of negotiating new trade deals with the EU and other trading partners.

The crisis may offer an opportunity. In a matter of months consumer attitudes and choices towards food have substantially changed. Being confined to their households and having to cook for themselves and their families, people started thinking more about food waste and local food systems (Connors et al., 2020). According to a recent YouGov poll commissioned by the RSA's Food, Farming and Countryside Commission (FFCC)¹⁶ more than 38% respondents say they are cooking more from scratch and 33% are throwing away less food. A majority (85%) wish to see at least some of the personal or social changes experienced during lockdown to continue afterwards. Although the long-term impact of Covid-19 on food habits is uncertain (Connors et al., 2020), the crisis

¹⁶ See <https://www.thersa.org/press/releases/2019/brits-see-cleaner-air-stronger-social-bonds-and-changing-food-habits-amid-lockdown>

“Changing consumer choices and social practices towards more sustainable food consumption is a key element of the transformation of the food system.”

could be an opportunity to stimulate the public to make more sustainable choices.

Consumer choices and social practices

Changing consumer choices and social practices towards more sustainable food consumption is a key element of the transformation of the food system. Retailers have an important role in encouraging the shift towards healthier and more sustainable diets. They have many tools which can shape selection environments and create incentives rewarding customers for more sustainable food choices (e.g. labels, re-arranging product displays to promote healthy and sustainable products, premium schemes rewarding healthy choices). Retailers recognise that combinations of these tools are more effective in influencing behaviour than single channels (e.g. labels alone have a limited impact on consumers).

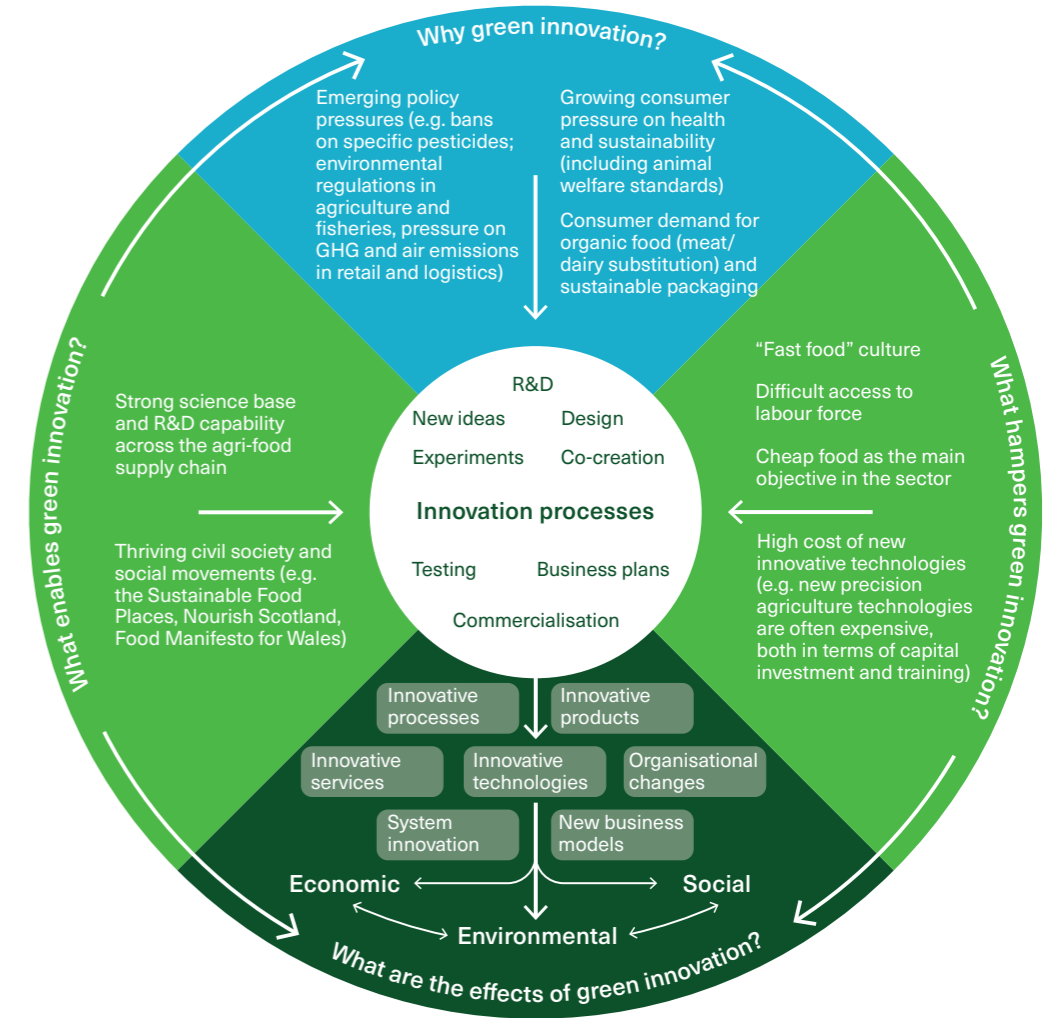
Stakeholders consulted by GIPC saw the need to rethink the relationship between retailers and consumers and between retailers and local communities, including the most vulnerable groups. Some retailers already engage in community projects with schools and care homes.

The role of institutions and organisational models

One of the key challenges is scaling up and normalising sustainable food practices currently adopted by relatively small groups of consumers. To embed these practices, one needs to go beyond economic incentives and consider other drivers and ramifications of social practice, including ethical and moral considerations.

Purpose-led institutions and social movements could be potential vehicles to embed and normalise sustainable practices, especially in local and regional communities. There are many established and novel forms of multi-stakeholder partnerships and purpose-led organisations in the UK which have emerged as an alternative to profit-oriented models. These institutional forms have a potential to channel, scale and give organisational structure to bottom-up collaborative initiatives driven by public purpose. There is a need to experiment with alternative institutional designs to tackle problems requiring collaboration between multiple stakeholders. Institutional innovations are important especially in the context of situating innovative solutions in specific local contexts and reaching out to disadvantaged and vulnerable social groups.

Figure 15. Incentives, barriers, and enablers of green innovation in the food system



Box 9

Examples of green innovations in the sector

Process innovation

- Nature-based solutions (e.g. carbon sequestration in soils, peatland restoration);
- New sustainable farming techniques (including precision farming, pest management, water-efficient agriculture, organic fertilizers)
- Sustainable food processing (low-GHG energy input, heat recovery, industrial symbiosis)

Products and service innovation

- Innovative services and business models to avoid food waste (e.g. Too Good to Go, Oddbox)
- Alternative lower-impact foods (plant-based and myco-protein meat; dairy substitutes)
- Lower-impact animal feed (e.g. insect protein as animal feeds)
- Innovative food packaging (from new designs to better recycling) developed in partnerships between packaging manufacturers, retailers and waste managers
- New approaches to delivery and retail (low-emissions transport, efficient refrigeration)

System innovation

- Innovative food infrastructure (e.g. cross-sectoral synergies with water, transport and built environment; circular economy approaches e.g. cascades);
- Shortening supply chains to promote food products based on locally grown food

Social and institutional innovations

- Innovative use of information instruments (e.g. innovative user-led design of labels)
- Institutional and governance innovations (e.g. “National Nature Service” from the Natural Capital Commission; advertising bans as e.g. in London)
- Multi-stakeholder partnerships and networks (e.g. Sustainable Food Places)

“**The policy needs to recognise the complexity and interconnectedness of the food system.**”

Policy portfolio for green innovation

Towards transformative innovation policy for the food system

The policy needs to recognise the complexity and interconnectedness of the food system. Current policy is fragmented and does not consider critical interlinkages between the food system and health. The policy needs to explicitly tackle big political questions on the future of the UK’s food system, such as: How far should Britain seek to feed itself? What are alternative scenarios and visions of sustainable food production and consumption in the UK? What is the UK’s food policy for the future? What is a role of innovation policy to make the food system resilient and sustainable?

Innovation policy enabling the transition towards a sustainable food system should be based on a long-term vision and evidence-based targets deliberated together with key stakeholders. The policy mix needs to comprise a revisited regulatory framework and a comprehensive portfolio of instruments targeting key elements and processes of the food system, including production, trade and consumption.

A sustainable food system policy needs to address various elements of the food system, including farming and land use, food production, trade, food distribution, food services, consumption and food waste. While the system transformation requires changes in all elements of the system, it is key to recognise that upstream changes in production processes, land use patterns and trade have the potential to result in the highest environmental benefits as they predetermine choices made by retailers, food service providers and consumers. These upstream changes, however, will require a strong policy drive and close collaboration between many stakeholders across food value chains to work out alternative food production and consumption models.

Most of food policy falls under the responsibility of the devolved administrations. There are many parallel processes underway focusing on sustainable food in England, Scotland, Wales and Northern Ireland. In England, the Government appointed Henry Dimbleby to conduct a year-long review and set out policy recommendations¹⁷. Based on the findings and recommendations from the review, later this year, Government will publish a National Food Strategy. The following sections set out GIPC’s recommendations for UK innovation food policy to enable and foster green innovation to help transform the UK food system.

Create and shape demand for green innovation

The policy needs to comprise a set of measures to create and shape demand for green food innovation. These policy instruments should be addressed to actors along the value and supply chains from knowledge-intensive companies to consumers.

Fiscal policy instruments can be used to ensure the affordability and accessibility of sustainable food products and services (e.g. adjusting VAT on certain products and services). The affordability and accessibility of sustainable food products is a particularly delicate subject in the UK where large groups depend on food distributed by food banks and where most sustainable food choices are more expensive than unsustainable alternatives. Innovation food policy needs to carefully consider the affordability and accessibility of sustainable food options and diets to various social groups across Britain.

Government can also use fiscal instruments to encourage or discourage the use of specific products and practices by companies and farmers. This could include, for example, the use of differential capital allowances for investments in appropriate infrastructure and sustainable technologies or taxing the use of

¹⁷ See <https://www.nationalfoodstrategy.org/>

products causing environmental damage such as nitrogen fertiliser (see Sustainable Food Trust, 2017).

Public procurement can be used to promote innovative food products and services, for example, to deliver healthy and sustainable diets at schools and other public sector institutions. Green public procurement should be based on transparent criteria promoting healthy and sustainable food.

The policy should include a range of educational, information and awareness-raising instruments addressed to consumers, notably food labels. Customers are not sure about what “sustainable” means and often settle with “organic” when making purchasing choices. Existing food labels are too complicated and should be redesigned to offer clearer guidance on how various products compare and which products to choose. One way to improve the labels is through engaging consumers in the co-design of labels. It is important to emphasise, however, that although labels and other information instruments are important, systemic food policy should aim at eliminating the most unsustainable products and services from the offer in the first place.

Boost green innovation investments

Numerous investments are needed to transform the UK food system, ranging from upgrading and building new technical infrastructures to investing in research, development and deployment of innovative food products, services and business models. Government should ensure that investments in the food system are made with a view to transforming the entire system and minimising external costs (Sustainable Food Trust, 2017). The systemic approach could mean, for example, that investments in food system infrastructure, such as horticulture, would have a value chain perspective and focus on shortening the supply chains of specific good products in order to boost local innovation in food processing which can create local products and local jobs.

The systemic approach to the food system is well taken by Government. UKRI has recently supported research to fundamentally transform the UK food system.¹⁸ The £25 million call has a multi-stakeholder approach and aims to tackle health, environmental and social challenges simultaneously to develop evidence supporting systemic action across the food system. Government should ensure that a systemic approach to transforming the food system underpins all this investment.

Change the rules of the game

Transformative innovation policy needs to create a regulatory and institutional environment enabling green innovation and discouraging unsustainable food products and practices. Innovation policy should support and scale up emerging sustainable markets and, in parallel, start discouraging predominantly unsustainable practices (e.g. by applying polluter pays principle instruments). The policy shift needs to be based on the right balance of positive and negative incentives and a careful sequencing in phasing in and out specific instruments.

The policy framework must internalise externalities (Sustainable Food Trust, 2017) and be consistent in rewarding companies and consumers for sustainable choices, and in penalising those who take actions harming present and future wellbeing and ecosystems. The policy framework needs to enable and reward companies for investing in and delivering sustainable food products and services as well as to ensure that all consumers, especially these from disadvantaged communities, have access to affordable and sustainable food.

One route for changing the policy is, for example, an approach based on the

¹⁸ See <https://webarchive.nationalarchives.gov.uk/20200930163400/https://bbsrc.ukri.org/funding/filter/transforming-the-uk-food-system-for-healthy-people-and-a-healthy-environment-call/>

“**The UK should maintain parity with the best standards in the OECD and set its own higher standards for the benefit of consumers and nature.**”

principle of ‘public money for public goods’ to introduce payments for ecosystem services and rewards for improving ecosystems, neither of which can be delivered by unregulated market mechanisms focused on returning value to the producer and growing the wealth of shareholders. The new Agriculture Bill allows for such measures in England where farmers and land managers may be rewarded in the future for delivering public goods, such as cleaner air and water quality, higher animal welfare standards, improved access to the countryside for the public or measures to reduce flooding.¹⁹ These new mechanisms can create opportunities for existing and new sustainable businesses and be used to foster green innovation with benefits for disadvantaged groups in society. They need to be carefully designed, however, to ensure a fair distribution of the economic, social and environmental benefits from green innovation.

Public policy and the governance of the transition requires a fundamental shift in the rules and norms underpinning regulations and institutions. Innovation policy needs to be guided by a shared vision of a sustainable agriculture supported by binding targets and standards. It requires rethinking and experimenting with organisational settings, forms and mechanisms of collaboration as well as contractual frameworks to share the risks and benefits of innovation. These new arrangements and experimental spaces for the transition will need to be transparent and long-term; it is key that policy makers commit to them to make them credible in the eyes of stakeholders.

The food policy mix needs to comprise clear trade rules and binding standards which prevent imports of crops and food products which do not meet social and environmental standards applied to sustainable food production in the UK. Given that the UK relies to a large extent on food imports, trade policy can make a significant contribution to making food production and consumption in the UK more sustainable. If the trade is not aligned with sustainable food policy objectives, it limits the domestic options and undermines local sustainable food markets. This is particularly important in the context of the ongoing trade negotiations following the UK’s exit from the EU.

The UK should, as a minimum, maintain parity with the best standards in the OECD and, whenever possible and feasible, set its own higher standards for the benefit of consumers and nature. In the process of standard design and implementation government needs to take into account the risk of increasing food prices in which case policy makers should make sure that costs do not fall on consumers from vulnerable groups.

