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The social benefits of **infrastructure investment**

A report for the Civil Engineering Contractors Association

December 2018

The Civil Engineering Contractors Association is the representative body for companies who work day-to-day to deliver, upgrade, and maintain the country's infrastructure.

With more than 300 members based across Scotland, Wales, and six English regions, CECA represent firms who together carry out an estimated 70-80 per cent of all civil engineering activity in the UK, in the key sectors of transport, energy, communications, waste, and water.

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Contents

CECA Foreword

This report has been commissioned by CECA to bring a fresh perspective to the debate about the UK's infrastructure needs, and focus in particular on its *social* aspects.

The aim is to help improve decision making by contributing to a better understanding of the different ways in which various forms of infrastructure investment affect people's lives. Much of the debate to date has been conducted in terms of the relationship between infrastructure investment and monetary measures of economic performance, such as GDP.

While this vividly illustrates how infrastructure investment can lead to wealth creation, it misses some important impacts on people that should be taken into account in a more holistic approach to making decisions about the allocation of resources to infrastructure.

In fact the social and economic benefits of infrastructure are closely related. For example, there is evidence that quality of life, health and social inclusion are becoming increasingly important factors in long term economic prosperity, particularly as technology, working patterns and lifestyles develop in new ways.

The mechanisms by which infrastructure influences these factors have been considered less measurable in monetary terms than some of the other types of benefit. The risk is that certain social benefits could therefore be overlooked, i.e. not because they are any less important, but because they are less easily modeled and valued using traditional techniques.

Guest Foreword

Mark Thurston, CEO, High Speed 2 Ltd

For too long as a sector, in making the case for individual infrastructure projects, we have tended to focus on the economics. This is not a surprise, infrastructure is expensive, and when it involves taxpayers' money, the returns to the country must be greater than the cost.

As the Government's largest infrastructure project HS2 is no different.

HS2 is an investment in Britain's future. But with a budget of £55.7 billion over the next 15 years, and a completion date of 2033, we receive our fair share of attention.

For every £1 invested in HS2 the UK will receive £2.30 in benefits - £92 billion of benefits overall.

But when we spend taxpayers' money, we have a responsibility to do more than an economic cost-benefit analysis. We have to make sure the benefit to society – to quality of life – is as strong as the benefit to the economy.

It is difficult to model and value this important effect using traditional techniques. This can skew debate about investment priorities. The unintended consequence can be that short-term decisions do not address future challenges and needs.

That is why this new report from CECA comes at an important time for the industry, setting out the case for the social good that housing, transport and energy infrastructure can bring to the country.

The report is clear about the opportunity this offers the industry and why we must continue being bold in our vision for infrastructure. Why we must talk about social outcomes, not engineering outputs. And why we must help the public make the intuitive leap about what infrastructure might mean for them.

That is what we are doing at HS2. People are starting to understand that HS2 offers an amazing opportunity to completely reshape the way we travel across the UK and the future of our economy, our regions, our local places and our communities. Put simply, HS2 will join up Britain and put opportunity within the reach of many.

It is clear for the whole of the sector that the debate on infrastructure investment priorities has to shift from cold, hard-nosed calculations alone. I therefore encourage the industry to support the efforts underway to address the measurement of social benefit from infrastructure investment.

I am proud to have worked in the construction and infrastructure sector since my apprenticeship over 30 years ago. Throughout my career I have seen the power of infrastructure to transform lives. This report is an important step forward in ensuring that we make sure others see that power too.

Introduction

Infrastructure is fundamental to our lives

Although – or perhaps because – our infrastructure is of vital importance to our everyday lives, we often take it for granted. We depend on it for services that play a fundamental role in enabling us to be healthy, fulfilled and productive. It was only through the work of Victorian visionaries who conceived and built highly ambitious infrastructure schemes of the kind seen in Figure 1 that Britain was able to bring into being the first modern cities. The canals and railways brought people together in towns and cities, creating opportunity and wealth, while later schemes succeeded in transforming social conditions by providing people with plentiful clean water and sanitary living conditions. Four major outbreaks of cholera occurred in London between 1832 and 1866, killing tens of thousands of people. Once London's sewers had been completed by Joseph Bazalgette, no further outbreaks occurred.

Figure 1: Liverpool Lime Street station & Thirlmere Aqueduct, two examples of Victorian infrastructure still in use

Today access to transport and communications still determine every aspect of our daily lives. They frame the choices we make about the work we do, our leisure activities, and where we choose to live, and influence many other aspects of the quality of our lives. These choices give rise to social and environmental consequences themselves. These include, for example, poor health arising from sedentary lifestyles and polluted air in cities, climate change impacts from transport and energy emissions, and so on. Infrastructure solutions are also an important part of our response to these, for example developing renewable energy sources and more sustainable transport systems. At the same time, ensuring everyone in different areas and regions has access to the opportunities they need to lead fulfilling lives is an important part of building an inclusive society. Figure 2 shows Northstowe, a sustainable new town benefitting from a Guided Busway connection to Cambridge, and Spinningfields, a major employment centre which has benefitted from significant transport investment connecting Manchester City Centre to a growing labour market catchment area.

Figure 2: Northstowe, Cambridgeshire and Spinningfields, Manchester

Some sorts of infrastructure are important in more specific ways; for example, flood protection enables us to use land in certain locations in more productive ways by protecting life and property from the impacts of extreme natural events.

The past record of UK governments in embracing infrastructure investment as a means of influencing economic performance and social outcomes has been inconsistent, in contrast to our continental neighbours. There has been a positive shift in recent years, however – for example the establishment of a National Infrastructure Commission (NIC) and the planned publication of a new National Infrastructure Strategy in 2019. The emerging Industrial Strategy also has strong infrastructure themes.

Although our cities still rely on much of the infrastructure that was built in the Victorian era, we are once again entering a period of rapidly changing needs. If we are to respond to the opportunities and challenges of the 21st Century world, a visionary approach is called for once again. An important aspect of this is to plan and deliver infrastructure in ways that recognize its fundamentally *social* nature and the various ways in which this can be manifested.

Figure3: The Thames Barrier, which protects London from catastrophic flooding

The social nature of infrastructure

Sometimes infrastructure systems or individual projects become icons of the city or country in which they are situated, acting as sources of civic or national pride or symbols of collective identity.

They can enhance a city's brand or contribute to the local economy by offering a specific visitor experience, such as the Forth Bridge or the 'Electric Mountain' power station at Dinorwic in Snowdonia.

More broadly, much of our infrastructure offers a form of collective consumption that is partially or wholly independent of people's personal or household income. For example, high quality urban realm for walkers and cyclists is free at the point of use, while public transport fares are often set at levels deemed to be broadly affordable. High quality infrastructure, along with other public goods, can therefore reduce social inequality and contributes to a sense of an inclusive society. This will itself generate consequential benefits such as lower health, social security and policing costs associated with social exclusion.

Figure 4: High-speed rail systems such as the Shinkansen (Bullet Train) in Japan and TGV in France enjoy iconic status

Fundamentally, however, infrastructure is provided to meet the needs of individuals. It is nevertheless different from other assets because its provision and use is necessarily *social* in nature. None of us as individuals can choose the infrastructure that is provided for us, in the way that we can make choices about most goods and services, e.g. the food we eat or the laptop we buy.

As far as the individual is concerned, infrastructure is a given - decisions about its provision have to be made on our behalf, in a way that meets our collective needs.

This is because infrastructure has very high fixed costs that have to be shared amongst large numbers of people. In other words the unit costs of the services it provides decrease as the number of people sharing the total cost increases. Infrastructure 'cost sharing' opportunities are an important reason why people settle in towns and cities.

Infrastructure isn't therefore optimised to the needs of every individual – it has to be provided in a common way to many people. In the case of transport and communications, individuals respond

Figure 5: The Forth Bridge near Edinburgh serves both as a key rail connection and a tourist attraction

to the infrastructure that is available to them. For example, in choosing where to live, the ease and cost of getting to work will be an important consideration.

