NATIONAL ENGINEERING POLICY CENTRE

Royal Academy of Engineering

Beyond COVID-19: laying the foundations for a net-zero recovery

Five foundations for a net-zero recovery

1. **Ensure recovery packages work together as a whole to pivot the UK towards a net-zero economy**. The packages must stimulate immediate, low-regrets actions that help set the UK on the path to achieving net-zero, recognising that this is only a first step. Further large-scale and cumulative change is required over the coming decades.

2. **Apply outcomes-based procurement processes for all public-sector infrastructure and building projects with a focus on low carbon**, including projects that are part of the stimulus package. Procurement is an essential lever for transforming the construction industry and driving decarbonisation of the built environment.

3. **Prioritise diversity and inclusion for jobs and skills to reverse COVID-19 impacts and help build net-zero capacity and strengthen long-term capability**. The pandemic has had an inequitable impact on women and the Black, Asian and minority ethnic (BAME) community. A strong focus on diversity and inclusion must be present in any short-term measures to create jobs and in longer-term skills planning, to reverse impacts and ensure that there is the capacity and capability to transition to a net-zero economy.

4. **Drive digital transformation as an essential enabler of net-zero and resilience**. Digital technologies offer the opportunity to reduce carbon and deliver wider benefits, including resilience, through improvements to existing infrastructure and buildings. Data allows individuals and organisations to understand and manage carbon emissions, which is vital for meeting carbon reduction targets.

5. **Deploy cross-sectoral systems approaches to policymaking that underline the interconnectedness of different policy areas and economic sectors**. This will ensure that policy interventions work most effectively together to achieve net-zero and deliver co-benefits, reduce the risk of unintended consequences, and help account for social, cultural and behavioural factors, which can act as both barriers to and levers for change.

Executive summary

In the midst of the COVID-19 crisis, the UK is on a pivot. It could choose to either revert to 'business as usual', where the UK risks being locked into a high-carbon future, falling short of its legislated commitments and failing to show global leadership in the lead-up to COP26. Or it could instead choose to make a bold move towards 'better'. The short-term economic stimulus can set the UK on a confident trajectory towards meeting its net-zero territorial emissions target by 2050 and creating a thriving, low-carbon economy.

In this briefing the National Engineering Policy Centre[1] (NEPC) calls for an economic recovery that pivots the UK towards a net-zero future, rather than one that locks us into a high-carbon future. It offers **five foundations, accompanied by actions that the government, engineering community and others could take, which will secure a low-carbon and resilient recovery**. These practical steps or building blocks will enable the UK to be an authentic and strong leader and cement its place as a global science power by sending a powerful message about how the UK plans to make a step-change in its response to climate change.

This briefing sets out an engineering perspective on opportunities for decarbonisation as the UK responds to the COVID-19 crisis. It focuses on the net-zero challenge rather than broader 'green' issues, for example, resource efficiency and air quality, while recognising these are not unconnected. It highlights the importance of a socio-technical perspective, a key element of a systems approach, and that learning from past policy initiatives that have attempted to deliver similar objectives is essential.

The government's plans to support jobs and deliver a low-carbon economic recovery through clean technologies and energy reduction measures are welcome. However, this must be viewed in the context of the **cumulative, connected change required across different policy areas and economic sectors** to deliver net-zero. The plans are an example of immediate, low-regrets actions that the UK must urgently take to remain on track with the net-zero target. The actions must include support for enabling work to help realise medium- and long-term opportunities, as well as quick wins. Future policy decisions around net-zero need to mobilise entire industries in response to the crisis, and capitalise on the changing attitudes of financial markets towards low-climate-risk investments. All of this needs to be done at the scale and pace required to meet the emissions target. **Consistent policy is essential if supply chains and markets are to be successfully established and returns on funding realised.**

The COVID-19 crisis has severely impacted employment and training, with major knock-on effects for engineering sectors and the staff they employ. In the oil and gas sector, an estimated 20% of the workforce – 30,000 workers – are at risk of losing their jobs, while in construction, 43% of people surveyed in June 2020 anticipated making redundancies, affecting up to 20% of their workforce. In the short-term, **people with at-risk jobs could be redeployed, while supporting the UK's net-zero aims** by creating employment opportunities in low-carbon industries. In the energy sector alone, it is estimated that 400,000 new recruits will be needed in the next 30 years to build the net-zero energy workforce.

The inequitable impact of COVID-19 on women and BAME communities is likely to have slowed progress on diversity and inclusion in employment across all sectors of the economy, including engineering. Engineering education and training have also been affected, with implications for young engineers and the pipeline of STEM skills. **Proactive policies on diversity and inclusion in employment and training will help reverse the impact of COVID-19 and increase the UK's capacity and capability for delivering net-zero**.

With **accelerated spending of £5 billion on new infrastructure and £1 billion on school buildings** as a key component of the government's economic stimulus plans, as well as £2.8 billion on hospital buildings, there is an urgent need for net-zero principles to be embedded into planning and design. For example, urgent changes to public procurement processes are needed so they become **outcome-focused and take into account whole-life carbon evaluation**. This will provide the stimulus for the construction industry to deliver innovative, low-carbon projects and increase its international competitiveness.

COVID-19 has also affected existing infrastructure and buildings, including the energy and transport systems, and homes, schools and offices. Across the UK, demand for public transport fell by up to 95% during the early months of the pandemic, while national electricity demand during the same period fell 12%. The impacts during a winter lockdown remain to be seen. Infrastructure and buildings need to be resilient, flexible and able to adapt to shifting patterns of use. **Policymakers and engineers together have a chance to seize an opportunity**, to rethink, plan, design, retrofit, operate, maintain and repurpose existing infrastructure and buildings, and factor in social equity, net-zero and resilience from the outset. Building on increased use of **digital technologies through the crisis, digital transformation will be an essential enabler of decarbonisation and resilience**. The UK has a chance to make the best use of existing assets and to develop more flexible and efficient infrastructure systems for the future.

There is a risk that, as the UK presses forward with a rapid recovery, plans for a truly green recovery unravel and the UK simply returns to past norms. Real progress on climate change will need to build on the short-term recovery, be sustainable over successive governments, and able to withstand disruptive events in future. This is where **applying cross-sectoral systems approaches to policymaking** will help. For example, recognising the interconnectedness of different policy areas and economic sectors and learning from past policy initiatives to understand the bigger picture, including wider social and behavioural factors, can lead to a more resilient policy planning and more successful outcomes.