There needs to be a national discussion about the desirable balance for food system resilience between sustainable local production and imports produced to the same high standards, considering existing capacity to produce and distribute locally grown products as well as the interests of trade partners, particularly developing countries.

Nurture dynamic innovation ecosystems

Government recognises the interconnected and complex nature of food system. This realisation is key for the work on the National Food Strategy. Just as the food system is multi-dimensional and complex so is ecosystem of innovation actors and networks playing different roles at different stages of food value chains. Transformation of the UK food system will need a vibrant agri-food innovation ecosystem enabling cross-sectoral and multi-disciplinary collaborations. Government should nurture existing local, national and international research and innovation collaborations in the agri-food sector by providing sufficient R&D and innovation funding for challenge-led innovation collaboration, demonstrators, and business support for innovative agri-food start-ups.

¹⁹ See <https://www.gov.uk/government/news/agriculture-bill-to-boost-environment-and-food-production>

“**Food policy should recognise the critical importance of infrastructure investments for rebuilding the UK’s food system.**”

Lay the physical foundations for a greener economy

Food policy should recognise the critical importance of infrastructure investments for rebuilding the UK’s food system. This is about the role of agri-food infrastructure (e.g. including horticulture) as well as the innovative design of other vital infrastructures to create cross-sectoral synergies (e.g. with water, transport or the wider built environment).

There is a need for more reliable data on the UK food system, including on food products and processes. To improve comparability of data, government with key stakeholders need to agree on key sustainability metrics applied to food products and services across the UK. The framework should include a basket of indicators which give a system view, including health and environmental aspects. Multi-stakeholder collaboration, including with consumers, is needed to trial and agree on how to communicate these metrics (e.g. on labels) and how to use this evidence to improve food production and services.

Rethinking policy processes and governance for green innovation

Multilevel and multi-stakeholder policy framework

To foster the transformation of the UK food system, government needs to adopt a multilevel and multi-criteria innovation policy. The policy should consider the complementary roles of different levels of governance and institutions in fostering the transition by recognising the specific roles of central government, devolved governments, local councils and partnerships, including LEPs, and business partners. The framework needs to combine top-down and bottom-up processes.

On the one hand, the government has a key political role to democratically deliberate and oversee the overall direction of transformation; provide a country-wide platform; develop and agree on shared food standards, criteria and metrics; design and implement fiscal and trade policies, including trade policy; build a country-level evidence base; and ensure the consistency and coherence of various policy and regulatory instruments. On the other hand, the new policy framework needs to empower local and regional actors. There is a need to build more resilient regional and local systems which enable bottom-up action and give an important role to local councils and public-public and public-private partnerships.

Knowledge for transformation

Policy with an ambition for system change requires a robust knowledge base and policy-learning mechanisms which allow policy interventions to be continuously monitored, evaluated and improved. This knowledge base should be systemic and interdisciplinary. It needs to be built in close collaboration with researchers and stakeholders. An insufficient evidence base will lead to policy failures which undermine credibility and trust in the government as a partner.

The GIPC roundtable on food urged government on all levels to support local experimentation and trials of innovative business models and institutional innovations to scale up sustainable food production and consumption practices. The government should ensure sufficient timescales and investments in trialling institutional innovations.

Policy roadmap - ensuring a common direction of travel

There is a need for a policy roadmap with milestones and transformation targets. The environmental targets could target GHG emissions; air, soil and water pollution and waste arising from agriculture; food production and consumption (e.g. footprint metrics capturing farm-to-fork environmental burden). It could also include food packaging in collaboration with stakeholders from the waste and resources sector.

The roadmap could also include production targets such as yields of specific crops to be achieved while reducing negative ecosystem impacts and without worsening the environmental footprint of production. The roadmap would be an overall strategy to ensure an overall direction of change and create space for bottom-up initiatives. It should be developed with key stakeholders. Lessons on how to develop such a roadmap can be learned from the energy sector as well as from international examples that have developed this approach (e.g. Germany, Denmark).

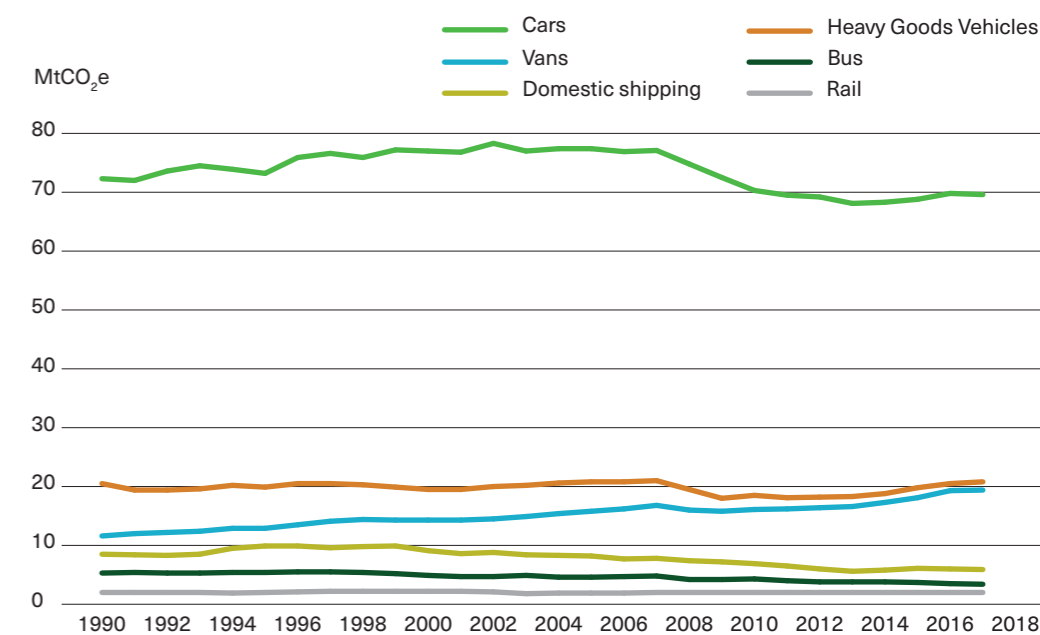
4.6 A spotlight on the transport of goods by road

Key challenges and opportunities for transformative green innovation

Road transport is one of the largest contributors of greenhouse gas emissions and air pollution in the UK. Policy and public debate on greening transport has focused on personal mobility: electric cars, public transport and cycling (DfT, 2020). But the green innovation pathway is much less clear for the mobility of goods. This is not a problem that can be ignored: heavy goods vehicles (HGVs) and vans account for a third of UK road transport emissions (ibid.), and 8% of total UK GHG emissions (CCC, 2018).

In contrast to the power sector, there has been little progress in reducing emissions from HGVs and vans (see Figure 16). Despite declines in recent years²⁰, urban air pollution kills more than 28,000 people in the UK every year²¹, some of which is attributable to emissions from road freight.

Figure 16. UK domestic transport emissions



Source: DfT 2020

20 See https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2018_issue_1#report_pdf

21 See <https://www.gov.uk/government/news/public-health-england-publishes-air-pollution-evidence-review>

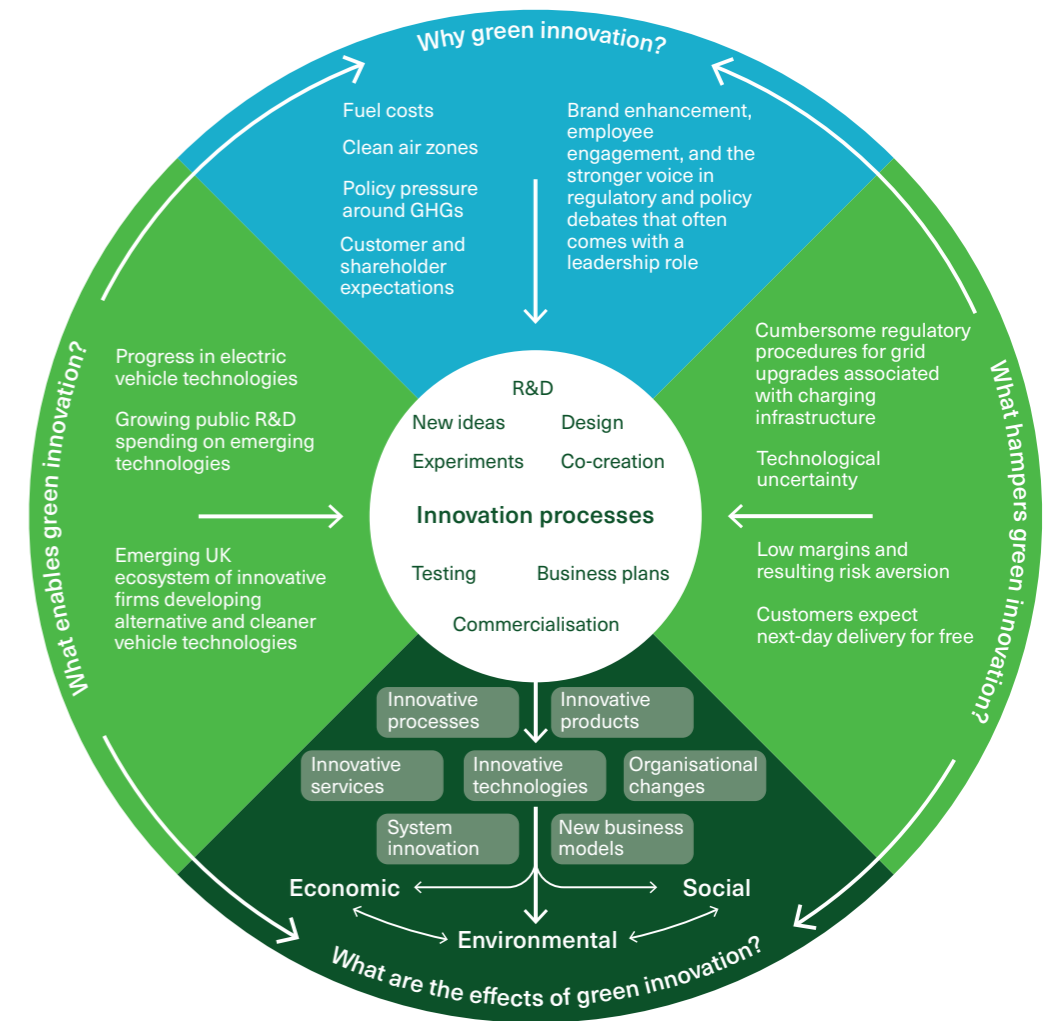
There are substantial opportunities for innovation in the sector, relating to both technologies and business models. For example, it has recently been estimated that the market for EV fleet charging services, such as ancillary grid services and energy management, could be worth \$6bn in the US alone by 2030 (McKinsey, 2020). Deployment and experimentation in this area (as with the SEUL project highlighted in box 10) helps to position UK firms to benefit from these global opportunities.

Priorities for green innovation for the mobility of goods include both near-term options that could substantially improve the environmental performance of existing fleets based on internal combustion, and efforts to accelerate the development and deployment of zero-emission options based on electricity and hydrogen.

Examples include:

- Facilitating market entry of cleaner fuels like biomethane
- Optimisation of range-extender engines, facilitating hybrid electric trucks
- Innovation in logistics systems, drawing on new digital technologies and data science
- Weight reduction and optimisation of batteries for HGVs, including for opportunity-charging (which involves frequent short charging periods, e.g. during deliveries)
- Design and development of electric delivery vehicles (e.g. UK start-up Arrival²²)
- Electric road systems, enabling electrification of HGVs²³
- Charger development and charging standardisation
- Smart charging technology to reduce the need for grid upgrades at depots
- Hydrogen and fuel cells for goods vehicles, and clean hydrogen production.

Figure 17. Incentives, barriers, and enablers of green innovation in road freight transport



22 See <https://arrival.com/news/ups-invests-in-arrival-and-orders-10000-generation-2-electric-vehicles>

23 See <http://www.csrf.ac.uk/2020/07/white-paper-long-haul-freight-electrification>

Box 10 Examples of green innovations from UPS

Smart charging systems: Smart Electric Urban Logistics (SEUL)

The Smart Electric Urban Logistics (SEUL) project was a world-first deployment of a smart charging system for a freight fleet, incorporating active network management, energy storage and new ways to assess grid capacity for charging. The project was part of the Low Emission Freight and Logistics Trial funded by the Office for Low Emission Vehicles (OLEV) in partnership with Innovate UK.

UPS has demonstrated that it can electrify its entire central London fleet without having to upgrade the local electricity grid, through a combination of smart charging and onsite energy storage. 20 mid-life UPS 7.5-tonne diesel trucks were converted to fully electric models, taking the total number of EVs above the threshold number that could be charged at the depot previously. The converted vehicles have already delivered significant air quality and greenhouse gas emission savings since deployment, with an estimated 74 tonnes of CO₂e saved in the first year of deployment.

The project has generated innovation that will benefit the UK's ongoing electric vehicle transition. As part of the project, UK Power Networks developed a new approach to quickly and efficiently assessing grid upgrade needs for customers with large EV charging demands, helping to reduce the need for, and costs of, local electricity infrastructure upgrades. The Cross River Partnership have taken the lessons from this project and seen them deployed elsewhere, including working with public sector fleet managers to develop vehicle electrification strategies. The project has also unlocked new avenues of research and development for UPS and one of the project's subcontractors, UK Power Networks Services.

For more information: <https://crossriverpartnership.org/projects/smart-electric-urban-logistics/>

Electrically-assisted (e-assist) cycles and walkers in the cities

The use of e-assist cycles and walkers for the last mile delivery has clear economic and environmental benefits in cities. UPS is designing new e-assist cycles and walkers, but there are regulatory barriers that make it difficult to scale these up.

E-assist cycles are governed by regulations conceived for passenger e-bikes, which limit motor power to 250W 'rated' power. This is not adjusted to freight: 250W is inadequate and results in cargo e-cycles having to be propelled by athletic individuals. The regulations should be adjusted to focus on the objective (e.g. speed, braking performance, etc.) rather than the means used to achieve it (e.g. motor power).

E-assist walkers (electrically-assisted hand-pushed carts) are not allowed on any pavements without a specific exemption. This is for reasonable safety reasons but it creates barriers to innovating urban delivery systems. There could be a more flexible approach to allowing e-assist walkers in specific areas (e.g. campuses or shopping malls) where they can be both beneficial and safe. In Dublin, UPS has collaborated with Fernhay to implement the world's first commercial e-walker operation, after receiving permission to do so from Dublin City Council.