A transport improvement might enable them to choose a larger house in a quieter location that is further away from their job than they would otherwise have contemplated. Such decisions, however, don't just affect the people making them, but have important impacts on others, i.e. they have social impacts. Crucially, these social impacts vary between different types of infrastructure solution. Moreover they can be very significant factors in shaping the quality of people's lives and the environment, both positively and negatively - and therefore should be important considerations in decision making about infrastructure provision.

For example:

- Improved public transport services and provision for active travel within urban areas will both promote positive social and economic impacts, including healthier lifestyles, and also help mitigate the negative social impacts of urban road traffic, such as congestion related delays, harmful emissions, and accidents;

- Different types of energy production also have differential social and environmental impacts. Investment in technology and infrastructure to enable sustainable energy sources to replace fossil fuel use in industry, transport and domestic heating will generate significant social benefits both at the local and global level.

Figure 6: Two sustainable energy projects remote from major employment centres: Rhyl Flats Offshore Wind Farm and Dinorwig Power Station

Infrastructure decisions can also be part of strategies to shape social and economic outcomes in ways that promote a more socially cohesive and fair society. This includes making sure that particular groups in society are not excluded from social and economic opportunities and also reducing the gap in opportunities for people living in different places, both at the local and regional level.

For example:

- Outside urban areas, road based transport is vital for a wide range of personal travel needs as well as for goods transportation. The freedom roads provide is an important social benefit for many people. Many parts of the country have no realistic alternatives to road based travel and depend on high quality road communications for their livability and prosperity;

- Many of the locations of sustainable energy projects are remote from major employment centres and are close to areas with high concentrations of deprivation that are in need of regeneration, such as seaside towns. The high quality employment opportunities they generate, both temporary (construction) and permanent (operation and maintenance) represent an important source of social benefit, supporting local services and enabling people to plan a secure economic future in areas that otherwise offer relatively few such opportunities.

Infrastructure investment needs breadth of vision

In recent years there has been greater recognition that infrastructure investment has an important role in responding to political and economic challenges. We have also entered once again a period of rapid technological and economic change, the consequences of which cannot be fully anticipated. It is clear however that there are a number of important emerging themes that are bringing about some fundamental changes in our future infrastructure requirements.

Technological changes such as ever-greater digitisation and automation are radically changing lifestyles, industries, and working patterns, with resulting effects on infrastructure demands. Direct effects on infrastructure include the 'roads revolution' with such innovations as alternative fuels, autonomous vehicles, and smart motorways – see Figure 7.

Politically, the UK's upcoming departure from the European Union will bring with it a number of changes. For instance patterns of trade may change, reducing demands on some trade nodes and increasing them elsewhere. Skill and labour shortages are a possibility, so new infrastructure could improve economic integration of different areas, the development of a more skilled workforce and help to tackle under-employment and non-participation. Broadly speaking, if international frictions increase, action will be needed to decrease them domestically.

Issues of social and economic inequality including regional disparities are coming to the fore and targeted infrastructure investment offers a means to address this. Environmental issues are gaining prominence, both local issues such as air quality in big cities, and the global concern of CO_2 levels and potentially catastrophic climate change.

Figure 7: A traditional black cab next to the hybrid LEVC TX developed in response to TfL environmental guidelines and a Waymo self-driving car undergoing testing in California

To make the most of the opportunities and address the challenges that these issues will generate, we will need to invest for the next generation of infrastructure. The social impacts of infrastructure or 'externalities' mean that competitive markets on their own cannot be relied on to provide a socially or economically 'optimal' outcome. Infrastructure will continue to need to be planned and regulated. Moreover, the very nature of infrastructure makes the task of coming to high quality decisions about its future provision highly complex and challenging.

For example, since there are long time lags to plan and construct it, decisions need to be made not with regard to current demand but forecast demand, which is often highly uncertain. This is further complicated by the fact that there are often large jumps between practical levels of infrastructure capacity. Once built, resources are committed since life cycles are long and most infrastructure has little or no alternative use value. There is sometimes therefore a risk that unforeseen technological changes (or other factors) will render a particular scheme obsolete, reducing the benefits or shortening its economic life. Some of these issues are exemplified in the example of Heathrow Airport. Having exhausted all the feasible means of incrementally expanding the airport, the controversial question of whether or not to proceed with building a third runway has had to be decided. Recent decisions of a similar nature which are now being implemented include HS2 (on which construction is underway) and Crossrail (due to open in 2019). Northern Powerhouse Rail and Crossrail 2 are decisions yet to be taken, but which need to be – to enhance the North's intercity connectivity and rail capacity into and out of London respectively.

It is important that these inherent difficulties are not seen as a justification for inaction. A common characteristic of infrastructure is the unknowable nature of many of the future *benefits* it brings, which means there is a significant degree of 'upside risk'. No one could have fully anticipated how canals and railways - the new communications technologies of their day – would unleash dynamic economic and technological forces that saw the rapid industrialisation and urbanisation of the nation during the nineteenth century, together with accompanying social transformation. They would not have been built if decisions were made on the basis of modern day cost – benefit analysis. They required however confidence and vision.

In this light there appear to be parallels between the complex impacts the building of the canals and railways had in the UK in the 19th century and the potential impacts of digital and modern transport infrastructure today. If we fail to invest in them adequately we risk foregoing a stream of technological and social changes that can't at present be foreseen. Despite the risks and difficulties it is important that we are bold and visionary. Although there is a vital role for the private sector as a provider, markets alone will not bring forward the right infrastructure solutions. Coordinated long term planning led by strong public sector sponsors is needed.

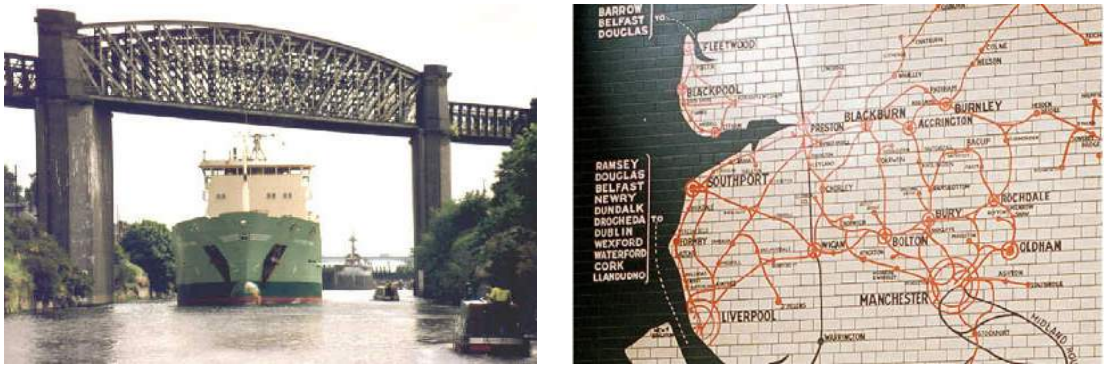

Figure 8: Manchester Ship Canal and 19th Century map of the Lancashire and Yorkshire Railway's network

Railways and canals in the Nineteenth Century

These technologies offered means of reducing the costs of transport but economies of scale were an inherent feature. Lower unit costs could be realised through consolidating people and goods for the 'trunk haul' elements of their journeys while the 'feeder' trips prior to and following these remained slow and costly, still relying on horse drawn vehicles.

These new 'lines of route' consequently offered greatly improved economic opportunities for people and firms willing to locate close to them, and they were critical in the transformation of Britain from a largely rural society into an urban, industrial one. These transportation networks were therefore fundamental drivers of economic growth, together with the technological innovation and urbanisation needed to facilitate it.

Scope & pupose of report

Understanding how infrastructure affects people in different ways is vital to good investment decisions. The purpose of this report is to explore the social impacts of infrastructure. Our aim is to go beyond the usual approach of estimating the 'first order' economic impacts and instead to consider how the benefits transmit through society to affect people's lives in different ways.

The following chapters explore various social benefits through examples and case studies, organised around the following three themes:

Delivering homes – improving opportunities for people to live in locations offering healthy and sustainable lifestyles with access to good employment opportunities and supporting Britain's growth.

Health and social inclusion – mitigating negative externalities from personal transport, facilitating active and inclusive transport, using digital infrastructure to create economic and social opportunity, ensuring rapid technological progress benefits all places and people.