Audience

This briefing is aimed at **policymakers** in national, devolved and local government working in net-zero, the economic recovery, government procurement, infrastructure, education and skills. It is also for the **engineering community** providing an aide-memoire on issues around the delivery of low-carbon and resilient infrastructure and implications for engineering skills in the light of the COVID-19 crisis.

Introduction

The world is on a pivot, it could either revert to 'business as usual' or move towards 'better' – a society in which patterns of behaviour change, and health, environmental quality, safety, resilience and wellbeing are more highly valued. Alternatively, an entirely different scenario may present itself.

The prolonged nature of the pandemic is quite different from disruptions in the past, providing time for people to experience different patterns of behaviour and shape attitudes to home and workplace, transport, leisure and digital technology. The role of the built environment has shifted. Countries have generated fewer carbon emissions,[2] and communities have experienced lower levels of air pollution and traffic, albeit as a result of pandemic response measures that had a great cost to the economy.[3]

There has been a disproportionate impact of the crisis on certain demographic groups and areas of the UK. A spotlight on racial inequality has demonstrated the urgent need to build a more inclusive, just society.

Uncertainty about the duration of the crisis remains. Even if the virus risk was removed, it is uncertain which aspects of our recent lives and livelihoods will revert, and which will stick. This has potentially wide-ranging implications for our built environment and the infrastructure systems upon which society and the economy depends, including energy, transport and digital communications. **There is a window of opportunity for positive change**.

As the UK economy enters recession[4] and is further impacted by the second wave of the pandemic, and the government prepares for a spending review with much more limited resources,[5] it is all the more vital that those resources are directed to areas that have strategic importance for the UK's future in order to catalyse positive and long-lasting change.

The engineering community's response

Accelerating the transition to net-zero has remained critical and unchanged throughout the pandemic. The crisis reinforces the consequences of being unprepared for the future and the potentially catastrophic impact of unchecked climate change. It reminds us all that a lack of preparedness is not an option and that we must consider resilience at every level.

The NEPC has joined other voices[6] calling for an economic recovery that pivots the UK towards a net-zero future, rather than one that locks us into a high-carbon future. The challenge for government is to tackle the short-term employment and economic crisis, while addressing broader objectives such as net-zero, resilience, UK competitiveness and a more equal society. These two goals are not mutually exclusive, it is possible to achieve both through a well-planned recovery.

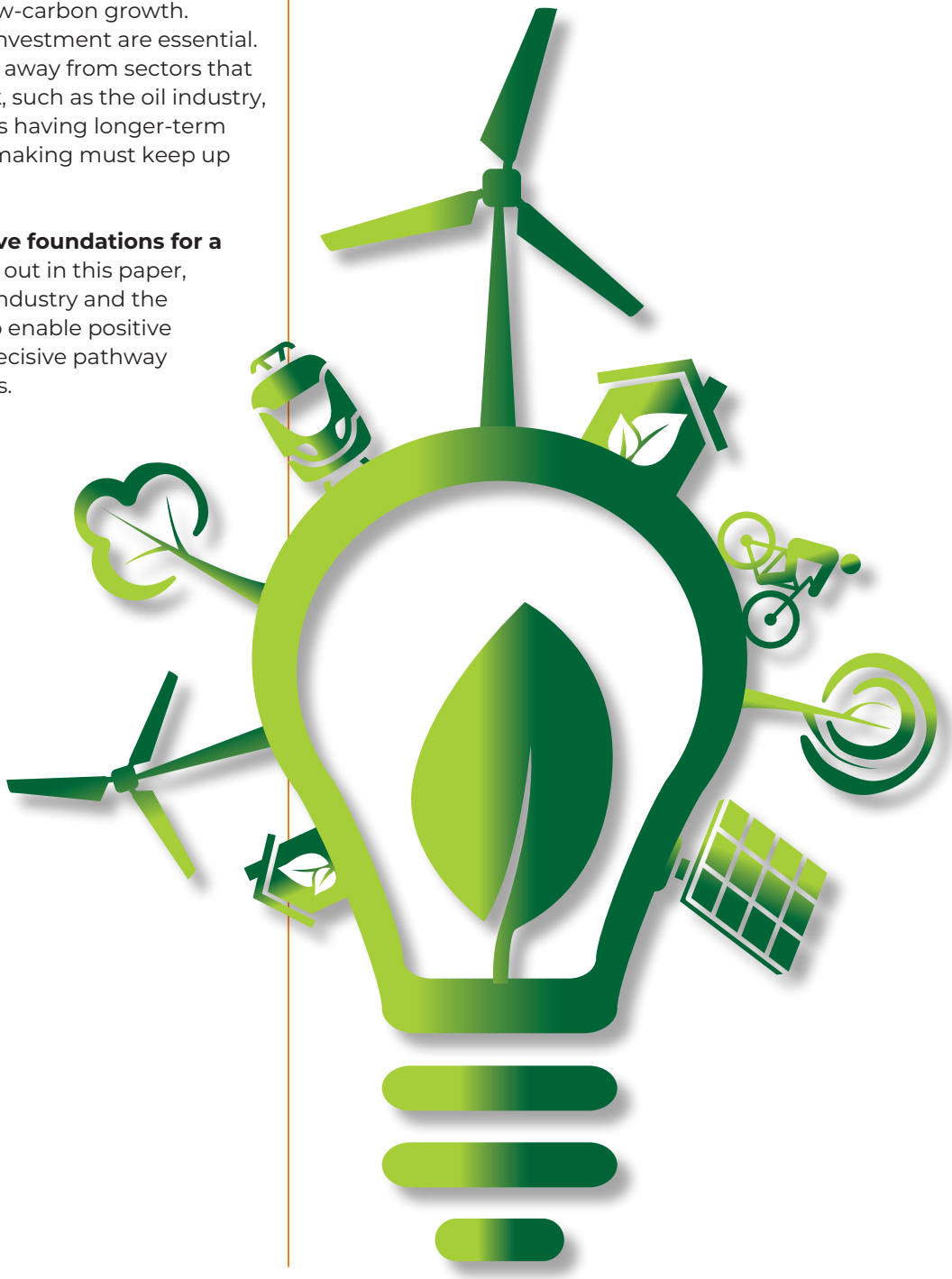
The government's publication of its *Plan for Jobs*[7] in July 2020, and the more recent *Winter Economy Plan*,[8] are welcomed by the NEPC given the urgent need to re-stimulate the economy and protect, support and create jobs. Job creation aligned specifically with net-zero objectives and a green recovery, including investment in decarbonising homes and public sector buildings and in clean technologies, can help place the UK on **a confident pathway to net-zero territorial emissions**. The government's announcement on infrastructure spending in the budget in March 2020, and the announcement in June 2020 to speed up infrastructure spending to boost the recovery,[9] provides an opportunity to drive forward the net-zero agenda.