For more information: <https://irishtechnews.ie/ups-and-dublin-city-council-to-reinvent-deliveries>

“Stringent, performance-based regulations can drive innovation. But poorly designed or inflexible regulation can inhibit innovation and experimentation.”

Policy portfolio for green innovation

Create and shape demand for green innovation

Consumers currently cannot differentiate between a clean or dirty supply chain when they shop, and so concern about the environment does not easily translate into demand for cleaner logistics and freight. Greening innovation in the sector requires stimulating demand for greener systems. Key options include:

- Urban access restrictions are the key incentive for delivery fleets to invest in cleaner technologies. These must be harmonised nationally to avoid a fragmented regulatory patchwork. Extended urban access times for electric vehicles, as well as dedicated lanes or parking facilities, can also be powerful non-price incentives.
- Road-user charging that distinguishes the fuel being used can incentivise 'clean miles' in dual-fuel vehicles.
- Public procurement can accelerate deployment of cleaner heavy-duty vehicle technologies.
- Fuel duty, which should rise, at least in line with inflation. Government has reduced real-terms taxation on petrol and diesel fuel by more than 20% since 2010, at an annual cost to the exchequer of over £4bn, which has reduced incentives to switch to cleaner fuels.

Boost green innovation investments

Cleaner vehicles, often made at low volumes, are more expensive than standard diesel vans and trucks. Private business cannot always bear the costs associated with investing in risky innovative solutions that have social benefits. Support for companies to invest in cleaner technologies is necessary to overcome this market failure and to shape the market for cleaner mobility.

Government has already funded green innovation in this sector, for example through UKRI. This has been essential, but it is not enough. R&D alone is not an efficient way of generating rapid innovation in this sector, where companies have existing knowledge and capabilities to deploy and test cleaner technologies if they have the right support. Key priorities include:

- Direct public and public-private investment in electric mobility infrastructure
- Public funding, for example through a new National Green Investment Fund, to crowd-in private investment for demonstration and experimental deployment
- Enhanced capital allowances which facilitate investment in cleaner transport technologies.

Change the rules of the game

Stringent, performance-based regulations can drive innovation - and the new mandatory targets for the CO₂ intensity of new heavy duty vehicles will help accelerate green innovation in the sector (DfT, 2020). But poorly designed or inflexible regulation can inhibit innovation and experimentation – as illustrated by the case of e-cycles and e-walkers in box 10. Opportunities and priorities include:

- First, as noted above, urban access restrictions can be powerful but must be harmonised to avoid a confusing array of locally differing clean air zones.
- Second, changes to the planning process can create opportunities to foster deployment of cleaner vehicles and fuels. Requirements on developers to include clean refuelling and charging facilities in distribution centres – so that they are accessible to multiple companies and fleets – can enable greater access and higher usage than infrastructure installed at depots.

- Third, there is a need to consider whether and how to regulate access to data in the sector. New digital technologies and data science can enable more efficient logistics operations systems. The scale of the innovation opportunities here may depend on data ownership and access. Finland has been a pioneer in promoting data sharing among transport operators²⁴ - there is a good case for government to review whether data sharing rules should be introduced.

To ease the burden of regulation, government could explore having an approach in which 'trusted' fleets that demonstrate high compliance standards are given greater flexibility. This might apply, for example, to permitting processes for clean fuels infrastructure at logistics facilities (where local authorities unfamiliar with low-carbon fuels often take a long time to approve developments); or simpler compliance processes to secure access to clean air zones in cities.

Nurture dynamic innovation systems

The UK Government has supported innovation collaboration focused on low-carbon transport, e.g. through UKRI²⁵. This support should be expanded to include collaborative deployment, experimentation and demonstration activities run in partnerships with operators and local authorities. These collaborations have an important regional dimension as they address specific local challenges.

International collaboration is an important part of a successful innovation strategy in this sector: many of the major vehicle manufacturers and operators are global players, and the UK must work to stay engaged in emerging international value chains for new technologies.

Lay the physical foundations for a greener economy

Charging infrastructure is currently an important barrier for the wider adoption of electric delivery vehicles in cities. Widespread charging infrastructure could enable 'opportunity charging' strategies (e.g. charging while unloading), enabling smaller batteries and hence cheaper vehicles. Supporting the development of charging infrastructure can also generate cross-sectoral innovations in charging technology that can have wider commercial value, as demonstrated by the SEUL project (see box 10).

The current arrangements for grid upgrades are cumbersome: UPS raised the example of having to pay for upgrades to grid assets belonging to the Distribution Network Operator (local grid owner) in order to enable charging in their electric vehicle depot in north London. Regulators, DNOs and the government must work together to more clearly share the costs associated with grid upgrades for commercial vehicles. The social benefits of electric vehicle adoption are widely shared and the costs should therefore be more widely shared too.

There is also a need for innovation in infrastructure options, in several key areas:

- 'Electric roads' (in which vehicles are charged while driving) are already being trialled in other countries²⁶. They enable cheaper vehicles with smaller batteries, and allow electrification of HGVs that travel long daily distances

“**There is a need for government, in collaboration with industry and researchers, to set out a clearer pathway to a zero-emission system.”**

with large loads.²⁷ Electrification is much more efficient in terms of energy consumption than other low- or zero-carbon alternatives.

- Micro-consolidation and reorganisation of operations: Logistics innovations that result in fewer trips from near-empty vehicles reduce pollution and congestion. Innovation ideas include: 'physical internet'; shared infrastructure between fleets; smarter routing locations of depots; micro-consolidation or micro-distribution centres (notably in relation to cycle- and walker-based last mile deliveries). These strategies are not risk free, since unintended shifting of congestion and pollution to other parts of the network can occur, but they are an important area for research and experimentation.

Policy processes and governance

A key issue for road freight is the lack of a clear roadmap – in contrast to the clarity for passenger vehicles. There is a need for government, in collaboration with industry and researchers, to set out a clearer trajectory that includes the medium-term options for cleaner fuels and systems on the pathway to a zero-emission system. Roadmaps can help to co-ordinate R&D activities, and there is a strong appetite from the sector for a more decisive government view.

The transition to a sustainable logistics and freight sector will involve a process of experimentation, with new challenges at each stage, and it will require regulatory agility to remove barriers as they become apparent. Closer government-industry dialogue will be important, and intermediary bodies like the Low Carbon Vehicle Partnership may need additional resources. The Office for Low Emission Vehicles has been an important part of the government's approach to low-emission vehicles. However, it is perceived in the freight and logistics sector to have been too narrowly focused on passenger cars and electrification, rather than a broader portfolio of innovation options.

Local governments have a key role in enabling the transition: through the planning process, by facilitating experimental deployment in urban 'test beds', and through procurement. But local authorities often lack capacity and they need support. The proliferation of local clean air zones has illustrated both that local communities are eager to take action to accelerate green innovation, and that there is insufficient co-ordination and support for local authorities to live up to their potential role.

²⁴ See <https://www.lvm.fi/-/data-utilisation-and-intelligent-automation-to-boost-the-digitalisation-of-logistics-970248>

²⁵ See <https://www.ukri.org/news/networks-to-prepare-uk-transport-for-a-low-carbon-future/>

²⁶ See <https://www.theguardian.com/environment/2018/apr/12/worlds-first-electrified-road-for-charging-vehicles-opens-in-sweden> and <https://www.power-technology.com/news/germany-launches-first-electric-highway/>

²⁷ See <http://www.csrf.ac.uk/2020/07/white-paper-long-haul-freight-electrification/>

5.

Policy and governance for transformative green innovation

5.1 Political momentum and social contract for green recovery

“ Making innovation policy fit for the net-zero ambition requires significant changes to its objectives, design and implementation as well as governance mechanisms.”

The UK has developed an ambitious stance on the environmental and climate crisis. The Climate Change Act now commits the UK to at least 100% reduction in GHG emissions relative to the levels in 1990 to be achieved by 2050.²⁸ It imposes legal obligations on the government and will be enforced by a proposed new Office for Environmental Protection. The upcoming Environment Bill 2020²⁹ aims to introduce a comprehensive overarching framework to address some of the major environmental challenges to deliver on the ambition on the 25 Year Environment Plan. Meeting these ambitious environmental goals will require a coherent approach across government departments, at all levels of governance and across Britain's regions.

Innovation policy with its focus on fostering transformative change in economy and society will need to be central to government's efforts to meet its environmental goals. Making innovation policy fit for the net-zero ambition, however, requires significant changes to its objectives, design and implementation as well as governance mechanisms to work more effectively with business and social partners.

The challenge of transformation is not solely about inventing a radically novel technology: the transition to a low-carbon and resource-efficient economy requires a variety of innovations, many of them incremental, that together can transform the economy. Innovation policy needs to find a balance between quick and slow “wins” by investing in both a wider diffusion of proven green technologies and supporting novel, often disruptive, innovations. The focus on diffusion is important for delivering economic, social and environmental benefits in the short term and responding to urgent needs. Investing in more radical system innovations, such as electrifying entire cities or greening food systems, is riskier, requires trialling involving many actors, and inevitably takes more time to implement. But system innovation is essential to developing alternatives to the current unsustainable patterns of production and consumption.

Driving green innovation will require a series of policy interventions and government investments which leverage private capital. Getting this right will require a careful examination of evidence and engagement of policy makers, business, scientists, civil society, and other stakeholders. Many of these issues will be contested and must be deliberated in an inclusive and transparent way.

The transition to a net-zero economy will create losers as well as winners and will at times be politically difficult. In such a context, it is more important than ever that innovation policy is inclusive, and that it does not exacerbate regional and social inequalities. Government must be consistent in rewarding companies and consumers for sustainable choices, and in penalising those who take actions harming present and future wellbeing and ecosystems. Innovation policy driven by societal goals cannot be reduced to business goals but needs to embrace at its core ethical and moral concerns.

²⁸ See the Climate Change Act 2008 (2050 Target Amendment) at www.legislation.gov.uk/uksi/2019/1056/contents/made.

²⁹ See <https://www.gov.uk/government/publications/environment-bill-2020>

Innovation policy can be galvanised by pursuing carefully selected missions to address local and global sustainability problems (Mazzucato 2017, 2018; UCL MOIIS, 2019; Miedzinski et al., 2019). These missions should not involve being overly prescriptive in terms of what technologies will be needed but should foster alignment and long-term collaboration between the public, private, and third sectors to jointly work towards common goals.

Headline recommendation 1

The government must consolidate political commitment to a net-zero target and build a new social contract for a green recovery and transformation towards a green, fair and resilient society

There is a need to solidify and reinforce the cross-party commitment to act to meet ambitious environmental targets. The commitment should be based on a new social contract based on binding targets and commitments shared with business and society. Government could use the momentum in the run-up to COP26 in Glasgow to lead a public debate and build a multi-stakeholder, cross-party consensus on transforming Britain into a sustainable, fair and resilient society. The development and implementation of the Environment Bill's targets offers a significant opportunity to progress this commitment; the target-setting process should be conducted transparently and be informed by independent expert advice.

Institutional lead: Leadership of UK political parties; Key partners: Parliament and devolved administrations, business leaders, civil society, scientists; Existing commitments and on-going initiatives: The Climate Change Act & The 25 Year Environment Plan, The Environment Bill 2020 (under deliberation in Parliament); Timeline: 2020 (before COP26 meeting in Glasgow)

Headline recommendation 2

Government should boost the role of innovation in the green recovery process

Green innovation should be at the centre of the post-COVID recovery. Government should rebalance its support to green innovation from R&D towards a more hands-on support for market formation, experimentation, demonstration and commercialisation of innovation addressing sectoral and regional challenges and opportunities to accelerate the transition to net zero. Government should prioritise cross-sectoral innovation missions and sector deals to make demonstrable contributions to accomplishing societal goals while bridging the gap to achieving a net-zero target and wider environmental goals.

Institutional lead: Cabinet Office; Key partners: BEIS, DEFRA, UKRI; Existing commitments and initiatives: Industrial Strategy, R&D roadmap, UKRI strategy.

5.2 Policy mix for green innovation

Society's environmental challenges will not be overcome by single instruments such as higher investment in R&D funding or a carbon tax, important though these may be in themselves. Evidence suggests that addressing environmental and social challenges requires a comprehensive and coherent policy mix including a broad set of diverse instruments drawn from various policy areas.

There is a gap between upstream innovation policy (focused on R&D, universities and innovative SMEs) and environmental policy (focused on fiscal instruments, regulation). Government has not joined up policy linking environmental goals with innovation – the result is that 'green innovation' policy is not mission-oriented enough, and it fails to link policy areas in search of synergies. Government needs to ensure internal consistency of its policies and align them towards shared long-term targets.

Headline recommendation 3

Government must strive for a coherent and comprehensive green innovation policy portfolio to foster and scale up innovation to deliver on its environmental goals

Overall coherence needs to be supported in the design and implementation of individual instruments and policy portfolios. The UK Government should strengthen the application of the precautionary principle and ensure that future investments and regulations are consistent with the UK's environmental goals. Central government should also work constructively with the devolved administrations to ensure this is effective across the country. This should be supported by the Environment Bill and enabled by transparent due diligence processes.

The new Office for Environmental Protection should be a key independent public body with a mandate to check on and continuously monitor all government instruments supporting research and innovation against stated top-level environmental goals and targets. The Office should have guaranteed independence from the government, including a ring-fenced five-year budget. The first tailored review of the Office should be conducted transparently and consider explicitly whether it has sufficient institutional and operational independence to fulfil its functions effectively.

Institutional lead: Cabinet Office (design, implementation), New Office for Environmental Protection (scrutiny); Key partners: government departments, business leaders, civil society; Existing commitments and ongoing initiatives: The Climate Change Act, The Environment Bill 2020 (under deliberation in Parliament).

What is required is the implementation of a policy mix for green innovation which includes policy instruments, policy processes and governance arrangements. There are six areas in which government can strengthen its policy and accelerate green innovation:

- Create and shape demand for green innovation: from niches to global markets;
- Boost green innovation investments: from R&D to innovation diffusion;
- Change the rules of the game: progressive and agile regulation;

“**Fiscal policy can spur green innovation as well as help phase out environmentally and socially harmful products and processes.**”

- Nurture green innovation ecosystems: cross-sectoral collaboration and experimentation;
- Make infrastructure work for a greener economy: innovative infrastructure;
- Working together to foster green recovery: challenge-led policies and governance.