Regional rebalancing – using transport infrastructure and investments in clean energy or construction to accelerate growth or isolated or underperforming areas of the country.

1. Unlocking homes to support competitive cities

Solving Britain's 'housing crisis' is not simply a question of building a particular number of new homes, but of ensuring that there are opportunities for people to have access to an appropriate range of different kinds of housing *in the right places*. Issues of affordability – i.e. average prices or rents as a multiple of incomes – are concentrated in the south of England, particularly in London, its commuter belt, and in successful cities such as Oxford and Cambridge. There are different problems with access to housing in other parts of the UK. For example a shortage of high quality family housing with good access to major employment centres in the North may constrain its future growth potential.

There is evidence that in London properties within 500m of an Underground or National Rail station command a 10.5% price premium relative to those 1,500m or more away; people are willing to pay extra for convenient access to city centres.[1] Given that development opportunities in London are constrained, it is unsurprising that there is a strong price response. In less supply-constrained areas, transport infrastructure could lead to increased supply as well, expanding access to employment in big cities beyond its current extent, supporting their growth to the benefit of the whole country and allowing workers a greater choice of places to live whilst still enjoying a reasonable commute to productive employment.

The role of cities and the importance of agglomeration

In an ever more services- and knowledge-based economy, cities are home to the majority of high-productivity jobs in knowledge-intensive sectors of the economy, and therefore to rapid growth. Large cities house almost 40 per cent of the world's population but generate nearly three quarters of its economic output, and their success is expected to continue. McKinsey projected that the top 600 cities will generate more than 60% of global growth to 2025.

Fundamentally, cities are a mechanism for supporting interaction between people through a high density of employment. This generates productivity-enhancing agglomeration economies, which can be broadly categorised as follows:

- 'Learning' through knowledge spillovers, as proximity of firms in the same or similar industries facilitates the exchange of best practice and the transfer of skills as employees move between companies;
- 'Matching' of jobs to workers, suppliers to firms and firms to customers. A high density of related firms means that, for example, workers can easily move to employers whose requirements best fit their skills;
- 'Sharing' of risk, opportunities for specialization, and access to intermediate inputs. For example as suppliers of intermediate inputs locate close to clusters of firms, they will enjoy lower average transport costs and increasing returns to scale.

Agglomeration effects are critical in determining how places develop. As people respond to the availability of transport and communications infrastructure and reap the benefits, a virtuous circle of agglomeration and growth takes place. In other words, there are strong feedback processes between demand and supply for transport infrastructure, as illustrated in Figure 9.

1. *House Price Index Special Report*, Nationwide, 2014. Cited in Land Value Capture, Final Report, Transport for London, 2017.

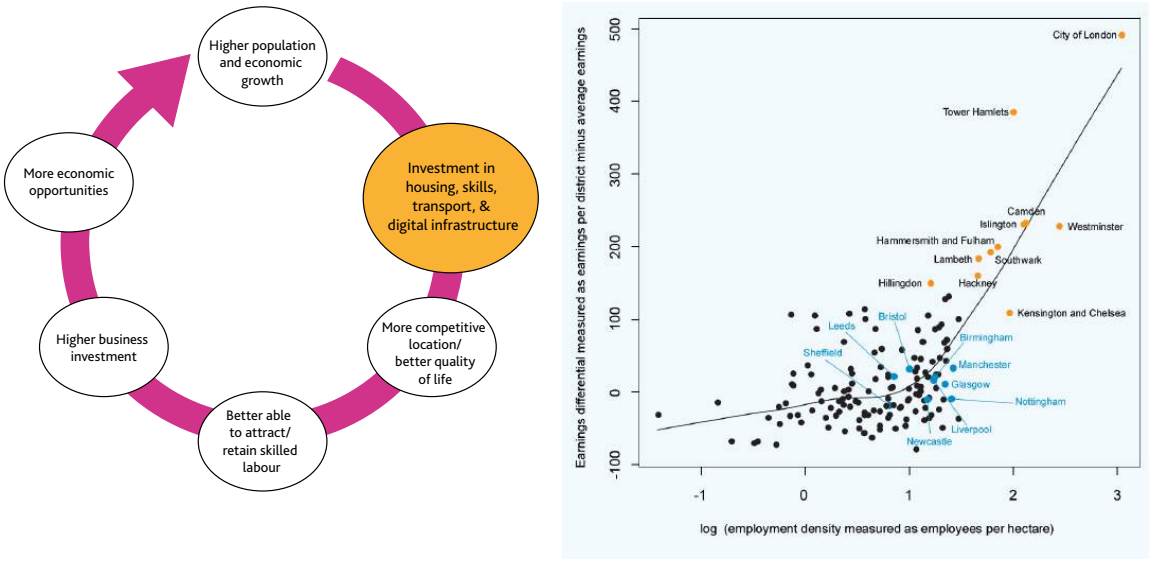

Figure 9: (a) interactions between location, investment, and economic growth; (b) relationship between employment density and productivity in UK employment centres.

The sheer scale and density of such jobs in London generates agglomeration benefits that cannot currently be replicated elsewhere as Figure 9 (b) illustrates. This shows the relationship between productivity, as measured by average earnings, and employment density in 100 UK employment centres. None of the UK's regional cities are currently large enough to offer agglomeration benefits on a scale that could make them globally competitive and diverting growth in London's global city employment to them is not a feasible option.

This is consistent with work undertaken by TfL to investigate whether a more decentralised model of economic growth would offer any savings and

"…even if it was in theory achievable there would be negative economic consequences with the loss of productivity from reduced agglomeration economies. Over time these would significantly outweigh any savings from lower costs of infrastructure. There would also be adverse environmental effects including higher car mode shares and more diverse patterns of transport that are difficult to serve through public transport. Overall, the firm conclusion is that "investment in density offers good payback" and there is no suggestion that diminishing returns will appear as densities increase. This is at the heart of the case for further investment to support the growth of the CAZ [London's Central Activities Zone]."

Jobs in 'Knowledge Intensive Business Services' (KIBS) are the most susceptible to agglomeration economies. Figure 10 shows that London hosts far more of these jobs than any other UK city and also that employers seek agglomeration economies in London more vigorously than elsewhere, as the data on the relative densities of KIBS jobs in city centres illustrates. Given the much higher property and other costs of locating in central London, firms must perceive some very significant benefits from locating there.

Figure 10: Numbers and densities of private KIBS jobs in major UK cities. Source: "Investing in City Regions", TfL & TfN, 2014

Therefore London's success in national and international terms should be celebrated and supported. Much of its growth is additional at the UK level as it isn't competing for activity and workers with the regional cities but with cities such as New York and Hong Kong. This isn't to say that the disparities between the capital and the regional cities should be accepted – rather that 'regional rebalancing' should not just be about shifting high value activity away from London which would be counter-productive in terms of its 'net national' impact. Instead it would be sensible to make the regional cities more internationally competitive – their individual sizes are at the heart of the issue, so economic integration with each other and with London is an important part of the answer. Maintaining London's role as a global city and growing its regional peers are therefore complementary objectives, not mutually exclusive.

HS2 will bring improved connectivity and greater economic integration between London and the regional cities, enabling them to harness their comparative advantage. In such a scenario London could, for example, specialise even more strongly in the highest value activities and cities such as Birmingham, Manchester, Leeds and Liverpool could seek to grow their city centre knowledge economies in complementary activities. A promising way forward would be to develop a Randstad type economic network of competitive, well-connected cities that can grow the economic mass of regional cities by integrating them both with London and with themselves, harnessing the capital's world city status.

The inter-urban connectivity achieved through a major infrastructure investment like HS2 can facilitate interaction and agglomeration between cities, but intra-urban connectivity, infrastructure at the level of the individual city, also matters. London supports the level and density of employment it does due to decades of continuing investment in transport infrastructure. Per-capita transport investment is higher in London than any other region of the UK. Though this regional disparity is a source of controversy, high investment is essential for the capital's global city role. The railway network within and beyond London allows thousands of people to commute to their place of employment every day from a wide catchment area which includes much of eastern and south-eastern England. Housing affordability issues indicate, however, the importance of unlocking further housing in areas with good access to jobs.