However, the NEPC strongly believes that a large gap remains between the scale of change required for net-zero and recent government initiatives. Government must prioritise net-zero capacity and

capability building in the workforce in future spending decisions, as well as accelerating other policy decisions that support the net-zero agenda. Achieving genuine **cross-sectoral working is part of the challenge**.

Much depends on the sheer scale of ambition and level of public and private investment that can be injected into the economy to ensure low-carbon growth. Policy decisions that support investment are essential. Financial markets are pivoting away from sectors that have been very exposed to risk, such as the oil industry, into areas that are perceived as having longer-term resilience. Government policymaking must keep up with this shift.

The NEPC recommends the **five foundations for a net-zero recovery** that are set out in this paper, with actions for government, industry and the engineering profession to help enable positive change, and set the UK on a decisive pathway to net-zero territorial emissions.



Foundation 1:

Ensure recovery packages work together as a whole to pivot the UK towards a net-zero economy

In summary: key actions for a net-zero recovery

For government:

a. Ensure that recovery packages stimulate immediate, low-regrets actions that help set the UK on a confident path to achieve the 2050 net-zero target.

b. Step up the level of investment in clean growth to a scale that is comparable with other ambitious nations[9], and build upon the UK's strengths and capabilities in clean technologies.

c. Make stimulus funds for carbon-intensive industries contingent on long-term, ambitious and achievable emissions reduction commitments.

d. Set progressive targets and incentives to maintain progress on decarbonisation beyond the short-term economic stimulus package.

e. Ensure policymaking encourages and leverages a shift in investor behaviour towards low-climate-risk investments.

f. A combination of progressive targets and incentives for decarbonisation is urgently needed on a sector-by-sector basis incorporating a whole systems approach to maintain progress beyond the short-term economic stimulus package.

Immediate investment in low-regrets measures[10] to reduce carbon emissions will support the UK's economic recovery, through creating new jobs, markets and UK-based supply chains, while setting the UK on a confident pathway towards achieving its net-zero target by 2050.[11,12] These measures must include support for enabling work to help realise medium- and long-term opportunities, as well as quick wins. Conversely, recovery measures that support the return to a high-carbon economy, such as investment in carbon-emitting energy infrastructure, or policies that lock-in the use of high-emissions transport, can make the target more expensive, or even impossible, to reach.

Demonstrating global leadership, stepping up the level of investment in clean growth to a scale that is competitive with other ambitious nations[13] will be essential, while building upon on the UK's strengths and capabilities in clean technologies. This is vital for international competitiveness and in ensuring that the UK's impact on decarbonisation extends beyond its borders. Strengthening the position of UK manufacturers in global supply chains is an important consideration when prioritising technologies for investment.

When assessing interventions to stimulate economic recovery, government should examine the case for each in terms of its contribution to a high- or low-carbon future. It should also **consider how spending decisions as a whole impact upon the net-zero goal**. Priority should be given to interventions that deliver co-benefits, such as those that generate employment, increase resilience and support levelling up across the UK's nations and regions. Opportunities to strengthen the UK's manufacturing and technology base and drive growth must also be identified.

Access to recovery funds for carbon-intensive industries, such as aviation, rail and energy-intensive manufacturing such as steel production and chemical-processing, **should be contingent upon their commitment to ambitious but achievable targets** for reducing greenhouse gas emissions.[14] This has been recommended by the Committee on Climate Change and reflects the consensus of many of the UK's leading

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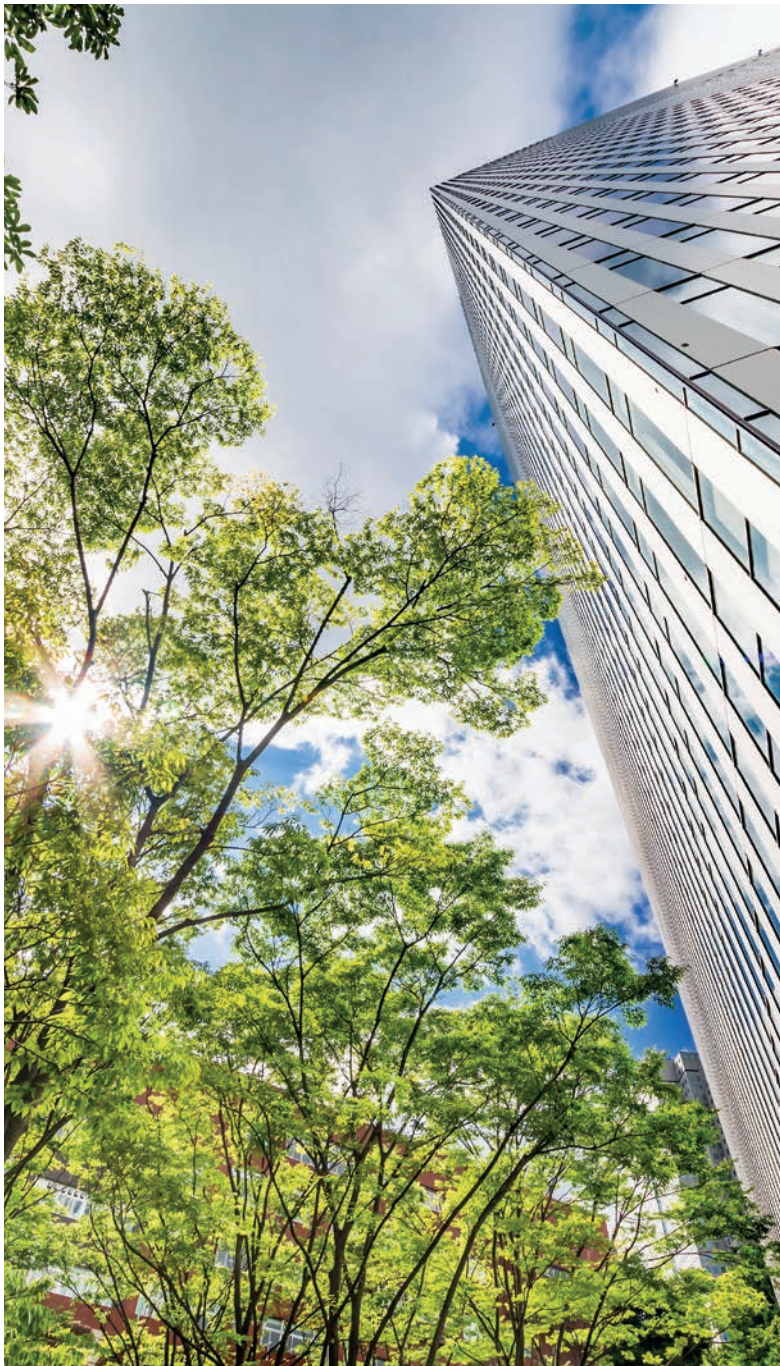
businesses,[15] and professionals working across the UK's energy industry.[16] Setting this condition has the potential to stimulate research and innovation, and create entirely new industries.