5.2.1 Create and shape demand for green innovation: from niches to global markets

Government can deploy a number of demand-side instruments to boost market pull needed to further diffuse existing green technologies, products and business models as well as to commercialise and scale up applications of novel transformative innovations. These tools range from fiscal instruments, through public procurement to information tools influencing consumer choices.

Headline recommendation 4 Create and shape demand for green innovation

In order to foster the transition to net zero, government should use its demand-side instruments to create and scale up market pull for innovative green products and services.

Fiscal reform for the sustainability transition

By introducing a system of financial rewards and penalties based on the environmental performance of companies or products and services, fiscal policy can spur green innovation as well as help phase out environmentally and socially harmful products and processes. The UK's experience of the landfill tax has demonstrated that environmental taxes can generate transformative change. Decades of research confirm that price induce innovation. Policies that put a price on pollution and waste are a key to foster green innovation.

Specific recommendation 4.1

Government should use fiscal instruments, including a strengthened carbon price, to foster and reward green innovation

Government should revisit the fiscal system to consistently tax harmful activities, including GHG emissions, and reward activities creating public value. This includes the use of fiscal instruments, including tax incentives and R&D tax credits, to support innovating companies developing and bringing top-performing green products and services to market. The Government needs to ensure that the fiscal system rewards companies and consumers who choose more sustainable goods and services. Fiscal instruments should be coherent with other government instruments targeted at innovative business (e.g. R&D grants).

Institutional lead: HM Treasury; Key partners: BEIS; Existing commitments and initiatives: Clean Growth Strategy, The Road to Zero (e.g. R&D tax credit; tax incentives for ultra low emission cars; company tax diesel supplement), Resource and waste taxes.

“**There is a need to agree on binding procurement criteria favouring sustainable infrastructures, products and services and moving to more innovative approaches such as performance procurement.**”

Bold public procurement for green innovation

Procurement should be explored as a way of driving and incentivising green innovation and supporting a green recovery. In the UK, government procurement makes up around 14% of GDP (OECD, 2017). If only a small fraction of this is leveraged towards environmentally preferable infrastructure, products and services, it could bolster demand for green innovation (e.g. sustainable buildings, cleaner transport, locally procured organic food etc.).

Lessons can be learnt from national and international initiatives on sustainable and circular procurement and innovation-focused schemes such as GovTech and SBRI in the US. The work can build on the guidance documents developed by the Cabinet Office Efficiency and Reform Group.³⁰ There is a need, however, to bolster the current practices and agree on binding procurement criteria favouring sustainable infrastructures, products and services and moving to more innovative approaches such as performance procurement.

Specific recommendation 4.2

Government should scale up green public procurement

Government should revisit procurement frameworks to introduce sustainability criteria as an integral part of scoring tenders. As a minimum, public authorities on all levels should ensure that public procurement is not used to purchase environmentally harmful goods and services when there are alternatives available on the market. The government should invest in building institutional capacity on all levels to implement stringent green public procurement guidelines on the national and local levels.

Institutional lead: HM Treasury; Key partners: BEIS and DEFRA; Existing commitments and initiatives: adjusting Government Buying Standards (GBS) through Greening Government Commitments.

Specific recommendation 4.3

Government should bolster pre-commercial procurement of green innovation

Government needs to bolster innovation procurement and pre-commercial procurement to bring innovative green goods and services to market. This should be accompanied by investments in institutional capacity to introduce and roll out innovation procurement by procurers on the national and local levels. Setting up a network of procurers and innovation investors to exchange existing practices could support this process.

Institutional lead: BEIS, UKRI; Key partners: Department of Finance, DEFRA, UK ARPA; Existing commitments and initiatives: Guidance on innovation procurement by The Cabinet Office Efficiency and Reform Group.

Shaping choice environments to favour sustainable consumption

Demand-side innovation policies can also influence the choices of consumers. Government has a range of instruments it can use to this effect, including regulations on advertising and product labelling, as well as education and information campaigns. There is, however, a need for a more consistent, decisive and innovative use of these instruments which can be co-designed and trialled in collaboration with business and civil society.

³⁰ See <https://www.finance-ni.gov.uk/publications/guidance-documents-innovation-and-public-procurement>

Specific recommendation 4.4

Government should incentivise people to make more sustainable consumption choices

Government should design choice environments to ensure consumers can fully benefit from green products and services. Based on the insights from behavioural science and experimentation, it should change the design of product and service labels to ensure that they are effectively communicated to consumers.

Government could consider learning from dynamic labelling schemes rewarding best performance (e.g. Japan's Top Runner scheme) and testing similar approaches in the UK. The work on labels needs to be coordinated through new green standards, and be based on a good understanding of specific challenges, sectors and product groups (e.g. supporting sustainable diets in food policy, supporting durable and repairable products).

Government should seriously consider imposing selective bans and restrictions on advertising environmentally harmful products and services. This can draw on experience in banning and limiting advertising unhealthy products (including the public consultation on restricting advertising of food high in fat, sugar and salt).

Government should support and finance establishing of a free and generally accessible information platform with comparable assessments of key products and services.

Institutional lead: Cabinet Office, BEIS, Advertising Standards Authority; Key partners: Retailers; Manufacturers; Existing commitments and initiatives: Government Technology Innovation Strategy.

5.2.2 Boost green innovation investments: from R&D to innovation diffusion

Government is a major investor in R&D and innovation. State investment has played a crucial role in previous radical innovations, with government investing before the private sector at the riskiest stage of development (Mazzucato, 2013). However, despite having one of the largest financial sectors in the world, the UK has lower levels of investment in R&D by both the public and private sectors than comparable countries. The UK currently invests 1.8% of GDP in R&D compared to an OECD average of 2.4%. The need to increase R&D expenditure is acknowledged by the government, with its current target increase in R&D spending to 2.4% of GDP by 2027 and recent commitments to spending uplifts in the R&D roadmap.³¹

Headline recommendation 5

Government should boost green innovation investments

Public investment in R&D and innovation should prioritise developing and deploying green innovations with a potential to foster and accelerate transformation towards net zero. Government should create financial instruments to provide patient finance for innovations through public investment and leverage and “crowd-in” private investment in green innovations.

³¹ See <https://www.gov.uk/government/publications/uk-research-and-development-roadmap>

Prioritise, streamline and scale up strategic public investments in green innovation

It is essential that innovation policy has a systemic approach to financing innovation and ensures access to finance at every stage of the innovation process. Government has a range of instruments it can deploy to directly invest in innovation activities and to leverage private investment across the innovation chain. Government should streamline and scale up its investments in green innovation, ensuring that funding is available not only for curiosity-led research but also for close-to-market experimentations and deployment, and market formation through long-term contracts. These investments should be streamlined in order to avoid fragmentation of efforts.

Strategic innovation investments should be made in areas with a high demonstrable potential to create environmental and social benefits and where markets will not invest by themselves. The phrase “value for money” should be revisited to account for wider “public value” of government investments (Mazzucato and Ryan-Collins, 2019). Examples include investments in green infrastructures or in waste-heat recovery and effluent discharge heating of greenhouses. This is not a question of whether the public or private sector should invest, but rather how they can invest together for the greatest effect. Whenever it can maximise societal impact, public investments should be designed to leverage further private sector investment. Where government clearly sets out long-term aspirations in a certain area it can foster expectations of future growth, effectively “crowding-in” private sector investment (Deleidi et al., 2019). Effective means of collaboration and alignment between public and private investors are needed to achieve the UK's (and the world's) net-zero carbon and GHG targets.

Green innovation needs long-term, patient investment. Innovation is a highly uncertain process that inherently involves failure and has lead-times that exceed those normally considered by venture capital finance. Fostering investment from the private sector in such high-risk areas is therefore challenging, and around the world national investment banks have played an increasingly important role to support green innovation.

The UK is unusual compared to international developed economies in lacking significant sources of public innovation finance. Germany provides such finance through the KfW and Brazil through BNDES (Macfarlane and Mazzucato, 2018). Such an absence could be explained by participation in the European Investment Bank (EIB), however the UK is likely to lose access to this source of patient finance at the end of 2020. The Covid-19 pandemic and large quantities of financing for the private sector have demonstrated this gap in financing and the British Business Bank has had to rapidly scale its investment structures, and has moved into offering equity finance for the first time in the form of convertible loans.

One aspect of national investment banks that is particularly relevant to green innovation, is their ability to not simply seek out the fastest and greatest financial return, but rather to align with broader policy goals, such as the net-zero transition. This form of “directional” finance can involve investment portfolios with specific aims relevant to that objective, which, whilst delivering a financial return, additionally foster innovation and private-sector growth in areas desired by the government. The Scottish Government is expected to vest a new Scottish National Investment Bank with a “mission-oriented” mandate, including sustainability, in late 2020 (Mazzucato and Macfarlane, 2019).

A previous effort in this space, the UK Green Investment Bank (GIB), was privatised when it was sold to Macquarie in 2017. The GIB was financially successful and played an important part in the cost reductions in the offshore wind sector alongside government policies such as strike-price guarantees. The GIB demonstrated that a state investment vehicle could be a market-maker

in vital areas of green innovation, especially in the areas of commercialisation and deployment. The vital characteristic that the GIB exemplified which is needed now more than ever, was that it changed risk perceptions in the private sector and gave business the confidence to invest – this epitomises the “crowding-in” described above.

Specific recommendation 5.1

Government should establish a well-resourced National Green Investment Fund within the new National Infrastructure Bank to provide patient, long-term finance for green innovation

The newly formed UK National Infrastructure Bank (NIB) will bring new opportunities to finance sustainable infrastructure but there is a need for a bespoke fund within it to provide a more comprehensive and systemic approach to funding green innovation in the UK. Government should establish a new facility within the NIB to provide patient, long-term financing for green innovation and for sustainability initiatives. The National Green Investment Fund should be structured to be directional, funding only those projects that contribute to the UK’s sustainability commitments and policy agenda. The fund should be commercially successful providing a return on initial capitalisation. It should make investments to “crowd-in” rather than “crowd-out” private sector investment in the innovation process.

Institutional lead: BEIS, Treasury, NIB; Key partners: British Business Bank, Bank of England; Existing commitments and initiatives: establishment of the NIB, replacements for access to EIB post-Brexit, post-Covid green recovery initiatives. .

Specific recommendations 5.2

Government must prioritise, streamline and scale up public innovation investments which create public value

Government should systematically review all public R&D and innovation spending through existing financial instruments, considering their contribution to environmental sustainability and green transformation. Public investments in green innovation should be prioritised considering their short- and long-term societal and environmental benefits. Government should critically reflect which instruments are best suited to support challenge-driven innovation.

Institutional lead: BEIS, Treasury; Key partners: UKRI, Innovate UK; Existing commitments and initiatives: Existing R&D and innovation funding from UKRI; Upcoming UK APRA Upcoming review of the Green Book.

Specific recommendations 5.3

Government should rebalance public investments in green innovation from R&D to experimentation and commercialisation

Most green innovations that will drive transition to net zero in the coming decades already exist. The focus of government’s spending on innovation should, therefore, be rebalanced from R&D towards financing demonstration, commercialisation, market formation and wider deployment of green innovation. Government should focus on providing funds for green innovation where companies find it most challenging to access investments on an appropriate level. The funding should consider the maturity of supported innovation and the capabilities of firms and other innovation actors. Policy needs to actively support and cater for experimentation and demonstration of alternative innovation pathways and be open to social deliberation on how innovation may be scaled and embedded in economy, society and wider institutional and policy framework.

Institutional lead: BEIS and UKRI; Key partners: Finance sector, British Business Bank.

5.2.3 Change the rules of the game: progressive and agile regulation

Regulation is critical for directing innovation efforts of firms, most notably by enforcing binding norms and standards. There is strong evidence pointing to the key role of regulation for fostering green innovation as firms innovate to comply with changing regulatory frameworks. Getting regulation right is crucial to an effective green innovation policy.

Headline recommendation 6

Change the rules of the game

Government must align the regulatory framework with its own environmental targets. Regulations need to foster market redesign towards a shared direction of transformation by enforcing consistent binding targets, norms and standards across Britain while ensuring that the regulatory framework is agile and adaptable to the changing context and new evidence.

Regulation has a double-edged relationship with innovation. On the one hand, regulation can provide a spur to innovation. There is ample evidence pointing to existing and expected government regulations as key drivers for adoption of environmental innovation (Horbach et al. 2012; Bitencourt et al., 2020). On the other hand, established regulatory regimes can hamper innovative approaches and inhibit entry of innovative companies and experimentation, especially involving new disruptive technologies (see e.g. Lockwood et al, 2019; Hall et al., 2020).

The experiences of GIPC members confirm that regulation is a critical driver of wider diffusion and can become a catalyst for experimentation and demonstration of new radical green innovation. To achieve net zero, regulation will play a key role across different sectors. It will need to be revisited and redesigned to not only foster incremental change but also enable more transformative and systemic changes.

Tilting the playing field: making regulation fit for a net-zero target

A regulatory framework designed to face current and emerging environmental challenges cannot be neutral. Regulation is instrumental for introducing an overall direction of transformation by enforcing binding targets, norms and standards across Britain. It has to ensure that progressive businesses are not undercut by environmental laggards.

Regulations in place should consistently enforce and reward sustainable processes, products and services, and discourage and penalise unsustainable ones. Eco-design and Extended Producer Responsibility (EPR), for example, have a potential to become strong drivers of change. If designed to reward resource-efficient design and make producers fully responsible for whole life costs of products, EPR can directly influence business practices and create strong incentives to shift away from environmentally harmful product designs. Government can also exercise the right to ban environmentally harmful practices, products and materials, especially when alternative approaches are available.

Progressive and agile regulation

The journey to net zero involves considerable risks and uncertainty. New regulatory barriers are bound to emerge in the course of transition since the existing regulatory structures were developed without foreknowledge of technological developments to come. Government needs to be agile to respond to these changes by adjusting regulatory frameworks. Regulations and standards should be progressive in the sense that they follow and reward best practice and become increasingly stringent on a predictable timescale. This approach combines long-term vision and targets with short-term adjustments reflecting the speed and scale of technological, market and societal developments. New regulatory barriers are bound to emerge in the course of a major transition in our socio-technical systems since the existing regulatory structures were developed without foreknowledge of technological developments to come.