Unlocking the full growth potential of regional cities must also rely on a major increase in transport investment; Manchester now has the worst traffic congestion of any city outside London as identified in the National Infrastructure Commission's recent 'league table', acting as a drag on its ability to attract employment growth to the centre.[2] Upgrading congested roads and investing in public transport could unlock potential for Manchester and other cities to develop further. Equally, improved urban transport is vital to the UK's regional cities (and other high-growth locations such as Oxford and Cambridge) to expand the range and quality of housing available to current and future prospective workers.

2. https://www.nic.org.uk/news/manchester-tops-traffic-congestion-league/

The manifestation of agglomeration benefits that will be unlocked through infrastructure investment that enables our cities to grow will be improved opportunities of various kinds at the level of the individual, which include the following:

- More productive and interesting work that enables people to develop their skills and knowledge in ways that would not otherwise be possible and gives them higher incomes;
- Higher quality housing for city workers in locations that offer a higher quality of life, such as suburbs or rural areas, whilst still allowing for a reasonable commute into work;
- Better services for local communities where skilled commuters live. As they spend their earnings and generate economic multipliers a positive cycle of development can result.
- Enjoyment of specialised cultural and leisure opportunities that are only available in big cities – quality of life factors such as these are becoming more important in employment decisions as documented in *The Flat White Economy* by Cebr founder Douglas McWilliams.

In the section that follows we examine how infrastructure at the regional level will help to unlock housing-led growth in and around the high value employment centres, enabling them to reap greater economies of agglomeration and become more internationally competitive.

Connecting and growing northern cities

The The Northern Powerhouse concept was developed to enable the North of England to realise its full economic potential, helping close a long standing productivity gap between it and other parts of the country that has resulted from long term structural shifts in the UK's international competitiveness. It is predicated on the existence of significant opportunities that can only be realised through planning and coordinating major, long term investment to achieve a realignment in the North's economic geography. The Northern Powerhouse Strategy was first published in 2016 and is due to be refreshed in 2019.

A key part of this strategy is transport investment to encourage agglomeration in the North's major cities and housing development around them. Lichfields estimated that the North needs 500,000 houses over the next ten years alone to support ambitious growth of the kind envisaged in the 2016 Northern Powerhouse Independent Economic Review (NPIER), with most of these in the main city regions – the Leeds and Manchester regions for instance account for 23% and 20% respectively of the Objectively Assessed Need.[3]

Northern city regions, most notably Manchester, have succeeded in developing dynamic, knowledge-based economies in and around their city centres and there are further strengths in a range of sectors across northern regions. In terms of comparative economic performance however, the North continues to lag the UK and peer regions on the Continent, e.g. the Randstad in the Netherlands and Rhine – Ruhr in Germany, particularly in terms of productivity.

Figure 11: GVA per employee, economic inactivity by selected NUTS 1 regions, England. Produced using ONS data.

The NPIER identified a need to address both relatively low economic participation rates and low worker productivity, which contribute roughly equally to the overall gap in output per capita; the disparities between the northern regions and England (particularly London and the South East) are illustrated in Figure 11 – the combination of lower productivity and higher economic inactivity means that the northern regions are significantly lagging England, especially its most successful regions in London and the South East, on GVA per capita. The NPIER set out a number of 'people' and 'place' related reasons for the existence of this gap. Investment in skills and infrastructure – including improved transport capacity and connectivity - within a framework of integrated spatial and economic policymaking is needed to address these issues, and should lead to a more consistently competitive and inclusive economy in the North. In particular, improving both intra and inter–urban transport will promote the economic integration of outlying settlements into wider city region economies and of labour markets between the city regions.

3. *Future Housing Requirements for the North*, Nathaniel Lichfield & Partners Ltd, 2017 (on behalf of Homes for the North)

The North's poor connectivity and resulting lack of agglomeration is a legacy of land uses focused on achieving strong single industry localisation economies with little need for interaction between settlements. This means that many areas, often containing sizeable settlements, have historically had poor connectivity, and are therefore less economically integrated with neighbouring areas than would be expected on the basis of their geographic proximity. These 'left behind' small- to medium-sized post-industrial towns can realise significant opportunities through connections with nearby city regions, making them more attractive for business investment, enhancing visitor economies, and making them desirable locations for commuting into big cities – both benefitting existing residents through expanded employment opportunities and attracting new, affluent residents who spend money earned at city-centre jobs in these towns, supporting their economies.

Northern cities will be affected both by HS2 and the proposed Northern Powerhouse Rail (NPR). NPR involves the connection of the west-east trans-Pennine corridor from Liverpool to Hull, and will be accompanied by road investment, with the government's 2015 Road Investment Strategy touting a road tunnel through the Pennines between Manchester and Sheffield as a possibility. The impact of these road and rail projects will be to reduce journey times both within the North and from London to the North and vice-versa.

Figure 12: Northern Powerhouse Rail - planned upgrades, new lines, and connections to HS2.

Figure 12 shows in detail the plans for Northern Powerhouse Rail. The most substantial investments including entirely new lines are planned in the east-west direction to better integrate Liverpool, Manchester, Leeds, Sheffield, and Hull with each other and connect them to Manchester Airport. A line upgrade to the north of Leeds improves the connection to Newcastle. Figure 13 shows how these improvements will increase the numbers of people who can access these hubs. Transport for the North estimates that once NPR is delivered 1.3 million people in the North will be able to access four or more of the largest economic centres within an hour – up from just 10,000 today.

The 2018 Budget announced up to a further £37 million to support the development of Northern Powerhouse Rail, building on £300 million already committed to ensure HS2 infrastructure can accommodate future potential Northern Powerhouse Rail services. The deposit of the HS2 Phase 2B Bill has been pushed back to mid-2020 to make sure HS2 takes full account of the emerging vision for Northern Powerhouse Rail.