Scaling up ambition towards priorities that support both economic recovery and the UK's transition to net-zero, such as reducing energy use and supporting a shift towards net-zero energy and transport systems, would represent a step-change in climate ambition and allow the UK to show **global leadership in climate policy in advance of COP26**.

A combination of progressive targets and incentives for decarbonisation is urgently needed on a sector-by-sector basis to maintain progress beyond the short-term economic stimulus package, with timescales for change that are stretching but realistic. These should be aligned with the UK's carbon budgets and create a level playing field that enables industries to appropriately plan and invest to meet long-term requirements.

The impact of the crisis on financial markets is likely to increase demand from funds and other private-sector investors for investments with moderate, secure, long-term returns that address climate risks.[17] Furthermore, clean energy investment has proved to be more resilient than oil and gas during the crisis,[18] since the low oil price has made investment in oil exploration and production less attractive. In the UK, the low oil price has called into question the future viability of UK Continental Shelf exploration and extraction given cost pressures- and accelerated the transition of major players in the sector away from unabated hydrocarbon production towards net-zero compatible technologies, namely carbon capture usage and storage (CCUS), hydrogen and offshore renewables. As a result, the major operators and tier one contractors[19] are increasingly diversifying their portfolios away from hydrocarbons.[20]

The demand for low-climate-risk investments should be harnessed to enable funding of new low-carbon infrastructure and improvements to existing infrastructure. This could include clean utilities infrastructure and other decarbonisation projects that have stable government support, such as the proposals for green energy investment made by OFGEM[21] and investment in green gas network infrastructure made by the Energy Networks Association.[22] **The engineering community, in collaboration with financial institutions, has a key role to play in developing business cases for these investments**. It will take time for technologies and business models to become ready for market. Consistent policy over successive governments is therefore essential if supply chains and markets are to be successfully established and returns on funding realised.



Foundation 2:

Apply outcomes-based procurement processes for all public-sector infrastructure and building projects with a focus on low carbon

In summary: key actions for a net-zero recovery

For government:

a. Use outcomes-based procurement processes for all public-sector infrastructure and building projects drawing on international best practice in low-carbon procurement.

b. Identify opportunities to embed improved procurement processes into HM Treasury's Green Book.

For industry and the engineering profession:

c. Identify practical and usable carbon assessment tools to enable consistent assessment across different projects and inform good decision-making.

d. Ensure that individual new build and retrofit projects draw on national and international best practices in design and engineering to deliver regenerative and net-zero results.

e. Use industry cohesion and momentum resulting from the COVID-19 crisis to drive change, building on recently developed networks and relationships.

In June 2020 the Prime Minister announced plans to accelerate £5 billion of infrastructure projects.[23] He also announced an initial funding package of £1 billion to rebuild schools.[24] Funding for a major hospital building programme was announced last year.[25] The NEPC has identified the need for urgent change in procurement practice by central, devolved and local government that must reflect broader definitions of **whole-life value including whole-life carbon performance**,[26,27] and not just short-term cost.[28,29,30] Procurement is an essential lever for transforming the construction industry and driving decarbonisation of the built environment.

Infrastructure and building projects create high levels of emissions through carbon-intensive materials, such as steel and cement, and construction processes. **Best engineering practices and engineering innovation should be at the heart of the design and deployment of all new infrastructure**, ensuring it dramatically reduces global greenhouse gas emissions throughout its lifecycle, including during construction. The construction industry has the capability and the tools to deliver low-carbon, resilient infrastructure. It must signal its ambition to government that it is ready to drive a step-change in carbon performance for the government's proposed programme of infrastructure investment.

Carbon assessments are vital in brief setting and procurement, as well as design and performance monitoring. These must be practical and user-friendly to enable consistent assessment of carbon performance and make meaningful comparisons across different projects. In some cases, investment in reuse or repurposing of existing assets, enabled by digital technologies and data, is more appropriate than creating new assets and can carry lower financial and environmental costs, including impacts on CO_2 emissions.[31] These assessments must be set and applied now.

Rapid learning from national and international best practice will transform procurement and construction practices. The construction sector and government should take inspiration from other countries such

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as Denmark and the Netherlands, which are already implementing low-carbon public procurement practices,[32] and businesses and sectors such as the energy sector, which are achieving improvements in carbon performance.[33] More broadly, the infrastructure adopted must lay the foundations of a net-zero carbon UK, and deploy systems engineering expertise to ensure that all parts of the infrastructure sector work together towards a net-zero, resilient future.[34]

Both private and public sectors should strengthen approaches to procurement and investment decisions, ensuring that both the impacts of climate change and shorter-term events such as pandemics are assessed and managed. Opportunities to embed this best practice should be a priority when reviewing the HM Treasury's Green Book.[35]

Achieving the necessary scale and pace of change across all sectors of the economy requires government, industries and the many other stakeholders to act in partnership at scale and in a joined-up and coordinated way. The urgency in providing an effective crisis response has brought together industries, such as construction and manufacturing, to speak with one voice. Effective collaboration between large and small companies, and across competitor and sector boundaries, has resulted in decision-making at pace.

There is much to learn from the rapid mobilisation of organisations and industries during the crisis that can be applied to the net-zero challenge. The networks and relationships developed during this time should be supported, maintained and actively encouraged.