The UK Government is already committed to developing an agile regulatory approach that supports innovation and protects citizens and the environment, notably in the context of the fourth industrial revolution (HM Government, 2019a). This commitment should be reinforced and applied consistently across departments and agencies. The key issue is the need for government flexibility in the process of market redesign, which requires mechanisms for government-industry dialogue enabling government to hear from businesses what is working, what is not working, and what changes might be possible or necessary in future.

Specific recommendation 6.1

Government should mandate the Regulatory Horizons Council to report specifically on market redesign and regulatory reforms for green innovation

Government must ensure that the governance of regulations, including the processes of design, consultation, impact assessment and revision mechanisms of newly introduced and existing regulations, allows for revision and adjustments of targets, standards and regulatory incentives. The revisions should consider new evidence of technological, economic, environmental, social and political trends relevant for achievement of the goals. The newly created Regulatory Horizons Council should focus specifically on regulatory reforms and market redesign for green innovation and green recovery.

Institutional lead: Regulatory Horizons Council; Key partners: BEIS, DEFRA, Better Regulation Executive, BSI, UKRI, DEFRA, Business leaders; Existing commitments and initiatives: The Climate Change Act, The 2020 Environment Bill; The Magenta Book.

Innovative performance-oriented standards

One approach to making regulation more agile is shifting towards performance-based standards bound by stringent environmental targets. The focus on performance helps to avoid setting standards linked to existing technical and technological practices. In transport, for example, regulation based on a performance standard focuses on top speed, acceleration or braking rates rather than on the means used to achieve this (e.g. motor power). In construction, the focus could be on energy efficiency and environmental performance of materials in specific projects, rather than the use of specific materials or designs.

Specific recommendation 6.2

Government should introduce performance-oriented standards to foster green innovation

Government needs to review existing legislation in key sectors to ensure that existing standards and norms do not constitute a barrier to green innovation, and consider introducing performance-oriented standards into regulations targeting industry and business when they can induce green innovation that improves environmental performance.

Performance-oriented standards should be designed to be create synergy with other innovation policy instruments (e.g. innovation finance). They need to be designed to ensure that they do not lead to new social or environmental risks.

Institutional lead: BEIS, Better Regulation Executive; Key partners: BSI, UK Regulators Network (UKRN), Regulators Innovation Network (RIN); Existing commitments and initiatives: Regulatory sandboxes.

Regulatory innovation to foster transformative green innovation

Sometimes regulation may hamper experimentation and the introduction of innovative technologies, products and services as they may be considered harmful or risky. While regulatory frameworks should be stable and predictable, they should not become barriers to innovation that has potential and demonstrable benefits for society and environment.

One example of developing environments in which new regulatory frameworks are tested is known as a “regulatory sandbox”. A regulatory sandbox is a virtual or physical space where selected firms work with regulators to jointly explore, trial and test innovative products, services and business models without having to meet all the usual requirements for compliance. Sandboxes also offer a space to trial new standards in active collaboration with business, consumers and government.

UK has a unique experience and capacity in designing and running regulatory sandboxes (e.g. the Regulators’ Pioneer Fund and Regulators’ Innovation Network). The UK Government is a one of world leaders in regulatory innovation. The Financial Conduct Authority (FCA) ran the world’s first regulatory sandbox in 2016. In recent years, other UK regulators followed suit and introduced similar programmes, including Ofgem and the Civil Aviation Authority.

Specific recommendation 6.3

Government should use regulatory sandboxes for green innovation

Government should consider establishing “green innovation regulatory sandboxes” with a mission to meet the net-zero targets and co-design regulatory environments encouraging collaborations between regulators, business, research actors and social partners from across different sectors. This can build on the concept of the cross-sector sandbox recently developed by FCA (FCA, 2019). Green innovation sandboxes could be place-based and focus specifically on innovations tackling environmental challenges in the selected regions, industrial zones, cities or municipalities (e.g. “green experimentation zones”).

Institutional lead: BEIS, UKRI, Better Regulation Executive; Key partners: UK Regulators Network (UKRN), Regulators Innovation Network (RIN); Existing commitments and initiatives: Regulatory sandboxes; Cross-Sector Sandbox.

5.2.4 Nurture innovation partnerships: cross-sectoral collaboration and place-based experimentation

The success of innovation largely depends on cross-sectoral collaborations that benefit from geographically concentrated innovation ecosystems with networks of big and small innovation players (Cooke and Morgan, 1998; Cooke et al., 2004; Cooke, 2011). The evidence gathered in the sectoral chapter confirms that green innovation opportunities are place-based and emerge at the interface between sectors (e.g. energy and mobility). The challenge for the government is to ensure that all UK’s regions play to their strengths and build innovation capacities to drive transition to net zero across the nation.

Britain is home to world leading clusters and innovation powerhouses such as London, Cambridge and Oxford (Cornell University et al., 2020). At the same time, there are major disparities in R&D and innovation performance between UK’s regions. The regions of London, Cambridge and Oxford concentrate 46% of public and charitable R&D and 31% of business R&D (Forth and Jones, 2020). The UK’s regional disparities in R&D spending have contributed to imbalances

in economic performance; a recent report for Nesta estimates that many regions of the UK, including North England, the English Midlands, and South West of England, together with Wales and Northern Ireland, have missed out £4 billion of government R&D spending each year which could have leveraged a further £8 billion from the private sector (ibid.).

Headline recommendation 7

Government should nurture green innovation partnerships and regional innovation ecosystems to foster transition to net zero across Britain

Government must actively support cross-sectoral innovation collaborations to foster the low-carbon transition. It should balance its R&D and innovation investments to strengthen regional innovation ecosystems and foster transition to net zero across Britain.

New innovation collaborations and partnerships

Innovative collaborations are often not just about optimising existing operations but building new value chains cutting across sectors. Examples of such collaborative models include circular economy models such as industrial or urban symbiosis or new approaches to building design where buildings are redesigned as energy hubs.

For example, to drastically reduce emissions from buildings, innovation is needed in improving the energy efficiency of heating and cooking, but also in how buildings are designed or retrofitted to provide new functions, such as charging points for electric vehicles or spaces for urban agriculture.

Box 11

Example of cross-sectoral innovation collaborations: Offshore Wind Innovation Hub

The Offshore Wind innovation eXchange (OWiX) at Offshore Wind Innovation Hub

The mission of Offshore Wind Innovation Hub is to coordinate the entire innovation landscape of offshore wind in the UK. The Hub established the Offshore Wind innovation eXchange (OWiX). OWiX is an innovation platform focused on solving concrete offshore wind industry challenges by running competitions to connect solution providers in different sectors with offshore wind industrial businesses. Six companies are implementing demonstration projects with a technology manufacturer and a utility. OWiX is funded by Innovate UK and delivered by the Knowledge Transfer Network (KTN), with support from the Offshore Renewable Energy (ORE) Catapult.

The new collaborations between sectors are driven by a combination of new business opportunities, policies and societal challenges. They are increasingly enabled by rapid technological changes, notably by digitalisation. These trends challenge the traditional perceptions of sectoral boundaries and what constitutes the core business of a sector. Cross-sectoral collaborations create unique environments for experimenting, demonstrating and scaling up innovative technologies and business models. Their greatest promise is identifying synergies between major functional systems such as energy and the built environment, energy and mobility or food, water and energy.

“Major infrastructure investments can accelerate investment and innovation in cleaner technologies by reducing the risks faced by investors and innovators.”

Specific recommendation 7.1

Government must actively encourage and fund challenge-driven innovation collaborations that span sectors and make full use of the opportunities offered by digitalisation and artificial intelligence

Government should ensure that ongoing support for collaborative R&D and innovation is aligned with the need to build challenge-driven and mission-oriented innovation coalitions that encourage collaborations between sectors and across value chains. These collaborations should be open to organisations not engaged in R&D but with an active role in designing and implementing new business models and social innovation.

Institutional lead: BEIS; Key partners: UKRI, UK Innovate, Businesses; Existing commitments and initiatives: Catapults and the Catapults Network. The Knowledge Transfer Network

Regional innovation ecosystems and local niches for collaborative experimentation

The UK Government faces a major challenge to reduce regional economic disparities by rebalancing its R&D, innovation and infrastructure investment. The regional imbalances in R&D spending across Britain are considerable. A recent report for Nesta estimates that many regions of the UK, including North England, the English Midlands, and South West of England, together with Wales and Northern Ireland, have missed out £4 billion of government R&D spending each year which could have leveraged a further £8 billion from the private sector (Forth and Jones, 2020). The authors demonstrate that deliberate policy decisions have had a contribution to these imbalances by, for example, concentrating 71% of public investments in research infrastructure made between 2007-2014 in London and the East and South East of England (ibid.). The regional disparities in R&D spending have further deepened imbalances in regional economic performance in the UK.

Levelling up is one of the key priorities of government. We argue that green innovation for net zero transition should be part of this agenda. There is a need to reinvigorate and strengthen regional innovation systems to foster and scale up green innovation. Government should invest in regional innovation ecosystems to scale up innovations needed to accelerate transition to net zero across Britain's regions and cities.

Government should work with regional partnerships to develop regional green innovation strategies and invest in new capabilities needed for net zero and key specialisation areas which can contribute to tackling local challenges and achieving the net-zero target. All sectoral and cross-sectoral collaborations need to be localised and embedded in specific regional contexts.

Strengthening the regional dimension is crucial for both boosting the potential to develop new innovative solutions as well as to build capacities to be able to absorb and benefit from existing technologies more effectively.

Refocusing on the local and regional levels is fundamental for improving public engagement and ensuring public acceptance of government investments. Stakeholder engagement will be critical to exploring alternative innovation pathways and finding common ground for the most desirable, feasible and resilient innovation pathways for Britain.

Specific recommendation 7.2

Government should foster and nurture local and regional innovation ecosystems

Government needs to recognise the potential of regional innovation ecosystems for experimentation and demonstration of transformative green innovation. Government should invest in regional innovation ecosystems to demonstrate and scale up green innovations needed to accelerate transition to net zero across Britain. Government could become a facilitator and co-creator of local niches for experimentation and demonstration of transformative green innovation.

One measure could be to create “net-zero green business zones” with co-ordinated infrastructure investments and direct funding from the regional growth fund (e.g. similar to the Green Port of Hull). The zones would become spaces where specific solutions are co-created and trialled in collaboration with local partners and government. These zones could be linked with regulatory sandboxes and provide local environments for tests and trials.

Institutional lead: BEIS; Key partners: LEPs, City councils, Business leaders, Universities, Catapults; Existing commitments and on-going initiatives: Local Energy Hubs, Local Industrial Strategies, Industrial Clusters, Catapults, Regulatory sandboxes.

Green skills for transformation

Ensuring that innovation ecosystems are an enabling environment for green innovation requires investment in education and the development of skills needed to achieve net zero. This ranges from practical skills needed for the retrofitting of buildings to strategic capabilities to foster cross-sectoral linkages and broker new innovation partnerships (see Aldersgate Group and CUSP, 2020).

Skills development is a long-term task that requires a consistent approach. Government should avoid the mistakes of the ‘Green Deal’ which saw the market respond by installers investing in training, only to have the market pulled out from under them when the Green Deal was discontinued.

Specific recommendation 7.3

Government needs to level up regional capabilities and skills for green innovation

Government should conduct a review of absorptive capabilities and skills needed for green transformation across key sectors. The review should include assessment of key needs in terms of capabilities and skills development within companies considering varying needs in different sectors, sizes of companies and regions. Government should also identify new skills and jobs needed to foster more radical green innovation (e.g. linked to emerging technologies and business models).

Institutional lead: BEIS, Department for Education and Skills, Ministry of Housing, Communities & Local Government; Key partners: Business leaders, Local Enterprise Partnerships (LEPs), Universities and technical education institutions.

5.2.5 Lay the foundations for a greener economy: innovative infrastructure

Headline recommendation 8

Government should lay the foundations for a greener economy

Use government investments in infrastructure to enable and accelerate the transition to a greener and fairer economy. Ensure that all government's infrastructure investments consider a variety of alternative solutions and unlock opportunities for green innovation from businesses and citizens.

Infrastructure choices must enable innovation for net zero

Across the political spectrum, infrastructure investment is seen as essential to boost productivity, promote regional rebalancing, and enable the achievement of the UK's commitment to reach net-zero emissions in 2050. Infrastructure has a critical role in enabling but also locking in current and future green innovation processes.

Many new technologies that are essential for net zero require large infrastructure investments (e.g. electric mobility). Investments in new infrastructure can enable and accelerate the deployment of clean technologies. Such infrastructure investments can also accelerate innovation as they drive down the costs and improve the performance of such technologies. This is because investments in improving and up-scaling new technologies are typically hampered by uncertainty. Where infrastructure availability is a source of that uncertainty, strategic infrastructure decisions and investments by government that remove it can crowd-in private investment into those cleaner technologies.

Infrastructure choices shape the 'search space' for new solutions and ideas, by changing expectations and risk assessments of future market opportunities. To illustrate: smart grids catalyse investment in innovations for energy demand management; bike lanes catalyse innovation in cargo-bike last-mile delivery business models. Experience has shown that major infrastructure investments can accelerate investment and innovation in cleaner technologies by reducing the risks faced by investors and innovators.

Innovative approaches to infrastructure can reduce environmental impacts and save money

The construction and operation of major infrastructure sectors (water supply, wastewater treatment, communication, energy, transport and solid waste management) exert a direct and large influence on the natural environment, especially through demand for carbon-intensive materials (Hertwich et al., 2019). There is considerable scope for innovation in design, construction and operation to reduce the direct environmental burdens associated with infrastructure. Examples include:

- Use of cleaner, lighter and more durable materials and components (lower-temperature asphalt; 'eco'-cement; energy efficient IT and data equipment in networks, etc.);
- Design for remanufacturing (e.g. modular building components), and for recovery and recycling or reuse of key components (Iacovidou and Purnell, 2016).

- Use of cleaner processes and management during the construction & maintenance phases – including better care for existing infrastructure to prolong useful lifetimes
- Design to minimise impacts in use (noise, visual amenity, impacts on wildlife, etc.)
- Better management of end-of-life leading to higher recovery and recycling of materials (Cooper and Allwood, 2012).