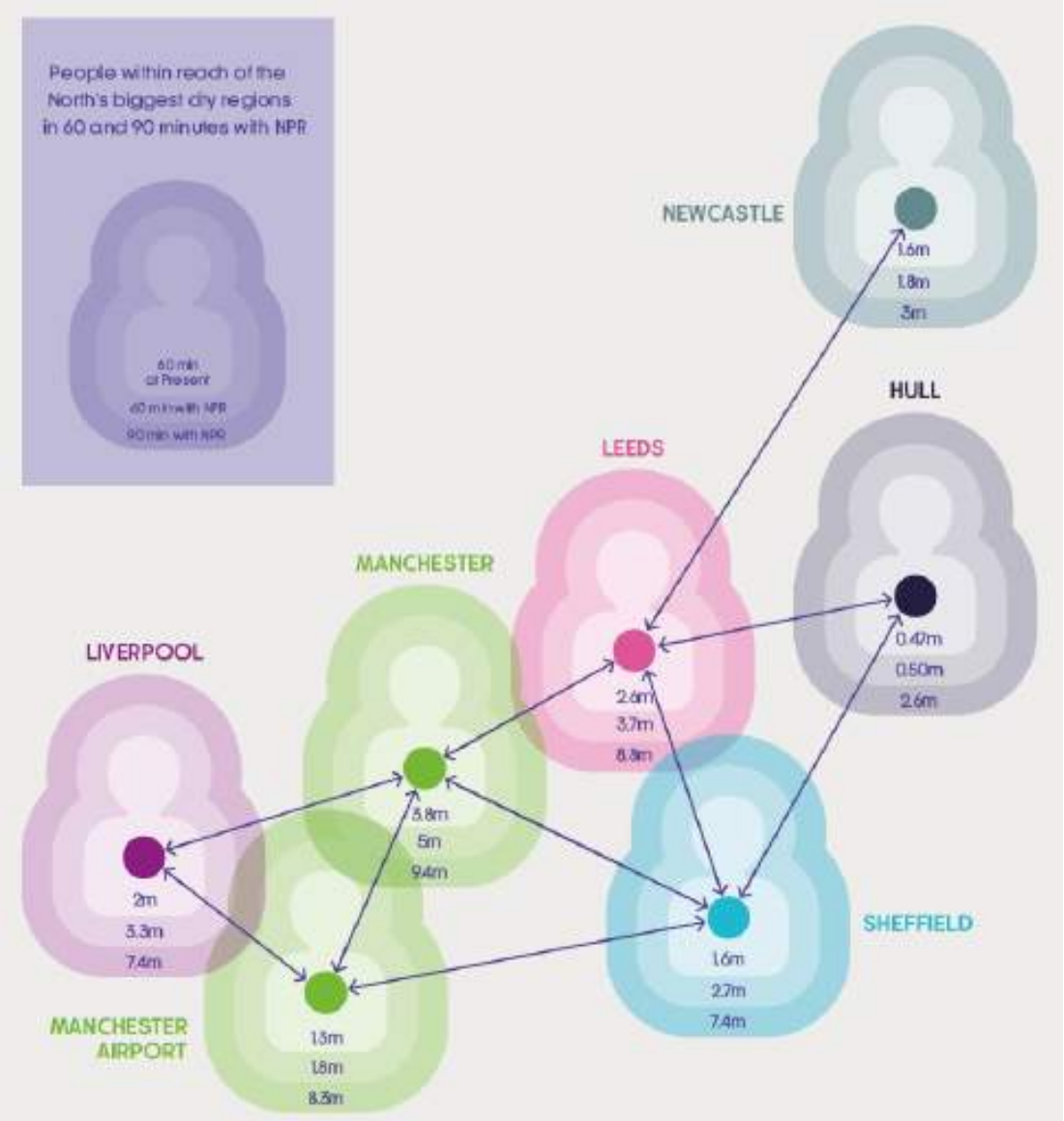

Figure 13: Northern Powerhouse Rail expected connectivity impacts. Source: Transport for the North, Northern Powerhouse Booklet

Lichfields emphasises the importance of attracting and retaining skilled workers. Quality housing with access to employment is central to this. At the level of the individual family, better connecting big cities that offer a range of job opportunities can allow a couple to live together but commute to different places in order to access jobs that best match their skill sets. Improved transport infrastructure will also bring new areas within the commuting radius of big cities, spurring housing investment in rural areas and small towns which are currently sparsely developed, allowing city workers to live in desirable yet affordable locations. Of course, all of this comes with wider economic benefits as better job matching improves productivity and other big city agglomeration economies are realised.

Some struggling northern towns are beginning to see something of a renaissance; Burnley for example is enjoying strong growth in digital technology including 3D printing for the aerospace, automotive, and medical sectors. Without transport investment, this success and the chance to reverse a trend of decline may be held back by a lack of commuting and freight capacity.

Improved connectivity within & beyond the Midlands

Whilst the Midlands is at the heart of the UK economy – home to over one-sixth of its jobs – and a major hub for manufacturing and logistics its productivity currently lags behind the national average. **Midlands Connect**, a partnership of LEPs, transport authorities, and businesspeople, estimates that closing this gap would grow the Midlands economy by £25 billion. Though achieving this would require progress in a wide range of areas, for instance skills development, Midlands Connect claims that one fifth of the required GVA per worker and 300,000 new jobs could be delivered through the direct outcomes of transport infrastructure investment.[4] This growth is contingent on attractive housing opportunities being available for prospective workers in locations with access to cities like Nottingham and Birmingham. In turn this necessitates an expansion of the employment catchment areas of the city centres in order to improve access to existing housing in outlying areas and open up new areas for residential development.

Further to access to better housing opportunities, a range of other quality of life improvements are being targeted – for example minimising the time commuters spend on congested roads or crowded trains, improving access to leisure activities, and reducing negative impacts of travel like noise and pollution.

The Midlands already has some successful urban transport schemes. **Nottingham Express Transit** is a 32km, 51-stop system covering Nottingham and its neighbouring towns. It was opened in 2004 and a second phase in 2015 more than doubled its size, extending coverage to the south of the city.

Figure 14: Nottingham Express Transit and the West Midlands Metro, urban transit systems providing intra- and inter-urban connectivity to their cities

In future, the southern part of the NET may be extended further to Toton, where a new **East Midlands Hub** station is planned as part of HS2. Thus the tram network and its access to Nottingham city centre would be integrated not just with the existing rail network (as it already is, at Nottingham station) but with the high-speed network, significantly improving connectivity to Birmingham, Sheffield, Leeds, and London. This will include a route to **Birmingham Airport**, which in 2026 will become the UK's first HS2-connected airport, and is itself well-connected to the Birmingham region via the **West Midlands Metro** as well as other rail services.

4. *Midlands Connect Strategy: Powering the Midlands Engine,* March 2017

Nottingham Express Transit: environmental, economic, and accessibility benefits

The environmental statement preceding the construction of NET Phase Two outlined a number of social and other benefits resulting from the initial scheme:

An estimated 30% of passengers transferred from cars or made use of park and ride – consolidating demand onto the tram and easing congestion in the crowded city centre.

Congestion relief improves quality of life for commuters and residents, ensures the city reaches its growth potential, and reduces pollution and casualties.

The fixed and therefore relatively permanent nature of tram infrastructure boosts confidence and certainty for businesses, boosting investment.

Trams have wide doors and low floors making them highly accessible for the elderly, disabled, and parents with young children.

Phase Two connected deprived parts of Nottingham with high economic inactivity and low car ownership to key employment centres like the hospital and both of the city's universities.

The impacts of such schemes will have a cumulative effect on locations like Nottingham and Birmingham. They will have wider effective commuting radii and better international connectivity, making the Midlands a more desirable location for inward investment and helping to close the earlier-mentioned productivity gap through an expanded labour market catchment area and agglomeration economies. This could lead to a range of beneficial socioeconomic outcomes, including regeneration in struggling areas. Where journeys move from road to rail as a result of the improved connections, wider environmental outcomes will also be improved. Greater connectivity may also help in the fulfilment of other productivity objectives, for example by connecting residents with educational and training opportunities.

The West Midlands is expected to be the fastest growing regional economy outside of London and the South East from 2017-2026 and is increasingly attractive to inward investors, having attracted 151 Foreign Direct Investments (FDI) projects in 2016/17, up from 57 projects in 2011/12. This inward investment created more new jobs than in any other region in the UK outside of London (over 6,500 jobs in 2016/17).[5] In addition to large global companies, the West Midlands is home to a thriving ecosystem of small and medium-sized businesses. More than 17,000 new companies were registered in Birmingham in 2016, the most of any UK city other than London. The city's growing digital cluster is bolstered by having access to eighteen universities, all within an hour's drive.[6]

5. *EY UK Regional Economic Forecast*, Issue 3: Winter 2017-18

6. *TechNation 2017*, Tech City

The South Wales Metro - connecting the Valleys to urban centres

The South Wales Metro project aims to vastly improve the currently slow and relatively infrequent heavy rail service through conversion of the Valley Lines to light rail operation and offering faster, quicker and higher capacity services as part of a more thoroughly integrated public transport offer across the region.

Settlements in the Valleys have not fully adjusted to deindustrialisation and tend to have weaker local economies and relatively lower demand for housing. Improving connections to the more dynamic Cardiff City Region will benefit residents of the relatively deprived Valleys by giving them better access to employment and leisure opportunities and while also providing improved access to affordable housing for Cardiff's growing workforce. Existing rail infrastructure will be enhanced and bus and rail will be integrated further with each other as shown in Figure 15. The first phase was approved for development in 2013 and the investment is planned to be delivered incrementally by 2030.