Foundation 3:

Prioritise diversity and inclusion for jobs and skills to reverse COVID-19 impacts and help build net-zero capacity and strengthen long-term capability

In summary: key actions for a net-zero recovery

For government, industry and the engineering profession:

a. Make diversity and inclusion for jobs and skills an immediate priority to reverse COVID-19 impacts and help build net-zero capacity.

b. Plan for the engineering skills requirements needed to deliver net-zero over the longer term.

c. Prioritise a pipeline of transferrable STEM skills to provide the basis for adaptable engineering skills that can deliver the net-zero agenda.

d. Ensure greater public understanding of the role of STEM subjects in providing the basic skills for addressing crucial societal challenges to attract people to STEM jobs that will help deliver net-zero.

For government:

e. In the short term, focus job creation on immediate actions for net-zero and a just transition.

f. Demonstrate to the public that a net-zero recovery represents an opportunity to create jobs and stimulate the economy.

Inequitable impacts of the crisis

The crisis has had inequitable effects on certain communities. It has particularly impacted the livelihoods of women,[36] who have taken the burden of childcare and been most likely to lose, or had to leave, their jobs or shift to part-time employment.[37] The health impact on the BAME population has also been disproportionately severe,[38] with knock-on effects likely on employment[39,40] and on young people.[41] The disruption to education and training has especially affected apprentices[42] and school pupils from disadvantaged backgrounds,[43] with implications for levels of deprivation across the UK as well as diversity and inclusion within engineering sectors. It is crucial that sustained long-term investment in skills and jobs addresses reducing levels of deprivation.

More broadly, it is vitally important that, as part of the UK's economic recovery, diversity is addressed across all sectors, including engineering. An internationally competitive economy must be diverse, as well as low carbon, and there is a risk that the UK goes backwards in terms of diversity commitments in employment and training because of COVID-19. There is much evidence to show that diverse groups are more innovative, more effective, and ultimately, more productive in the economy.[44] Diversifying the engineering profession can help close the skills gap, better reflect the needs of society and lead to stronger outputs. Engineers who feel more included are more likely to understand business priorities, be confident to speak out about improvements, mistakes or safety concerns and picture themselves undertaking a career in engineering.[45] But achieving improvements in diversity moving forward will require government and other organisations to put in place proactive and just policies.[46]

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The existing skills shortage and net-zero

Engineering skills will play a vital role in the transition to net-zero, since it is engineers from every discipline that will design, build, retrofit, operate and make safe the infrastructure and technologies to achieve a decarbonised UK.[47] However, an engineering skills shortage already exists in the UK as a result of an imbalance between the supply and demand for engineering talent.[48] In addition, future engineers will need new skills for jobs that do not yet exist or are not yet fully embedded into current engineering courses, such as sustainability, systems engineering, and digitalisation.

The UK energy sector alone is predicted to need to fill 400,000 roles between now and 2050 in order to reach net-zero.[49] **Of these, 260,000 roles will be newly created**. This includes the skilled workforce required for low-carbon electricity deployment, home retrofit, deploying infrastructure for hydrogen and CCUS, and installation of electric vehicle charging infrastructure. Both the construction and engineering construction industries will play an important role.[50] For example, the skill sets of workers in engineering construction are closely aligned to the skills needed to deliver industrial and energy decarbonisation, such as infrastructure for hydrogen and CCUS, as well as the necessary growth in offshore wind.[51] The government's *Lifetime Skills Guarantee*,[52] with its focus on lifelong skills and technical education, is welcome.

Job creation will need to be timed to coincide with work becoming available. For example, the Industrial Clusters mission[53] will require tens of thousands of workers across the six clusters during the construction phase.

Economic recovery and skills needs

The impacts of the crisis on employment have been considerable.

In the oil and gas sector, an estimated 20% of the workforce – 30,000 workers – are at risk of losing their jobs,[54]

while in construction 43% of people surveyed in June 2020 anticipated making redundancies, affecting up to 20% of their workforce.[55] Rapid and safe re-employment will be crucial to the economic recovery of the UK, for which job creation, upskilling and reskilling can play a part. Any effort to support re-employment would greatly benefit from an understanding of how specific skills can be transferred or deployed in strongly impacted sectors and where redeployment supports the UK's net-zero aims. The time taken to develop appropriately skilled workers must be considered.[56]

For example, the opportunity exists to deploy people from the oil and gas sector in Scotland, which has been strongly impacted by the crisis, to new employment opportunities in the offshore wind sector.[57] Other initiatives that aim to support retention of skills and retraining and redeployment of workers are welcome.[58,59] There is an opportunity to demonstrate to the public that a net-zero recovery can rapidly create jobs and stimulate the economy.[60]

There are more immediate challenges where decarbonisation actions are urgent and clearly defined, including home energy efficiency and heating system retrofit. The government's targeting of this area of activity is welcome,[61] as it will help tackle a major source of UK greenhouse gas emissions, which in 2018 accounted for 18% of the total, and achieve co-benefits such building resilience and creating local supply chains, as long as learning is applied from past policy initiatives.[62]

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The £3 billion announced for this to date[63] should only be viewed as a 'down-payment'. A sustained multi-year programme is required to establish the market, give supply chains the confidence to invest and consumers the chance to consider what retrofit measures would work best for them.

Education and training

The COVID-19 crisis is impacting the engineering talent pipeline at every stage, from primary and secondary education, through to higher and further education. A learning gap is opening up for the most disadvantaged students, due to a lack of access to online teaching resources and lower levels of parental support for home learning.[64]

The recruitment of new apprentices is in some situations being put on hold or stopped, although measures to shore up apprenticeship schemes have been put in place.[65] These measures are vital to reduce impacts on young people and the engineering skills shortage. For the current cohort of apprentices, the reduction in economic activity has led to fewer opportunities to gain experience through project work and many have instead been furloughed.[66,67] Training activities requiring practical experience are being severely impacted, although online alternatives are being created.[68] For example, in engineering construction, delivery of the CCNSG[69] safety passport was temporarily moved to online delivery during lockdown. The impact on further education and university education remains to be seen, although is likely to be large. There is an opportunity to rethink what is taught and how education is delivered.[70]

In the short term, government policy for the employment crisis must ensure that retraining and reskilling supports current and future net-zero needs, aligning with public and private sector investment in low-carbon industries. Upfront skills investment must support the development of skills in both training centres and the workplace in time for the use of these skills, requiring a joined-up approach that can resist market fluctuations.