One important strategy is to ensure that the UK avoids over-construction of infrastructure. This is important because unnecessary infrastructure imposes costs on consumers, and causes environmental impacts. Unnecessary infrastructure can also induce demand, as has been well documented for road transport (Hymel et al., 2010). Strategies include efficient use of infrastructure (McKinsey, 2013). The UPS experience, for example, has shown that smart charging technology can overcome power grid infrastructure constraints, reducing the need for costly grid investments (Ofgem, 2018).

Protecting and enhancing natural infrastructure solutions

Natural ecosystems provide a wide range of essential services. Exploiting synergies with ecosystem services can reduce the need for the construction of physical infrastructure if managed appropriately (Broadmeadow et al., 2018). Examples of nature-based solutions include collaborative approaches to river basin and coastal management preventing floods, agroforestry and conservation agriculture. Unfortunately, such opportunities received only scant attention in the National Infrastructure Assessment (NIC, 2019). There is a need to develop a systemic approach in public policy to designing and assessing the potential to address societal and environmental challenges by a greater variety of alternative infrastructural solutions, including nature-based solutions (Seddon et al., 2020).

Characteristics of an innovation-friendly infrastructure policy for net zero

Generating an innovation-friendly infrastructure policy is about more than competition in infrastructure delivery. An innovation-friendly infrastructure policy must also go beyond encouraging R&D and be designed to support real-world experimentation and demonstration, and help entrepreneurship and new business models. Infrastructure decision-making should also consider the potential for shifts to greater use of existing technologies, not focus mainly on emerging high-tech novelties.

The recent report on regulation of infrastructure from the National Infrastructure Commission highlighted the role of competition in driving innovation. Competition can enable innovation but experience has shown that efforts to foster competition in network industries have not always generated increases in innovation, and have sometimes resulted in substantial reductions in investments in innovation (Jamasb and Pollitt, 2008). Fostering an innovation-friendly infrastructure policy has to look beyond competitive bidding.

Specific recommendation 8.1

Government should make infrastructure planning and investment consistent with environmental objectives

All infrastructure choices and investments, including those set out in post-COVID-19 recovery plans, should be aligned with green innovation policy and environmental targets. Policy choices should promote sustainable economic activities, including clean transport, efficient homes and a circular economy, and avoid unnecessary construction.

Co-ordinated system planning should support more efficient use of existing infrastructure as well as better delivery and utilisation of new projects. This includes making sure that the regulatory regime avoids creating incentives to over-invest in infrastructure provision and thus inflate the Regulated Asset Base (NIC, 2019).

Institutional lead: Cabinet Office; Key partners: National Infrastructure Commission (NIC), UKRN.

Specific recommendation 8.2

Government should consider natural assets and green infrastructure a transformational opportunity

Nature-based solutions based on ecosystem services can provide effective and often cheaper alternatives to “grey infrastructure” while also restoring and protecting natural habitats, sequestering carbon and creating new jobs and greater societal wellbeing. Government should develop a systemic approach to assessing, designing and financing nature-based solutions considering their longer-term environmental and societal benefits.

Institutional lead: BEIS, DEFRA; Key partners: NIC, UKRN.

Specific recommendation 8.3

Government should harness the potential of digital and space infrastructure to accelerate green innovation

Government should look beyond traditional infrastructures when considering the role of infrastructure in transitioning to a green economy. The smart use of new infrastructures, such as digital and space infrastructures, can provide better access to data and remote control of elements of traditional infrastructure, allowing better monitoring of performance of traditional infrastructures as well as helping to manage complex processes and systems.

Smart applications of these new technologies can improve the effectiveness and efficiency of existing infrastructures and improve their quality and longevity as well as help design and construct new projects.

Institutional lead: BEIS; Key partners: NIC Existing commitments and ongoing initiatives: NIC’s work on “data for the public good” and the Construction Sector Deal.

5.2.6 Working together to foster green recovery: innovative government and governance

Government should be open to the possibility that the current institutional setting, coordination processes and organisations are not fit for fostering a transition to a sustainable economy. Indeed, the government’s own Industrial Strategy Council called for a refresh of the strategy to put the grand challenges at the fore and enable greater cross-departmental and cross-sectoral coordination (Industrial Strategy Council, 2020).

Headline recommendation 9

Working together to foster green recovery

Government needs to build new capabilities, institutions and governance mechanisms to strengthen its capacity to design and implement better policies and to become a catalyst and driver of transformative green innovation partnerships.

“**Government needs to invest in the ability to experiment, innovate and learn more effectively and flexibly within and across departments as well as with the private sector.**”

New capabilities and governance mechanisms

Government needs to invest in new capabilities, such as the ability to experiment, innovate and learn, which will allow it to work more effectively and flexibly within and across departments as well as with the private sector and other stakeholders (MOIIS, 2019; Kattel, 2018). Government should develop governance mechanisms to better coordinate and align instruments deployed by different departments and agencies, and approaches to monitoring and evaluation to track progress towards key sustainability objectives. One example of a strategic mechanism could be a green innovation policy roadmap with targets and milestones, dedicated policy portfolios and governance arrangements allowing stakeholders to continuously monitor, collectively reflect and adjust roadmaps, drawing lessons from experiments, evaluations and international comparisons (Miedzinski et al., 2019).

Policy integration requires new institutional arrangements across Whitehall which need to be designed to ensure overall coordination of government action while encouraging bottom-up experimentation, creativity and participation.³² These bodies should include representatives of business and other key stakeholders as active participants. The institutional arrangements need to build on lessons drawn from similar successful and unsuccessful institutional approaches in the past and draw on the expertise of all government departments and agencies. This may also foster new forms of organisations, such as the newly created UK version of the US Advanced Research Projects Agency (ARPA), as well as encompass new approaches to technology and regulatory demonstrators, experimentation, and innovation prizes and grants.

New ways of working with the private sector

Innovation policy aiming at transformative change needs to be built on a new social contract and positive vision co-created by politicians, business, civil society and scientists. This new social contract – or “New Deal” – should underpin commitments to achieving environmental goals. Developing closer collaboration with business is key to building mutual trust between the government and private sector and making the intent of government to reach ambitious environmental goals credible to business, big and small. Government needs to be open to new ways of collaborating with progressive businesses.

³² The UCL Commission on Mission-Oriented Innovation and Industrial Strategy (MOIIS) co-chaired by M. Mazzucato and D. Willetts developed policy recommendations, including “ways of working” across government, to deliver this challenge-oriented approach. See UCL MOIIS (2019).

“**Green transformation is a process requiring active engagement and collaboration across and between all governance levels.**”

This may include designing new mission-oriented public-private partnerships based on shared commitments, novel contractual arrangements allowing the risk of investments in green innovation to be shared, as well as new ways of working side by side on system-level transformative green innovations (e.g. building on regulatory sandbox approaches).

Multi-level governance: empowering regions and leading international STI collaboration

Green transformation is a process requiring active engagement and collaboration across and between all governance levels, ranging from local place-based partnerships to global science, technology and innovation (STI) cooperation.

On the one hand, there is a need to empower UK regions and cities so they can better exploit their innovation potential for the net-zero transition. On the other hand, government needs to support companies, researchers and civil society leading international efforts in tackling global environmental challenges, notably in developing countries such as through UKRI's Global Challenges Research Fund (GCRF). Government should assess which level of collaboration and engagement is likely to achieve most impact for the UK and globally, and actively engage in building international STI partnerships.

Specific recommendation 9.1

Government should establish a Green Innovation and Sustainability Transformation Council to lead and coordinate government's work on green transformation and recovery

Establish a Green Innovation and Sustainability Transformation (GIST) Council coordinating Sector Deals and missions. The Council would be chaired by the Prime Minister, and bring together ministers and high-level representatives from business and academia. GIST would be responsible for cross-departmental coordination and promote the whole-government approach. It would be supported by thematic and mission-oriented cross-departmental working groups. The new body should have a clear mandate and be based on commitments shared across government and – when relevant - with business and social partners (see recommendations 1 and 2). The design of the council should consider lessons from previous experiences, such as the Green Economy Council.

Institutional lead: Prime Minister's Office; Key partners: Cabinet Office, Government departments, business and civil society.

Specific recommendation 9.2

Government should produce a Green Innovation Policy Roadmap to coordinate and build synergies between government initiatives, including missions and Sector Deals

There is a need for an overall strategic framework with concrete milestones and governance mechanisms to monitor progress towards net zero and other environmental goals, and adjust government policies in the face of new developments and evidence. The Roadmap could offer a strategic framework to align and coordinate government instruments and initiatives. It should be designed together with business partners leading Sector Deals and missions, and create a policy learning environment for a continuous improvement of policy.

Institutional lead: Cabinet Office; Key partners: Government departments, Business.

Specific recommendation 9.3

Government should work closer with regional and local actors to strengthen regional governance for green innovation

Reflect on the role of the regions, cities and local communities in fostering green innovation. Engage local authorities, businesses, civil society and research organisations to better understand the specific regional and local risks and opportunities of green transformation and to deliberate governance structures fit to better harness the potential of local innovation eco-systems. Pilot place-based green innovation experimentation and demonstration projects to contribute to levelling up and building the resilience of regions.

Institutional lead: Cabinet Office; Key partners: City councils, LEPS, BEIS, Ministry for Housing, Communities and Local Government (MHCLG), LEP Network; Existing commitments and ongoing initiatives: Smart Specialisation Strategies.

Specific recommendation 9.4

Government should provide leadership for global innovation cooperation addressing environmental challenges

Identify where the UK can lead innovation cooperation for net zero, and engage more actively in international collaborations on science, technology and innovation (STI) addressing the climate crisis. Consider establishing a new international innovation collaboration addressing one of the global environmental challenges. This could be announced at COP in Glasgow.

Institutional lead: Cabinet Office; Key partners: FCO, DFID; Existing commitments and initiatives: GCRF; IPCC, The 2030 Agenda, Addis Ababa Action Agenda.

Specific recommendation 9.5

Government should strengthen monitoring, evaluation and policy learning on green transformation across government

Government, in collaboration with the new Office for Environmental Protection, should establish robust metrics and strengthen monitoring and evaluation approaches to measuring and interpreting the outcomes and impacts of government regulations and policies supporting green innovation, including the evaluation of mission-oriented approaches. Overseeing the government's progress on its green innovation commitments should be part of the work programme of the new Office for Environmental Protection.

Government should strengthen its capacity to conduct evaluation using a variety of quantitative and qualitative methods and to reflect on complexity and uncertainty in the evaluation of the effects of policy interventions. It should build institutional capacity for policy evaluation and learning in key government departments and agencies, notably within the new Office for Environmental Protection. The guidance on measuring and evaluating green innovation should be included in the Magenta Book.

Institutional leads: Cabinet Office, the new Office for Environmental Protection; Key partners: Government departments, UKRI, science, business and civil society; Existing commitments and ongoing initiatives: The Magenta Book.

6.

Business leadership for transformative green innovation

“The transition to a greener economy through innovation will require major shifts in business practices and a new settlement between the public and private sectors.”

In the Prime Minister's speech on the economic recovery from Covid-19 in May 2020 he set out his vision directly citing Franklin D Roosevelt's 'New Deal'. This Commission too believes that what is needed is a new deal. It is only through constructive collaboration between government, business, the third sector, and citizens that we can tackle the technological and societal challenges presented by climate change and wider environmental issues. That is why this Commission has taken an innovative approach – we are not simply making recommendations to government; we are making concrete proposals of what business can put on the table too.

As we have shown throughout this report, businesses in Britain are already engaging in world-changing green innovation, both within and between economic sectors. In the right circumstances, businesses are prepared to do a lot more and to go further in driving green innovation and decarbonisation.

Climate change and other environmental crises present a systemic risk and uncertainty to many sectors. To face this uncertainty and better manage emerging risks, business is calling for a more coherent policy and regulatory framework that enables and rewards green innovation. This framework needs to be built on a new constructive partnership between government, business and civil society working productively on new regulation, trade deals and finance to foster green transition towards a greener and fairer economy and prevent further damage to the environment. Business coalitions such as We Mean Business and UN Global Compact already bring together companies willing to work themselves and with government towards decarbonisation. But this must go beyond simply setting an enabling environment, to a new constructive partnership to effect reductions in carbon emissions and prevent damage to the environment.

Private Sector Stepping Up its Game

The transition to a greener economy through innovation will require major shifts in business practices and a new settlement between the public and private sectors. As a Commission largely made up of representatives from the private sector, this report stresses that business must also step up its game.

The experience of this Commission is that it is unsurprisingly challenging for Directors with responsibilities for sustainability to sufficiently prioritise green innovation within companies. This reflects the many other calls on available corporate investment, the challenge of hitting hurdle rates for proof of concept proposals, the difficulties of accounting for full life cycle initiatives, lack of clear consumer demand, the vagaries of public policy and the persistent challenge of considering long term urgent issues in the context of a Board agenda of urgent short-term ones. Business leaders need help to get green innovation “over the line”. Solving this problem will require movement in a whole range of areas including clear direction and coherent policy from government, shifts in corporate culture, sectoral leadership, and top-down and bottom-up targets.

The Covid-19 crisis has presented new challenges to businesses but there are now few who believe that business-as-usual is an option. Governments around the world have stepped in to intervene in economies and markets in unprecedented ways. Whilst the Covid-19 pandemic has stressed the model of “stakeholder capitalism” in new ways, it has also prompted a renewed focus on resilience in the economy.

This chapter looks to make recommendations to businesses of all sizes – large, medium and small. With businesses responsible for a sizeable proportion of UK greenhouse gas emissions, companies of every size will have to adapt and change their practices if we are to hit the government targets. There are zero- or low-cost changes all companies can make, and even the smallest company can improve its energy efficiency and engage with its suppliers and customers through its supply chain or with its trade association. Net zero will also require

more transformative, often disruptive, innovation. Small companies can be powerhouses of creativity and innovative ideas, yet their ability to commercialise and scale up their projects is often limited. That is why this report places a strong emphasis on innovation collaboration bringing together big and small players enabled by government policy.

The public focus on climate change as a major political issue looks set only to increase. A younger generation of activists with passionate views on the need for a greener economy are the consumers and employees of tomorrow. Businesses should recognise that consumers are thinking about the environment in new ways and with greater engagement, and the brightest young people want to work for companies that are seeking to reduce their environmental footprint. Much of the private sector recognises that green transformation not only opens up new economic opportunities, but that it is also a moral issue of business responsibility for the wellbeing of, and a safer future for, generations to come. There is no systemic approach to climate change that ignores the private sector.