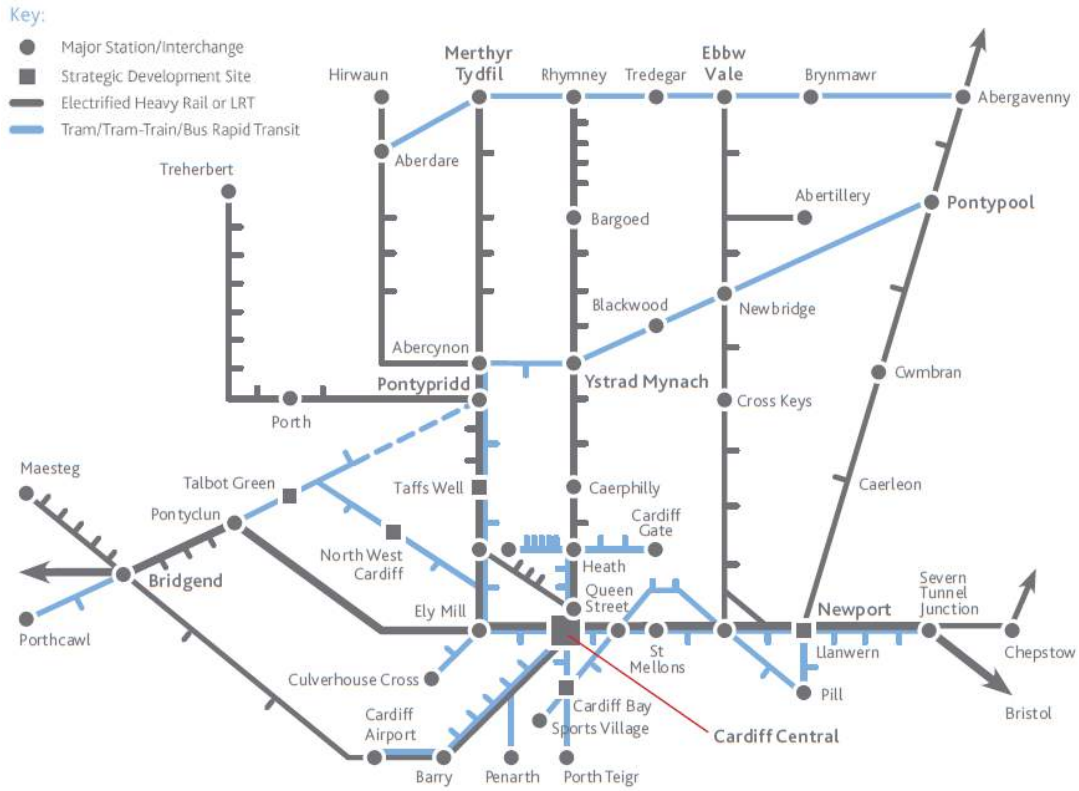

Figure 15: The proposed South Wales Metro Network (Source: Welsh Government)

Connecting up the Cardiff City Region, which contains about half of Wales' almost 3 million population, in this way could bring about a range of further benefits, including:[6]

- Broadening the range of jobs which residents can conveniently access by public transport will improve economic activity in remote areas and allow access to better-paid and/or more fulfilling employment.
- Commuters will benefit from shorter journey times, increased frequency, and increased train capacity with new carriages, making the commute more pleasant and flexible.[7] Objectives include: 95% of journeys on new trains by 2023, overall service capacity boost of 65%, and end-to-end Internet access on 85% of journeys.[8]
- Establishing centres other than Cardiff as highly-connected places with access to a large labour market, triggering private sector investment and developing the economic base beyond Cardiff. Housing development around metro stations in these towns could also result.
- Provision of cycle storage and rental facilities across the network will encourage active travel, with long-term positive health impacts.
- Established businesses will benefit from an increased effective density of employment, boosting productivity.
- Reduced road traffic and therefore CO_2 emissions, road accidents, and deaths. Additional road capacity for freight would be opened up.

Apart from these benefits from the operation of the system, the construction could also deliver significant productivity and regeneration improvements. Half of all new trains are to be assembled in Wales, and KeolisAmey, which is contracted to operate Wales and Borders rail services from October 2018, will recruit 30 new apprentices for each year of its contract.

6. A Cardiff Capital Region Metro: Impact Study, October 2013, Welsh Government
7. Merthyr Tydfil and Ebbw Vale for example will receive three or four trains an hour rather than one or two
8. https://www.bbc.co.uk/news/uk-wales-44316772

The Oxford-Milton Keynes-Cambridge corridor: the UK's Silicon Valley?

Conurbations other than big cities are also successfully serving diverse and innovative sectors of the economy and facing their own transport and housing challenges. To the north and west of London's greenbelt, the Oxford-Milton Keynes-Cambridge corridor hosts 3.3 million people, two world-leading universities, and a concentration of knowledge-intensive businesses and skilled workers. As with the intersecting London-Stansted-Cambridge corridor, the industries concentrated here are innovative and in sectors likely to see strong growth in the future – medicine, life sciences, biotech, and artificial intelligence including autonomous vehicles. Crucially, the corridor is not competing with the rest of the UK for them; it is competing on a global stage with its counterparts such as Silicon Valley and the Massachusetts Bay in the United States, Greater Munich in Germany/Switzerland, the Øresund in Denmark/Sweden, and Singapore. In a list compiled by fDi Intelligence of the European cities most attractive to investors, Cambridge placed 10th – an impressive achievement given its size, with Zurich, Munich, and Frankfurt the other non-capital cities in the top 10.[10]

Housing and transport investment in the Oxford-Milton Keynes-Cambridge corridor

An opportunity to boost collaboration between world-leading bioscience clusters and investment locations established around the UK's leading universities.

Connecting residents across the corridor to employment centres, enabling workers to live in a choice of desirable locations with a wide range of employment opportunities.

Shorter, more reliable, and comfortable commutes by both road and rail.

Housing and transport issues are evident though, potentially preventing the future growth of high-productivity, knowledge-intensive industries in Britain along with the high-quality jobs, supply chain impacts, and economic multipliers they bring. It is no coincidence that Oxford and Cambridge are now two of the least affordable cities in the UK, as is clearly illustrated in Figure 16, and are suffering increasingly severe labour supply constraints.[11] Transport links within the corridor are inadequate – in common with much of the South East poor orbital connectivity limits the potential for interaction between city centres and agglomeration effects and constrains the housing options available to prospective workers. Therefore planned interventions to ease these constraints could deliver substantial and widespread benefits.

The National Infrastructure Commission has identified a need for 1 million new homes in order to maximise the area's potential. The government has started work to meet this goal, for instance agreeing a deal with Oxfordshire which commits the county to a target of 100,000 homes by 2031. Radical options such as new garden towns (see Garden City Principles box) are also under consideration.

10. *Findings and Recommendations of the London Stansted Cambridge Corridor Growth Commission*, London Stansted Cambridge Corridor Growth Commission, July 2016

11. The ratio of median house price to earnings is 13:1 in Cambridge and 12:1 in Oxford. The national average is 8:1.

The opportunity to unlock new housing supporting the corridor's expansion will help to make the case for transport infrastructure investment, where major projects are already being planned in both road and rail:

- The Oxford-Cambridge Expressway would see a dual carriageway constructed between the A34 at Oxford and the A14 at Cambridge – this could significantly reduce journey times on a route where A-roads are meandering and often single carriageway. Five committed RIS 1 schemes meet much of the requirement but there is an outstanding gap between the M1 and M40.
- East West Rail is a proposed strategic rail connection which would run from Oxford to Cambridge via Bedford (with a branch to Milton Keynes), then on towards Felixstowe and Norwich in East Anglia. It would largely use existing and mothballed lines, with some new construction required on the central section.

In their report for the National Infrastructure Commission, Cambridge Econometrics and SQW investigate evidence for the corridor's latent economic potential that might be unlocked through infrastructure investment.[12] They find that the bioscience clusters based around the universities in Oxford and Cambridge are both world-leading in their own right – unsurprisingly, given that the universities are ranked 1st and 2nd in the field globally. There is little evidence of collaboration between the two, which raises the question of how much better they might do were the links between them stronger. Access to London – its financial institutions, research capabilities, and labour markets – are identified as important factors in the strength and growth of the Cambridge cluster. Few companies operate across the east-west axis of the (Oxford-London-Cambridge) 'Golden Triangle' however. Better connections could improve networking, collaboration, and talent retention (by enabling the development of careers across multiple employers) along it.