The project-driven nature of construction and engineering construction[71] contractors makes reskilling and upskilling a challenge. There is a role for professional bodies, working alongside the relevant training boards, trade associations, unions, training providers, skills accreditation bodies, and industries to raise awareness of the value of reskilling and upskilling, and improve access to skills provision.

In the longer term, prioritising a pipeline of transferrable STEM skills from primary education through to higher education, and reviewing future skills needs to complement a net-zero roadmap, are both crucial. Urgent action is needed to map the timeline to deliver net-zero and the associated skills needs to implement and then maintain engineered systems for net-zero. Developing the necessary skills will take time and requires a sustained, consistent long-term strategy.

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Foundation 4:

Drive digital transformation as an essential enabler of net-zero and resilience

In summary: key actions for a net-zero recovery

For government:

a. Support the development and adoption of digital technologies as enablers of decarbonisation and to boost productivity across all sectors, while addressing interdependent social and technical factors that affect their adoption.

b. Strengthen the UK's digital infrastructure through support for broadband and 5G to improve equitable access to the internet, ensure resilience and enable a data-driven economy.

c. Put in place policies that will ensure that digitally enabled systems are safe, resilient and secure.

For industry, government, research funders and the engineering profession:

d. Improve access to data by developing frameworks for trusted data sharing between sectors and organisations and build capacity to adopt frameworks.

e. Maintain momentum on developing secure and resilient digital technologies to support the transition to the future energy system.

The crisis has highlighted the important role that digitalisation already plays in the economy. During the crisis, digital technologies helped maintain resilience; for example, in enabling business continuity through home working and improving visibility of available capacity across critical supply chains.[72] COVID-19 has highlighted the importance of equitable access to digital technologies and infrastructure, and the need for resilient digital infrastructure. People are more accustomed to remote and flexible working. The opportunity to learn new digital skills online is now possible: for example, in April 2020, Enginuity and Made Smarter launched a digital engineering skills platform, which aims to upskill and reskill engineers and manufacturers.[73]

Digital technologies such as the Internet of Things, artificial intelligence and 5G along with better use of data and development of digital twins[74] must increasingly play a part in enabling decarbonisation. A secure and resilient digital transformation[75] is vital to support the transition to net-zero. Increased adoption of digital technologies can also play a role in boosting productivity. The impact of the crisis on vital infrastructure sectors such as energy and transport provides an opportunity to rethink their future with the net-zero target in mind (see pages 20 to 23).

Digital technologies and data will play an important role as enablers in these future systems, provided that the interdependent social and technical factors that affect their adoption are addressed.[76]

Digital technologies and data have the potential to enable reduction in carbon emissions in several ways:

a. **Monitoring progress on reaching carbon targets**: Access to the right data, of sufficient quality and with the appropriate controls in place,[77] is essential for monitoring the success of government decarbonisation policies,[78] and sector and business progress on decarbonisation.

b. **Enabling organisations and individuals to reduce emissions**: It is vital that individuals and organisations[79] can access data and information to inform decisions about reducing carbon emissions across their activities. Tools such as the WWF's carbon footprint calculator already exist for individuals.[80] Research and cross-sectoral sharing of best practice can improve understanding of where the biggest decarbonisation opportunities lie, and how digital technologies can best be deployed across sectors including services, manufacturing, agriculture and transport.

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c. **Reducing carbon emissions in infrastructure**: Shifting to a data-driven infrastructure system offers an opportunity to do far more with existing infrastructure assets. This will reduce the need for new build projects and help optimise operations and maintenance activities in existing assets to drive down carbon emissions.[81,82] **Measuring carbon emissions across the lifecycle of new infrastructure and building assets will also be crucial** for improving brief-setting, design and construction, and ensuring assets perform as intended. It requires appropriate data to be made available.[83,84]

d. **Reducing waste and enabling new circular economy business models**: Business models underpinned by circular economy principles, to reduce embodied carbon associated with products and materials, can be enabled by digital technologies and data. For example, access to data on the condition and availability of products, materials and resources can help extend the life of an asset or identify where materials can be reused.[85,86]

e. **Enabling the transition to smart local energy systems**: The transition to smart local energy systems can facilitate decentralisation and decarbonisation of the energy system and allow incorporation of smaller-scale energy assets.[87] This transition can be enabled by developing smart technologies for the gas and power grids, underpinned by digital innovation, enabling community energy trading and accommodating greater penetration of intermittent renewable generation on the grid.

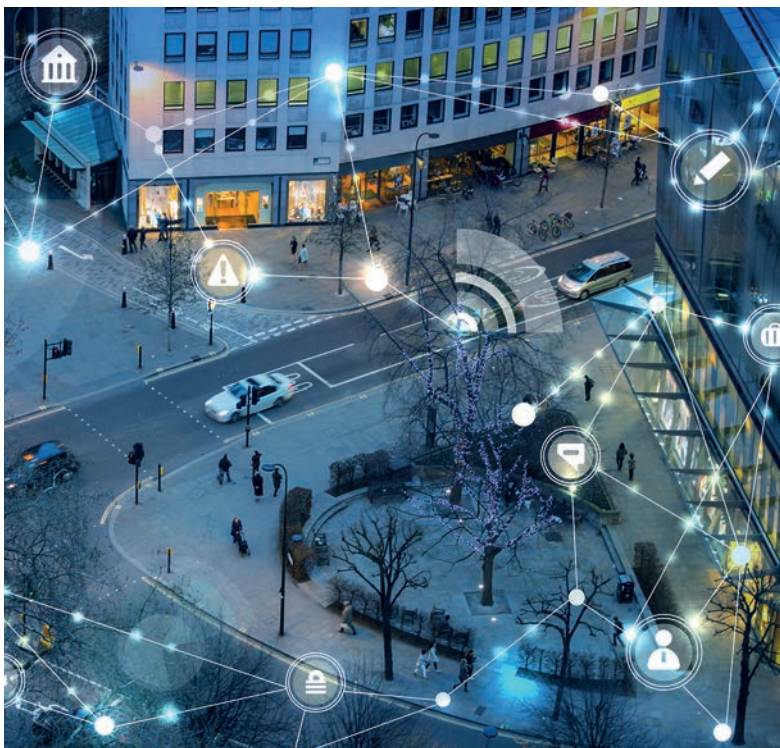
For digital technologies and data to play a role, support for the following is needed:

a. **Digital connectivity and infrastructure** that is fast, secure and resilient across both urban and rural areas of the UK: connectivity is an essential prerequisite for an advanced digital economy and ensuring UK competitiveness, since the fast, resilient and secure transfer of data is required for many data-driven systems.[88]

b. **Frameworks for trusted data sharing** within and across different sectors: appropriate frameworks are vital to ensure that data sharing meets commercial, regulatory, legal or ethical requirements.[89,90,91] Sharing data across infrastructure operators, owners and regulators is vital for ensuring cross-sector infrastructure resilience as well as finding opportunities for decarbonisation (see also Foundation 5).