Here we propose eight actions, synthesised from the business experience of Commission members, that business can take to foster transformative green innovation.

Board-level responsibility and corporate culture

It is vital that transformation towards a sustainable economy and society becomes a board-level issue that has prominence on the company agenda in a way that profit & loss and health & safety are having today. Sustainability should be a core consideration of corporate audit and risk committees. Adaptation and resilience to climate change must increasingly become a board-level issue, especially in light of the economic consequences of the Covid-19 pandemic.

The turn towards sustainability will require a culture shift, but businesses have made these shifts before, for example the increased prominence of health and safety (H&S). Today, every board in the country will look at health and safety figures, but few will know their carbon emissions; this must change. We also recognise that the prominence of H&S as a board-level issue was driven by powerful legislation with financial and criminal sanctions for those that did not comply and intermediation between government, business, health experts, and trade unions.

Business recommendation 1.1

We recommend that every FTSE 350 company should report on sustainability in their Annual Reports and Accounts, with a nominated Director responsible for sustainability.

Business recommendation 1.2

We recommend that the Financial Reporting Council add to the Corporate Governance Code a requirement for a nominated sustainability Director.

Net-zero commitments

Many individual companies and sectors have made their own net-zero carbon commitments – for example in the UK the water sector has committed to net zero by 2030 and 177 companies have signed the ‘Business Ambition for 1.5°C’ including a net-zero-by-2050 commitment.³³ These commitments should be encouraged, and are likely to be so by increased consumer awareness of these issues over coming years. This Commission welcomes this shift but also cautions that these commitments themselves will not achieve what we need – they must be backed by action plans grounded in science-based targets. It is not enough simply to say it will happen, to make it so.

Business recommendation 2.1

We recommend that every FTSE 350 company should have produced a commitment and a plan by 2023 of how it will contribute to net zero.

This should set out what each company’s contribution is to the transition to net zero in line with science-based targets. This should make a clear link to the company’s operations and have board-level oversight. Action plans to be relevant should be feasible and include early action including necessary collaborations with other companies and the public sector. Plans should be linked with other sustainability challenges.

Business recommendation 2.2

We recommend that sustainability plans be part of an initiative promoted by a new national business leadership initiative based on the success of the Hampton Alexander initiative on Women on Boards.

This body could grant a national prize every year – a Net-Zero Oscar – for the best company net-zero plan.

Monitoring and measuring progress towards net zero

One factor that effectively drives performance and gains the attention of corporate boards is when organisations can be clearly compared to each other. This is the case in financial performance and financial metrics reporting but comparative sustainability metrics do not fully exist. The United Nations Global Compact collates the largest database of corporate reporting, and various initiatives such as the Global Reporting Initiative (GRI) framework and those of the Sustainability Accounting Standards Board do exist. However, awareness and implementation of these metrics is patchy. Such metrics also need to be transparent.

Business recommendation 3.1

We recommend that business should collaborate within and across sectors and with government to agree on a set of indicators to measure progress on the pathway to agreed targets and milestones.

As addressed in recommendation 1, this should be reflected in the Financial Reporting Council review of the Corporate Governance Code, and in financial reporting standards of the British Standards Institute.

³³ See <https://www.unglobalcompact.org/take-action/events/climate-action-summit-2019/business-ambition>

Business recommendation 3.2

We recommend that government should move to make this form of reporting mandatory and transparent.

Co-creation and compliance with regulation

Regulation can drive business innovation and create new opportunities, whilst creating competitive pressure on inefficient businesses and those unwilling to adapt. GIPC recognises that we are extremely unlikely to achieve net zero without new regulations, and welcomes a new dialogue with government on how these can be best designed and implemented. In the UK, the announcement that internal combustion engines are to be banned from 2035 has created new market opportunities and accelerated innovation that was already occurring. The most effective regulation is where government picks up what the best companies are already investing in and accelerates it.

Business recommendation 4

We recommend that businesses and their lobbyists engage constructively with new environmental standards and regulations in the post-Brexit environment.

Sectoral leadership for transformative innovation

Sectoral leadership will be essential for the transition to zero carbon and a greener economy. All sectors encompass leaders and laggards, but collectively they can also improve their performance. In the UK, collective and strong sectoral leadership has led to the transformation of “old” manufacturing sectors (such as automotive) or the waste sector into higher-value-add industries.

Business recommendation 5.1

We recommend that sectors should be able to articulate what their contribution to net zero will be, and how they will achieve it. Sectors should set out the major steps that they will take together to drive green innovation.

There are opportunities here to link this with the government's Industrial Strategy and its development of ‘sector deals’.

Business recommendation 5.2

We recommend that as BEIS engages with sectors and trade associations in the process of developing a sector deal, it should be mandatory that this addresses net zero and related issues, and companies should not expect to be able to receive government support without net-zero plans in place.

Furthermore, in more fragmented or complex sectors that lack strong sectoral leadership there must be particular action to develop this and to prioritise net-zero planning.

New forms of innovation collaboration

New forms of leadership will require new ways of collaborating and working together within and across economic sectors. All businesses exist in a competitive environment, but achieving net zero and other environmental targets or “missions” might require sharing of best practice, data, and approaches, within sectors, between leaders and laggards. Again, the example of the shifts seen around health and safety culture are illustrative here.

In the past organisations like the Green Investment Bank had a function of being able to talk to both industrial sectors and the Treasury about what was nearly commercially viable and what small changes to regulations, levies, or support (e.g. the removal of VAT on the refurbishment of existing building stock) could enable it. This function served as a pre-competitive space where sectors could make asks of government that could trigger something massively productive.

Business recommendation 6

We recommend that trade associations and sectoral leadership (see recommendation 4) should develop plans to establish a collaboration platform relevant to the nature of their sector for sharing best practice towards net zero and environmental targets.

This does raise concerns around competitiveness, and businesses should work pro-actively and constructively with government to establish ways of working that do not breach Competition and Market Authority regulations.

Experimentation of transformative system innovation

Businesses have an opportunity to build multi-stakeholder, cross-sectoral partnerships to co-design and trial transformative and potentially disruptive innovations. Experimentation should be used to test and demonstrate novel business models, institutional arrangements and new technologies which create value for society and have a sound business case. The transport sector, for example, has good examples of such partnerships with bike-sharing schemes and shared charging infrastructures. UPS, one of the businesses represented on this Commission, has made breakthroughs in electrifying its vehicle fleet through cross-sectoral innovation with electricity networks and providers.

Businesses have a key role in driving these transformative system innovations. Given their long lead-times and high uncertainty, the investment risk should be shared with government.

Business recommendation 7

We recommend that businesses should raise funding and develop plans to establish pilot initiatives by 2022, and in return it is fair for them to expect that government will make available match funding.

Such match-funding could be made available from an existing InnovateUK Industrial Strategy Challenge Fund (ISCF).

Financial sector

Businesses interact closely with the financial sector, which must also adapt and change its practices to enable green innovation and decarbonisation.

Business recommendation 8

We recommend the finance sector should lead by example by providing comprehensive climate risk disclosures in line with the Taskforce on Climate-related Financial Disclosures (TCFD) recommendations and show support for the UK Government by fast-tracking the adoption of the TCFD recommendations ahead of them being mandatory.

The finance sector should also strengthen its leadership by proactively engaging clients on sustainability considerations and aligning pay rewards with good climate and environmental performance.

References

Aldersgate Group and CUSP. (2020). Policy Briefing. Upskilling the UK workforce for the 21st century. October 2020.

Altenburg, T. and Pegels A. (2012). 'Sustainability-oriented innovation systems – managing the green transformation', *Innovation and Development*, 2 (1), 5-22.

Arup. A new era for sustainability: could digital technology align humanity and nature? <https://www.arup.com/perspectives/a-new-era-for-sustainability-could-digital-technology-align-humanity-and-nature> Retrieved: 15/09/2020

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy* 37, 407-429.

Bitencourt, C. C., de Oliveira Santini, F., Zanandrea, G., Froehlich, C., & Ladeira, W. J. (2020). Empirical generalizations in eco-innovation: A meta-analytic approach. *Journal of Cleaner Production*, 245, 118721. doi:10.1016/j.jclepro.2019.118721

BPMIE and i24C (2016). Driving Transformational Change in the Construction Value Chain. Available at <http://bpie.eu/wp-content/uploads/2016/01/DrivingTransformationalChangeCVC2016.pdf>

Broadmeadow S. Huw T., Nisbet T, Valatin G. (2018). Valuing flood regulation services of existing forest cover to inform natural capital accounts. *Forest Research*. Available at <https://www.forestresearch.gov.uk/research/valuing-flood-regulation-services-existing-forest-cover-inform-natural-capital-accounts/>

Committee on Climate Change (CCC) (2018). Reducing UK Emissions: 2018 Progress Report to Parliament. Committee on Climate Change.

Committee on Climate Change (CCC) (2019). Reducing UK Emissions. 2019 Progress Report to Parliament. July 2019

Connors, C., Cohen, M., Canavan, S., Day M., and Sheppard, C. (2020). Consumers and the Food System Under Covid-19. A Bright Harbour Collective Report for the Food Standards Agency.

Cooke, P. and Morgan, K. (1998). *The Associational Economy: Firms, Regions and Innovation*. Oxford University Press, Oxford.

Cooke, P., Heidenreich, M. and Braczyk, H.-J. (2004). *Regional innovation systems: the role of governances in a globalized world*. Routledge, London.

Cooke, P. (2011). Transition regions: Regional and national eco-innovation systems and strategies, *Progress in Planning*. 76(3), 105-146. doi:10.1016/j.progress.2011.08.002

Cooper and Allwood (2012). Reusing Steel and Aluminum Components at End of Product Life. *Environ. Sci. Technol.* 2012, 46:18, 10334-10340.

Cornell University, INSEAD, and WIPO (2019). *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation*. Cornell University, INSEAD, and the World Intellectual Property Organization, 2019.

Cornell University, INSEAD, and WIPO (2020). *The Global Innovation Index 2020: Who Will Finance Innovation?* Cornell University, INSEAD, and the World Intellectual Property Organization, 2020.

- Deleidi, M., De Lipsis, V., Mazzucato, M., Ryan-Collins, J. and Agnolucci, P. (2019). The macroeconomic impact of government innovation policies: A quantitative assessment. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2019-06). Available at: <https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-06>
- Edie (2019). How digital technology can be a force for good in sustainability. Available at: <https://www.edie.net/news/8/How-digital-technology-can-be-a-force-for-good-in-sustainability/>
- Financial Conduct Authority (2019). Call for Input: Cross-Sector Sandbox. May 2019.
- Font Vivanco, D., Kemp R., E. van der Voet (2016). 'How to deal with the rebound effect? A policy-oriented approach', *Energy Policy*, 94 114-25.
- Forth, T. and Jones R.A.L (2020). The Missing £4 Billion: Making R&D work for the whole UK. Nesta. Available at: <https://www.nesta.org.uk/report/the-missing-4-billion>.
- Freeman, Chris (1995). 'The 'National System of Innovation' in historical perspective', *Camb. J. Econ.*, 19
- Fussler, C. and James P. (1996). *Driving eco-innovation: a breakthrough discipline for innovation and sustainability*, Pitman Pub, London and Washington, DC.
- House of Commons Library. (2009). Future of the Water Industry in England and Wales, Debate Pack. Available at: <https://commonslibrary.parliament.uk/research-briefings/cdp-2019-0008/>
- Geels, F. W. (2005). Technological transitions and system innovations: a co-evolutionary and socio-technical analysis. Cheltenham, Edward Elgar.
- Green Construction Board. (2013). Low Carbon Routemap for the UK Built Environment.
- Hall, S., Mazur, C., Hardy, J., Workman, M., & Powell, M. (2020). Prioritising business model innovation: What needs to change in the United Kingdom energy system to grow low-carbon entrepreneurship. *Energy Research & Social Science*, 60, 101317. doi:10.1016/j.erss.2019.101317
- Hekkert, M.P., et al. (2007). 'Functions of innovation systems: A new approach for analysing technological change', *Technological Forecasting and Social Change*, 74 (4), 413-32.
- Hertwich, E. G., Ali, S., Ciacci, L., Fishman, T., Heeren, N., Masanet, E., Wolfram, P. (2019). Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics, A review. *Environmental Research Letters*, 14(4)
- HM Government (2010). Low-carbon Construction. Innovation and Growth Team. Final Report.
- HM Government (2017a). Made Smarter Review. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/655570/20171027_MadeSmarter_FINAL_DIGITAL.pdf Retrieved: 15/09/2020
- HM Government (2017b). The Clean Growth Strategy. Leading the way to a low-carbon future. October 2017.
- HM Government (2019a). Industrial Strategy. Construction Sector Deal.
- HM Government (2019b). National Planning Policy Framework. Ministry of Housing, Communities and Local Government.
- HM Government (2017) Industrial Strategy. Building a Britain fit for the future.
- HM Government. (2020). Decarbonising Transport: setting the challenge. Department for Transport.
- Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact. The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, 78, 112-122.
- Hymel, K. M., Small, K. A., & Dender, K. V. (2010). Induced demand and rebound effects in road transport. *Transportation Research Part B: Methodological*, 44(10), 1220-1241.
- Iacovidou and Purnell (2016). Mining the physical infrastructure: Opportunities, barriers and interventions in promoting structural components reuse. *Science of the Total Environment* 557: 791-807.
- Industrial Strategy Council. (2020). Annual Report 2020. Available at: <https://industrialstrategycouncil.org/industrial-strategy-council-annual-report-2020>
- Jamasb, T. and Pollitt, M. (2008). Liberalisation and R&D in network industries: The case of the electricity industry, *Research Policy*, Elsevier, vol. 37(6-7), pages 995-1008, July.
- Kattel, R., Mazzucato, M. (2018). Mission-oriented innovation policy and dynamic capabilities in the public sector. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2018-5). <http://www.ucl.ac.uk/bartlett/public-purpose/wp2018-05>
- Kemp, R. (2011). Ten themes for eco-innovation policies in Europe, *SAPIENS*, 4(2).
- Kemp, R. and Pontoglio S. (2011). 'The innovation effects of environmental policy instruments. A typical case of the blind men and the elephant', *Ecological Economics*, 72 28-36.
- Kemp, R., Loorbach, D. and Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution for sustainable development, *The International Journal of Sustainable Development and World Ecology*, 14 (1), 78–91.
- Kemp, R., Arundel, A., Rammer, C., Miedzinski, M., Tapia, C., Barbieri, N., Türkeli, S., Bassi, A.M., Mazzanti, M., Chapman, D., Diaz López, F., McDowall, W. (2019). Maastricht Manual on Measuring Eco-Innovation for a Green Economy. Innovation for sustainable development network. Maastricht, The Netherlands
- KPMG, Affinity Water, New Business Models in the Water Sector/ Available at <https://stakeholder.affinitywater.co.uk/docs/KPMG%20-Water-sector-business-models.pdf>
- Labour Party. (2018). Clear Water - Labour's Vision for A Modern And Transparent Publicly-Owned Water System.
- Lang, T. (2020a). Feeding Britain: Our Food Problems and How to Fix them. London: Pelican.
- Lang, T. (2020b) Coronavirus: rationing based on health, equity and decency now needed — food system expert. The Conversation (23 March 2020). Available at <https://theconversation.com/coronavirus-rationing-based-on-health-equity-and-decency-now-needed-food-system-expert-133805>
- Lockwood, M., Mitchell, C., & Hoggett, R. (2019). Unpacking 'regime resistance' in low-carbon transitions: The case of the British Capacity Market. *Energy Research & Social Science*, 58, 101278. doi:10.1016/j.erss.2019.101278
- Lundvall, Bengt-Åke (1985). 'Product Innovation and User-Producer Interaction', Aalborg: Aalborg Universitetsforlag

Macfarlane, L. and Mazzucato, M. (2018). State investment banks and patient finance: An international comparison. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2018-01). Available at: <https://www.ucl.ac.uk/bartlett/public-purpose/wp2018-01>

Malerba, F. (ed) (2004). Sectoral systems of innovation. Cambridge University Press, Cambridge, MA.