12. *Cambridge, Milton Keynes, Oxford, Northampton Growth Corridor: Final Report for The National Infrastructure Commission*, Cambridge Econometrics and SQW, November 2016

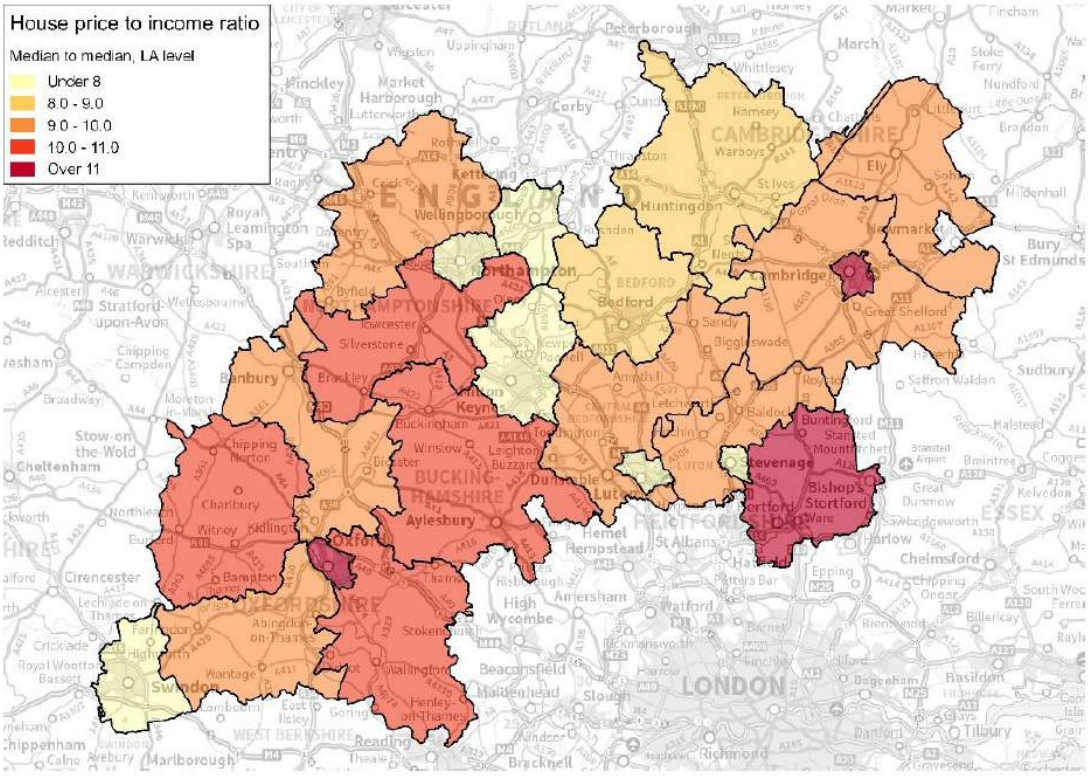

Figure 16: Oxford-Milton Keynes-Cambridge Corridor with house price to earnings ratio (Source: Savills)

The benefits of the investment in housing and transport infrastructure that is envisaged would be transformative. The further growth of successful, productive industries would grow the economy and help to address the UK's long-standing productivity issues. For those working in the corridor, the result would be more affordable housing, a higher quality of life, shorter and better commutes into work, and easier access to the rest of the corridor and country via an improved transport network.

Garden City Principles

Traditionally, new housing is provided through piecemeal urban in-fill or building over scarce green spaces in existing settlements. This can provoke local opposition and lead to low quality, poorly-planned housing without proper infrastructure. Lack of amenities and public or active transport provision in such developments results in car dependency, contributing to congestion and unhealthy lifestyles. An alternative development model is the building of new settlements according to Garden City Principles.

The Town and Country Planning Association (TCPA) describes a Garden City as 'a holistically planned new settlement which enhances the natural environment and offers high-quality affordable housing and locally accessible work in beautiful, healthy and sociable communities'. The principles for their delivery include:

Imaginatively designed, genuinely affordable homes with a mix of types and tenures

Provision of employment land to promote a range of jobs within easy commuting distance

An environmental emphasis, with green spaces and use of low-carbon technology

Integrated, accessible transport systems to encourage public and active transport

Settlements in the Oxford-Milton Keynes-Cambridge corridor built under Garden City Principles offer a route to delivering new housing to support the corridor's growth with a high quality of life for residents and avoidance of the issues associated with other development models. Prominent examples of garden settlements are Letchworth and Welwyn Garden Cities. The principles were often compromised in later New Towns. They are however being revived in the highly constrained Stansted-Harwich corridor in North Essex; construction on three new communities providing up to 43,000 homes over the next 50 years could begin as early as 2021. Poundbury in Dorset is a recent example of a new settlement carefully planned to encourage non-car journeys and include green spaces.

2. Healthy, sustainable places & inclusive growth

The last chapter showed how infrastructure investment contributes to competitive places. Realising the benefits of agglomeration to grow productivity and competitiveness relies on moving people around to interact with each other and drive economic integration between locations.

Figure 17: Amsterdam, a city renowned for extensive public and active transport provision; Manchester, a city which has relatively extensive provision of trams through its Metrolink but still experiences serious congestion issues

Infrastructure investment, however, can influence not only which journeys are taken but the means by which they are made, with important social consequences:

- Personal travel modes have their own social impacts – both positive and negative – so modal choice determines the extent to which these impacts manifest themselves, with implications for global climate change, local air quality, and individual health and wellbeing. Quality public transport provision also reduces congestion, driving the agglomeration economies described in the previous chapter.
- These decisions have implications for spatial organisation, for instance how cities are organised, and therefore for the quality of life of their residents and workers. These impacts affect place-based competitiveness. For instance railway stations used to be associated with negative social impacts on the areas around them, and busy, polluted roads still are. As trains have become cleaner, areas in the vicinity of busy stations have been opened up for high-quality, high-density residential and commercial developments.
- Some modes of transport are more socially inclusive than others in terms of who can access and afford them – all groups within society need to be considered in infrastructure provision. If transport provision is not inclusive, it risks excluding those who cannot access conventional private transport – the poor, disabled, young, and elderly – from employment, educational, and leisure opportunities.

While car use provides valuable individual benefits, it imposes costs on others. Not least, where car numbers in combination with other vehicles exceed road capacity, congestion results, reducing the benefits that roads offer and the appeal of the places they serve. Petrol- or diesel-driven cars, which remain dominant for the time being, create pollutants which damage local air quality and cause climate change. Furthermore, cars are associated with high accident rates relative to other modes – loss of life or serious injury represent a catastrophic human cost.

There are three broad approaches to addressing the social costs which can arise from car use:

1) Upgrading road infrastructure to improve capacity or reduce congestion

2) Supporting the use of alternative types of car associated with lower pollution (electric vehicles) or fewer accidents (autonomous vehicles)

3) Providing high quality alternatives to car use, either public transport or active transport. For instance investing in railways for long-distance journeys and dedicated infrastructure for buses at the urban or regional levels. For shorter journeys within cities, infrastructure to support active transport can be provided, removing both private and public motor vehicles from the roads, reducing air pollution, and improving people's health.

Naturally there will always be a role for private personal travel, the convenience of which is highly valued by users – but a balance is needed and interventions which expand public and active transport modes can reduce congestion and make roads better for all users. While car use will remain essential for meeting some people's mobility needs, there's a strong case for investment to enable attractive alternatives, particularly in and around urban centres.

High quality public transport and provision for active travel to improve intra-urban connectivity promote:

- Greater participation in employment or leisure as access to a range of opportunities is improved, including for those with no access to a car such as the elderly, disabled, or deprived;
- Reduced personal cost of travel as it is made less costly and stressful;
- Healthcare savings as regularly walking or cycling improves fitness;
- More compact forms of residential development, which promote viable local services, social inclusion, preservation of open space, healthier lifestyles, greater social interaction and better security in the public realm, and more vibrant local businesses.

These will in turn have further positive social benefits – lower healthcare and policing costs and reduced pressure on welfare spending. People can be connected to one another digitally as well as physically. The advent of the Internet has already transformed society and the economy in positive and surprising ways far beyond those initially anticipated, in much the same way that the connectivity provided by canals and railways once brought about changes that could not have been imagined. These have reshaped the competitive structure of the economy, breaking down information barriers and massively shifting power from producers to consumers. For example:

- A revolution in retail including e-commerce, more bespoke products, shorter lag times, and in some cases reshoring of production in order to be closer to consumers.
- Opportunities for remote or home working and the resulting rise of 'digital nomads', i.e. footloose digital workers.
- Real-time, face-to-face communication across the globe.