c. **Maintain support for the development and adoption of digital technologies in buildings and infrastructure assets** that enable decarbonisation as well as boosting productivity. This includes support for digital technologies that will facilitate the transition to the future energy[92] and transport systems (see pages 20 to 23), as well as those that can support the decarbonisation of the existing building stock and engagement with home occupiers.

d. **Put in place policies that can ensure that digitally enabled systems are safe, resilient and secure**.[93] This includes adopting sector-specific frameworks for cybersecurity in both the public and private sectors through procurement by incorporating the use of frameworks in project specifications. Furthermore, funding for new technologies and systems, and for developing digital twins, should include requirements to address the cybersecurity, safety and resilience issues associated with the technologies and systems.



Foundation 5:

Deploy cross-sectoral systems approaches to policymaking that underline the interconnectedness of different policy areas and economic sectors

In summary: key actions for a net-zero recovery

For government:

a. Reinforce mechanisms that facilitate genuine cross-sectoral working, to enable all stakeholders to act together at scale and in a coordinated way.

b. Strengthen central, devolved and local government capability and capacity to provide systems leadership and operationalise cross-sectoral systems approaches.

c. In the near term, apply systems approaches to inform decision-making on multiple, urgent low-regrets options across different sectors, setting the UK on the right path to net-zero.

For government, industry and academia:

d. Address resilience and decarbonisation challenges together, so that resilience is delivered on the path to net-zero.

e. Ensure that infrastructure interdependencies are considered to help identify decarbonisation opportunities and risks while improving the resilience of the UK's infrastructure systems.

Decarbonisation is a unique policy goal, because of the scale of ambition, perceived long timescales, the breadth of policy areas to which it links, and the number of stakeholders who must work towards a shared and yet uncertain goal.[94]

Deploying cross-sectoral systems approaches to policymaking will ensure that policy interventions for different sectors and stakeholders work most effectively together to achieve net-zero and deliver co-benefits, reduce the risk of unintended consequences and help account for social, cultural, economic and behavioural factors that can act as both barriers to and levers for change. Systems approaches can also help to identify the optimum points for intervention.[95,96] Stakeholders including government, regulatory authorities, industry and academia will need to act together at scale and in a coordinated way.

There are numerous aspects of the net-zero challenge where a systems approach will help. For example, hydrogen will be part of the future energy system, but it is uncertain exactly what role it will play and how its use will be balanced across numerous applications. **The use of hydrogen as an energy vector in transport will depend on decisions made in other sectors, including energy, built environment and industry, for example**. Similarly, decisions about pathways for decarbonising homes will be affected by many factors spanning the housing, energy, transport and industry sectors,[97] as well as local factors, that will in turn influence the balance between the use of heat pumps versus hydrogen for decarbonising homes. Whatever the balance, the scale of change is such that immediate action is needed on all fronts, including support for hydrogen demonstration projects and ensuring appliances are hydrogen-ready to enable timely deployment in the coming years.

In the near term, **multiple decisions about low-regrets options across different sectors must be made urgently, given the scale and pace of change required**. Low-regrets options are urgent priorities that appear in all scenarios and will have a significant impact on decarbonisation. They will unlock pathways towards the net-zero target, rather than blocking off options. They will build flexibility and reduce costs for the future, and will have clear social, economic and

Foundation 5

environmental co-benefits. There are many areas and sectors where low-regrets decisions will need to be made; however, they must work together to set the UK on the right pathway to net-zero.

Reaching the net-zero goal will require the appropriate institutions, governance frameworks and leadership structures across central government to be put in place to catalyse the necessary change, alongside analytical capacity and capability, funding for low-carbon technologies, access to finance and international collaboration.[98] A 'bigger picture' view of the policy problem and how it might be tackled will rely on evidence drawn from the widest, most diverse and critical perspectives. The capability and capacity to provide systems leadership and to operationalise systems approaches, in both central, devolved and local government, will be critical.

It is vital that resilience is delivered on the path to net-zero, and that resilience and carbon performance are considered together, and not in insolation.[99] Resilience thinking needs to be adapted to meet the requirements of future net-zero systems, whose attributes may be very different to those that are currently in existence. Engineers can help provide advice and leadership by assessing risks and suggesting mitigation measures.

Cross-sectoral systems approaches are vital in ensuring resilience[100] of organisations, infrastructure, supply chains or policy. Similarly to decarbonisation, resilience is a system-wide issue because the different entities are interconnected, most visibly through the reliance of one factor on another, so the consequences of any disruption become far more important than the local effects.[101,102,103,104] For infrastructure, interdependencies between different infrastructure sectors must be addressed, both to help identify decarbonisation opportunities and risks and to improve the resilience of the UK's infrastructure systems.

Final thoughts

Delivering net-zero in a just and economically beneficial way will require a huge and sustained engineering effort with accompanying societal, cultural, behavioural and structural change. It requires a stable commitment by government to net-zero policymaking over the long term, builds on the short-term economic recovery and responds to the scale and pace of change required. **A net-zero and resilient recovery will be vital in setting the UK on the right pathway to meet its target of net-zero territorial emissions by 2050**.

While the crisis is having a damaging impact on the economy and society, and uncertainty remains about how long this crisis will persist, it presents a window of opportunity for positive change. The opportunity exists to accelerate progress towards net-zero through changes to the built environment and the infrastructure systems upon which society and the economy depends, including energy, transport and digital communications.

Over the next few decades, there needs to be a strong focus on the people and engineering skills needed to help deliver net-zero infrastructure and technologies. The redeployment of people from areas of the economy impacted by the crisis in the short term to net-zero roles will support job creation and contribute to decarbonisation goals.

The crisis has resulted in whole industries coming together to respond with a single voice and make rapid decisions, requiring new ways of collaborating and networking. The lessons from these new ways of working can be distilled and applied to the net-zero challenge. The crisis emphasises that it is vital to address risks and be prepared to respond, and that the net-zero challenge cannot be ignored.