Mazzucato, M. (2013). The Entrepreneurial State. Anthem Press

Mazzucato, M. (2017). Mission-oriented Innovation Policy: Challenges and Opportunities, UCL Institute for Innovation and Public Purpose (IIPP) Working Paper Series, (IIPP 2017-01). Available at: <https://www.ucl.ac.uk/bartlett/publicpurpose/sites/public-purpose/files/moip-challenges-and-opportunities-working-paper-2017-1.pdf>

Mazzucato M. (2018). Mission-Oriented Research & Innovation in the European Union. A problem-solving approach to fuel innovation-led growth. European Commission. Directorate-General for Research and Innovation. Brussels.

Mazzucato, M. and Ryan-Collins, J. (2019). Putting value creation back into 'public value': From market fixing to market shaping. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2019-05). Available at: <https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-05>

Mazzucato, M. and Macfarlane, L. (2019). A mission-oriented framework for the Scottish National Investment Bank. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2019-02). Available at: <https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-02>

McKinsey Global Institute (2013). Infrastructure Productivity: how to save \$1 trillion a year. January 2013.

McKinsey & Company (2020). Charging electric-vehicle fleets: How to seize the emerging opportunity. March 2020.

Miedzinski, M. (2016). System Climate Innovation for a Transformative Impact, *Climate Innovation Insights*, Series 1.3. Accelerating the Evolution of Climate Innovation Clusters, Climate-KIC.

Miedzinski, M., McDowall W., Bleischwitz R. (2017). Eco-innovation and resource nexus challenges: Ambitions and evidence, in R. Bleischwitz, H. Hoff, C. Spataru, E. van der Voet, S.D. Van Deveer (2017) Routledge Handbook of the Resource Nexus, Routledge.

Miedzinski, M., Mazzucato, M. and Ekins, P. (2019). A framework for mission-oriented innovation policy roadmapping for the SDGs: The case of plastic-free oceans. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2019-03). Available at: <https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-03>

Moran, D., Cossar, F., Merkle, M. et al. (2020). UK food system resilience tested by COVID-19. *Nat Food* 1, 242. <https://doi.org/10.1038/s43016-020-0082-1>

OECD (2015). System innovation: Synthesis report, OECD Publishing, Paris.

OECD (2017). General government procurement spending as a percentage of GDP and total government expenditures, 2007, 2009 and 2015 in Public Procurement, OECD Publishing, Paris, Available at: https://doi.org/10.1787/gov_glance-2017-graph119-en

Ofgem (2018). Implications of the transition to electric vehicles. Future Insights Series paper 5. Available at: <https://www.ofgem.gov.uk/publications-and-updates/ofgem-s-future-insights-paper-5-implications-transition-electric-vehicles>

Ofwat (2015). Delivering Sustainable Water Strategy. Available at https://www.ofwat.gov.uk/wp-content/uploads/2015/10/rpt_fwd_20100303ofwatstrategy.pdf

Parkhurst, G., Kemp, R., Dijk, M., Sherwin, H. (2012). Intermodal personal mobility: A niche caught between two regimes, in Geels, F.W., Kemp, R., Dudley, G., Lyons, G. (Eds.), (2012). *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport*. Routledge, New York.

Policy Connect (2018). Is Staying Online Costing The Earth? Available at https://www.policyconnect.org.uk/appccg/sites/site_appccg/files/report/572/fieldreportdownload/isstayingonlinecostingtheearth.pdf

PwC and Yorkshire Water (2016). The water and wastewater sectors, The long view. Available at: <https://www.yorkshirewater.com/media/1827/the-water-and-wastewater-sectors-the-long-view.pdf>

Reeve P. (2019). A zero carbon UK by 2050: What it means for buildings, Trends, on-line 12 June 2019 (retrieved 2 July). Available at: <https://www.globalconstructionreview.com/trends/zero-carbon-uk-2050-what-it-means-buildings/>

Reid A. and Miedzinski M. (2008). Eco-Innovation. Final report for Sectoral Innovation Watch in Europe (SYSTEMIC). Europe Innova. Technopolis Group.

Rennings, K (2000). 'Redefining innovation--eco-innovation research and the contribution from ecological economics', *Ecological economics*, 32 (2), 319-32.

Rogge, K. and Reichardt K. (2016). 'Policy mixes for sustainability transitions: An extended concept and framework for analysis', *Research Policy*, 45 (8), 1620-35.

Rydge, J., Martin R. & Anna Valero. (2018). Sustainable growth in the UK: Seizing opportunities from technological change and the transition to a low-carbon economy. Special Report for the LSE Growth Commission. The Centre for Climate Change Economics and Policy (CCCEP). The Centre for Economic Performance. The Grantham Research Institute on Climate Change and the Environment.

Seddon N., Chausson A., Berry P., Girardin C.A.J., Smith A. and Turner B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Phil. Trans. R. Soc.* B37520190120

Smith, K. (2010). 'Innovation as a Systemic Phenomenon: Rethinking the Role of Policy', *Enterprise and Innovation Management Studies*, 1 73-102.

Steward, F. (2008). Breaking the boundaries: Transformative innovation for the global good. NESTA.

Sustainable Food Trust. (2017). The Hidden Cost of UK Food. Sustainable Food Trust. Available at: <http://sustainablefoodtrust.org/wp-content/uploads/2013/04/HCOF-Report-online-version.pdf>

The Guardian (2019). How to use technology to make our planet more sustainable, not less. Available at: <https://www.theguardian.com/sustainable-business/technological-innovation-sustainability-energy-green-investment>

UCL Commission on Mission-Oriented Innovation and Industrial Strategy (MOIIS) (2019). A Mission Oriented UK Industrial Strategy. UCL Institute for Innovation and Public Purpose, Policy Report, (IIPP WP 2019-04). Available at: <https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-04>

UK GBC (2014). Building Zero Carbon – the case for action.

UK GBC (2019). Net Zero Carbon Buildings: A framework definition.

UK Parliament (2018). Taxation of Road Fuels. Available at: <https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN00824>

United Nations (2015). Transforming our world: The 2030 agenda for sustainable development. A/RES/70/1.

Unsworth, S., Valero, A., Stern, N. (2020). Delivering strong and sustainable growth in the UK: A special decade for innovation and investment. Special Report for the LSE Growth Commission. The Centre for Climate Change Economics and Policy (CCCEP). The Centre for Economic Performance. The Grantham Research Institute on Climate Change and the Environment.

Voulvoulis, N. (2015). The circular revolution. Imperial College London/Veolia. Available at:

https://www.veolia.co.uk/sites/g/files/dvc1681/files/document/2015/07/LIVING_CIRCULAR_BROCHURE.pdf

Weber, K. M. and Rohrer H. (2012). Legitimizing research, technology and innovation policies for transformative change. Research Policy. 41 (6) 1037-47.

Annex I. GIPC Sector Roundtables

Roundtable on Green Innovation in the Resources and Waste Sector – 24 January 2020

Attendees:

Richard Kirkman, Veolia, GIPC Commissioner

Jane Bevis, OPRL

Paul Davidson, UKRI

Maya De Souza, DEFRA

Colin Church, The Institute of Materials, Minerals and Mining

Gev Eduljee, Innovate UK

Simon Ellin, The Recycling Association/IWPP Ltd/UKSSA

Jacob Hayler, Environmental Services Association

Stuart Hayward-Higham, Suez

Peter Maddox, WRAP

Vicky Midgley, Veolia

Libby Peake, Green Alliance

Tilly Pielichaty, Veolia

Deborah Sacks, Department for International Trade

Beverley Simonson, LWARB

Barry Turner, BPF

Kevin Vyse, RAP UK

Caterina Brandmayr, Green Alliance

Paul Ekins, UCL Institute for Sustainable Resources

George Dibb, UCL Public Policy and Institute for Innovation and Public Purpose

Will McDowall, UCL Institute for Sustainable Resources

Michal Miedzinski, UCL Institute for Sustainable Resources

Roundtable on Green Innovation in the Construction Sector – 13 February 2020

Attendees:

Ian Gardner, Arup, GIPC Commissioner
Mark Holmes, Mace
Mary Anne Roff, Clyde & Co
Julie Wood, Arup
Paul McCracken, BAM
Tim Chapman, Arup
Andrew Wolstenholme OBE
Helen Logan, Allies and Morrison
Alan Raymant, CGN UK
Tom Barton, GIRI
Fergus Harradence, BEIS
Victoria Borwick, former MP
Paul Ekins, UCL Institute for Sustainable Resources
George Dibb, UCL Public Policy and Institute for Innovation and Public Purpose
Michal Miedzinski, UCL Institute for Sustainable Resources
Caterina Brandtmayer, Green Alliance

Roundtable on Green Innovation in the Road Transport Sector – 25 March 2020

Registered attendees:

Peter Harris, UPS, GIPC Commissioner
Daniel Lambert, Air Liquide
David Hurren, Air Liquide
Dickon Posnett, Argent Energy
Averil Horton, Brunel university
Catherine Bowen, BVLRA
James Sinclair, Cleancar.io
Dominic Phinn, ClientEarth
Philip Fjeld, CNG Fuels
Shamala Evans, Coventry city council
Rob Evans, DfT
Bob Moran, DfT
Olly Craughan, DPD
Celene Cluzel, Element Energy
Thom Koller, Energy Networks Association
Ian Featherstone, Energy Saving Trust
Michael Ayres, Flexible power systems
Becki Kite, Freight Transport Association
Natalie Chapman, Freight Transport Association
Rob Wood, Gas Rec
Caterina Brandmayr, Green Alliance
William Tebbit, Green Biofuels Ltd
Callum Jones, Greenergy
Chris Smith, G-volution
Philip Greening, Heriot Watt
Greg Harris, Horiba-Mira
Justin Laney, John Lewis Partnership
Helen Masterson, London Borough of Newham
Brian Robinson, Low Carbon Vehicle Partnership
Jenny Peel, Magtec
Andrew Gilligan, Magtec
Jenny Luckman, MCIA
Mike Cole, Michelin
Dominic Schofield, Mint Green Sustainability
Kein-Arn Ong, National Grid ESO
Millie Pardoe, Pivot Power

Rishi Madlani, RBS
Nik Hill, Ricardo AEA
Chris Ashley, Road Haulage Association
Nigel Base, SMMT
David Rees, Sunamp
David Thackeray, TEVVA
Richard Lidstone-Scott, Tevva motors
Rebecca Campbell, Transport Scotland
Jim May, Transport Scotland
Lee Cobb, Ubitricity
Will McDowall, UCL
Michal Miedzinski, UCL
Carl Buckingham, UK Power Networks
Rachel Stanley, UK Power Networks
Molly Haugen, University of Cambridge
David Cebon, University of Cambridge
Sarah Bell, UPS
Claire Thomson-Sage, UPS
Sarah Wixey, WYG
Steven Meersman, Zenobē Energy

Roundtable on Green Innovation in the Water Sector – 24 April 2020

Attendees:

Graham Southall, Northumbrian Water, GIPC Commissioner
Alice Carrington Windo, Water UK
Tony Harrington, Dwr Cymru Welsh Water
Sam Larsen, Water UK
David Riley, Anglian Water Group
Gordon Rogers, Yorkshire Water
Paul Tipper, United Utilities
Angela MacOscar, Northumbrian Water
Anthony Browne, Northumbrian Water
Mark Williams, Scottish Water
Yvette de Garis, Thames Water
Paul Ekins, UCL Institute for Sustainable Resources
George Dibb, UCL Public Policy and Institute for Innovation and Public Purpose
Michal Miedzinski, UCL Institute for Sustainable Resources

Roundtable on Green Innovation in the Agri-Food Sector – 24 April 2020

Attendees:

Benet Northcote, John Lewis Partnership, GIPC Commissioner

David Baldock, Institute for European Environmental Policy (IEEP)

Helen Browning, Soil Association

Claire Hughes, Sainsbury's

Tim Lang, Centre for Food Policy, City University of London

Henry Leveson-Gower, DEFRA and Promoting Economic Pluralism (PEP)

Martin Lines, Nature Friendly Farming Network

Paul Ekins, UCL Institute for Sustainable Resources

George Dibb, UCL Public Policy and Institute for Innovation and Public Purpose

Will McDowall, UCL Institute for Sustainable Resources

Michal Miedzinski, UCL Institute for Sustainable Resources

On the Green Innovation Policy Commission

The Green Innovation Policy Commission (GIPC) brings together progressive businesses and leading academics to identify how policy can best support green innovation across the UK economy and reward the innovators, entrepreneurs and investors who generate value from the solutions to the global environmental challenges.

For further information on the Commission please visit <https://www.ucl.ac.uk/bartlett/sustainable/green-innovation-policy-commission/about-green-innovation-policy-commission-gipc>