The foundations set out in this paper, informed primarily by engineering perspectives but recognising the importance of other disciplines, are intended to help drive positive change and pivot the UK towards a net-zero economy and society. The engineering community stands ready to support this change, and to develop ways to embed net-zero principles and practices into the design, construction, retrofit and operation of infrastructure systems.

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Spotlight on:

The energy system – impacts of the crisis and opportunities for change

Impact of the crisis on the energy system

The energy system is being impacted by the crisis in several ways. Patterns of use are changing as industries, businesses and schools alter their operations and homes are occupied for longer. Electricity generation fell by 12% in the period from April to June 2020 because of the lockdown restrictions imposed.[105]

Changes in demand created system instability. In order to reduce generation to compensate for reduced demand, the National Grid established new market mechanisms, for example the Optional Downward Flexibility Management Service.[106] Most importantly, this involves paying power generation projects to produce less electricity, and includes an agreement to reduce the output of the Sizewell B Nuclear plant, with associated high costs.[107]

There was concern that keeping the most stabilising power sources online, to maintain inertia in the system that is not provided by renewables,[108] would lead to a reduction in energy generated from renewable sources,[109] but this proved not to be the case. Renewable generation in the period from April to June 2020 exceeded the total from fossil fuels, and there were increases for all forms of renewable energy. Coal generation fell to record low levels, because of the 67-day coal-free period in Great Britain between March and June, the longest since the 19th century.[110] The impact of lockdown on energy demand during winter months could be significant, but remains to be seen.

In the energy sector, supply chains were disrupted,[111] and the workforce had to adapt to operating changes as a result of social distancing. The crisis has affected business continuity, energy security and the economics of particular energy sectors. Retail energy suppliers have been hit very hard by the combination of falling demand and customers in financial distress; the structural impact of this on the sector is still shaking down but is already causing job losses and retrenchment. The oil and gas sector has additionally been severely impacted by low oil prices.

Implications for the future energy system

Looking ahead, it is expected that winter lockdowns would significantly increase home heating demand. It is estimated that the cost of the additional heating during a winter lockdown would increase energy bills by £49 per month, exacerbating existing fuel poverty for those who have had to shift to homeworking.[112] It also has implications for management of seasonal energy demand and the appropriate combination of energy sources.

The crisis has also underlined the importance of accelerating a transition to a secure and resilient energy system, for which reducing energy demand and digitalisation will be key enablers (see also Foundations 1 and 4). Business and institutional issues, and user perceptions, will need to be addressed to enable scaling up of local energy systems.[113] It is vital that the socio-technical issues around their acceptability and adoption are addressed, and that lessons are learned from past programmes, such as the smart meter programme. Engineers, alongside other disciplines, will play a vital role in developing, testing, deploying and operating these systems, and in providing advice on shaping appropriate governance and market mechanisms.


ENERGY
STORAGE

Spotlight on:

The transport system – impacts of the crisis and opportunities for change

Impact of the crisis on the transport system

The UK saw a decrease in transport demand during the strictest times of lockdown. Pre-crisis commuting was estimated to account for nearly 40% of UK transport emissions.[114] During the crisis, the reduction in commuting-related emissions resulted predominantly from reduced car use; rail and bus travel usually accounts for less than a quarter of travel to work,[115] with over three quarters making the journey by car.[116]

Unlike other instances of transport disruption, many people had to seek alternative ways to travel, or to avoid travelling completely, over an extended period. However, key workers and others whose work required them to travel had to use public transport if they had no alternative; this was particularly the case for people from BAME communities.[117] Active travel increased, with more people walking and cycling, although it is uncertain how much of this increase was due to a shift in leisure activities. Perceptions of the safety of mass transit like rail and buses changed because of people's fear of infection.

Implications for the future transport system

Transport over many decades has been the focus of much policy and political attention; the environmental impacts of motorised transport have been a central consideration. Momentum is building around how to deliver the UK's net-zero target, and other areas such as climate change and urban air pollution are also gaining further traction. The huge impact of the pandemic on transport also creates the opportunity to rethink its future. Across the UK demand for public transport collapsed. In late May, the Welsh Government indicated that the use of public transport was around 95% less than the same period last year.[118] In the North East, the Metro rail system reported a 95% drop in demand[119] as did the Manchester Metrolink service.[120] In London demand for the underground fell more than 90%, while demand for buses fell about 75%.[121]

If current travel patterns persist, it will transform the economics of public transport and the models around commuting in urban environments. Public transport is designed to support patterns of commuting: people travel into the centre of a city to work, and capacity is designed to accommodate peaks at certain times of day. In the future, demand may reduce if working and living patterns change, and it is likely that infection risk will drive people to avoid overcrowding. The economics will be impacted depending on the different choices people make about where they work.

There is an opportunity to rethink the future of passenger transport in its entirety to ensure it is comfortable and convenient, encourages the use of active travel, and meets broader objectives around decarbonisation and levelling up. The expertise of engineers working in transport planning, design, delivery and operation is valuable in identifying and testing future options for transport. While the risks from COVID-19 remain, it is likely that transport policy will need to take health issues more strongly into account, with implications for the role of lower-carbon

mass transit as an important lever for decarbonisation. Transport planning needs to capture local and national strategies, which requires joined-up and creative thinking.

Ways of ensuring the choice of active travel options is made easier and more appealing are needed, by providing infrastructure changes that enable active travel. Options for individual travel that do not impact adversely on carbon emissions should be explored.

There are many other opportunities to decarbonise the transportation of people and goods outside cities, through decarbonisation of individual transport modes, or encouraging shifts to less carbon-intensive modes. For example, government can take the lead in decarbonising its vehicle fleets, and in incentivising operators to do so.

There are opportunities to utilise the currently under-used rail network for transportation of goods, shifting freight away from road, if local solutions for the last few miles can be found. Using rail as an alternative to short-haul flights, for example, between London and Glasgow, is also possible. This needs better links between rail and roads so that the end-to-end journey becomes a more attractive option. The UK has an important global leadership role to play in the decarbonisation of shipping, including improved ship design, carbon-efficient shipping operations and the development of low-carbon shipping fuels. Decarbonisation of UK ports, across all of their activities, is essential.

Measures to manage and respond to demand on public transport, within and between cities, and in rural areas, are likely become even more important in controlling overcrowding and encouraging people back onto public transport and away from their cars. Digital technologies and incentives to travel at certain times can play a role in reducing over-crowding, and make public transport more comfortable and safe in the short term.[122]

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