These examples suggest that there is a strong case for being visionary and ambitious in future digital infrastructure investment to ensure that dynamic, unanticipated benefits like these are fully realised in the future.

Estimating the social benefits of cycle hire in London

Switching shorter trips within urban areas – i.e. journeys to and from work – to 'active modes' (walking and cycling) has positive health and environmental impacts. A 2017 study into the effects of active transport policies in Barcelona confirmed this. Between 2009 and 2013, the number of walking trips increased by 26.7% and the number of cycling trips increased by 72.5%. Injury rates for pedestrians and cyclists decreased – by 26.7% and 1.4% respectively.

This shows that modal shift away from cars can make active transport safer. These are only the easily measurable and quantifiable impacts of active transport – it also reduces air and noise pollution, and those engaging in more daily exercise are likely to realise significant health benefits in the long term. Where infrastructure such as cycle lanes or improved pavements can support walking and cycling as an alternative to motorised transport (private or public), the benefits described here could be replicated elsewhere. For those continuing to use the roads once these facilities are put in place, any reductions in congestion will save them time, improve reliability, and prevent stress.

World Health Organisation-based estimates of deaths prevented by London Bike Hire Scheme

Since their introduction in 2010, hired bikes have become a ubiquitous sight in London. The scheme now covers 100km^2 of the city, with 800 docking stations and 11,000 bicycles. Convenient, affordable cycle hire, strategically located near attractions and public transport links and with a strong presence in key employment centres, has made cycling an increasingly viable option both for those living in London and commuters who might otherwise use a bus or Underground train for the 'last mile' of their journeys.

TfL reports that: *"Since the cycle hire scheme was introduced, cycling in the capital has increased from 540,000 to 730,000 average trips per day. The Santander Cycles scheme has increased the availability of cycles, enabling both Londoners and visitors to explore and commute on two wheels."*

Based on this increase of 190,000 journeys each day, we have estimated the positive non-economic impacts arising from the scheme. In doing this we have assumed that:

- Half of these additional journeys are genuinely new, rather than replacing journeys that would have taken place on cyclists' own bikes instead, i.e. half of the increase in cycling would have happened without the bike hire scheme. This is a rough assumption based on TfL customer research which showed that: *"49 per cent of Barclays Cycle Hire members say that the scheme has prompted them to start cycling in London and 17 per cent of members state that they have increased the amount they cycle on their own bikes as a result of the scheme."*[13]
- An average trip length of 20 minutes, based on the TfL statement that: *"Around 93 per cent of all journeys made by Barclays Cycle Hire members have been under 30 minutes, which means that the vast majority of people using the scheme aren't paying any more than their access fees."*[14]
- Full take-up did not occur until four years after the scheme's introduction.

13. https://tfl.gov.uk/info-for/media/press-releases/2018/july/cycle-hire-scheme-celebrates-best-ever-month-of-hires
14. https://tfl.gov.uk/info-for/media/press-releases/2013/april/barclays-cycle-hire-southwest-extension-construction-works-begin

Feeding these assumptions[15] into the World Health Organisation's HEAT (Health Economic Assessment Tool) software gives the estimated reductions in preventable mortality shown in Figure 18 – net deaths prevented by increased physical activity and caused by exposure to air pollution and crash risk are shown, with percentage breakdown by channel:

Channel	*Deaths prevented, annual*	*Deaths prevented, 2010-2018*
Net deaths prevented	17	135
Physical activity (% of total)	105.9%	107.4%
Air pollution (% of total)	-5.9%	-5.9%
Crash risk (% of total)	-	-1.5%

Figure 18: Estimated impact on preventable deaths as a result of TfL's cycle hire scheme, 2010-2018

On this assessment, the impact of the cycle hire scheme has been an estimated 135 lives saved since its introduction – despite the additional cyclist deaths from air pollution and crashes, greater physical activity has prevented many more.

Beyond the hire scheme, making cycling a safer, better, and more appealing option is identified as a priority in the Mayor of London's Transport Strategy 2018[16], with proposed policies including:

- Designing and improving street environments to support cycling and walking for short journeys.
- An expanded network of cycle routes covering longer distances, including alongside busy roads. There are plans for the strategic cycle network to expand beyond inner London where it is currently concentrated to outer London, where car dependency is highest.
- Provision of more secure, accessible cycle parking in town centres, public transport interchanges, and other key locations.
- Expanding access to cycle hire schemes beyond the currently covered areas.

15. i.e., that because of the scheme London has 365,000 rather than 317,500 cyclists making two 20 minute journeys a day, with full take-up achieved gradually in the four years after 2010.

16. *Mayor's Transport Strategy*, Mayor of London, March 2018

This programme will increase the geographic scope of cycle networks and cycling hire, offset the dangers to cyclists from air pollution and collisions by providing more segregated cycle routes, and therefore improve take-up by making cycling more appealing relative to other modes.

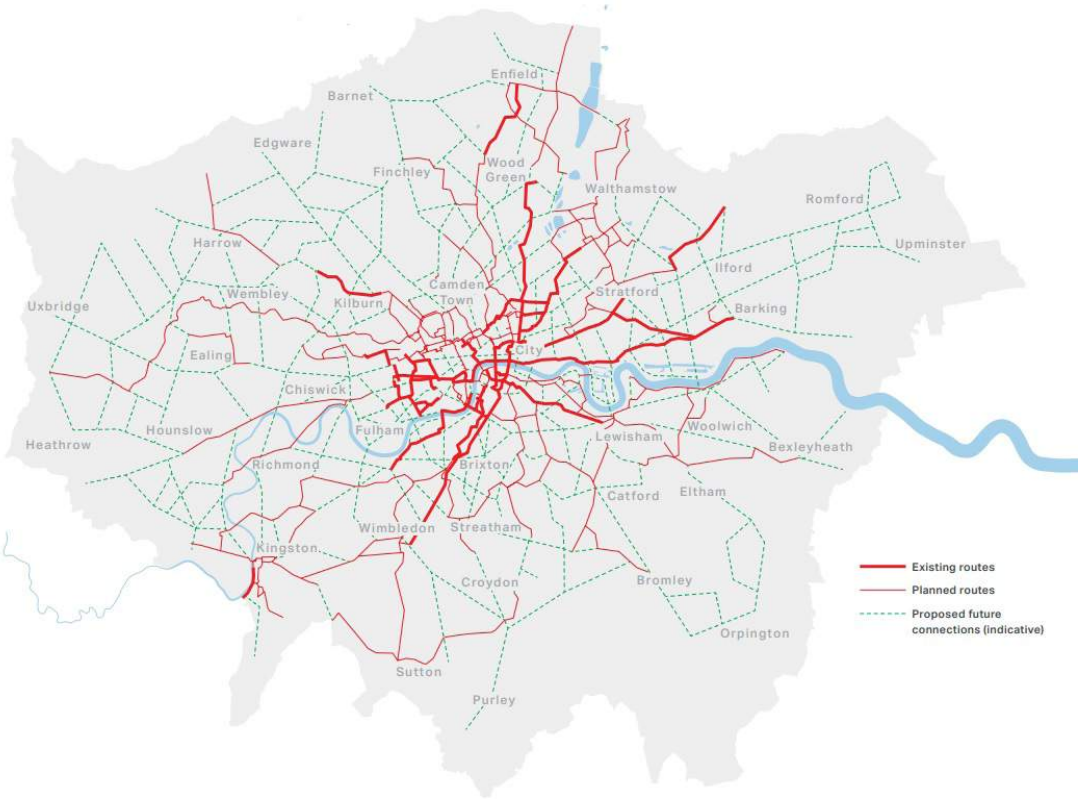

Figure 19 (a): Santander cycles on Exhibition Road, London; (b) Current strategic cycle network and proposals to 2041

Expanding the accessibility of public transport

The Disability Discrimination Act 1995 (repealed and replaced by the Equality Act 2010) set out to end discrimination against the disabled in the provision of goods, services, and employment. Public transport is an area where this legislation is particularly important; disabled people are often unable to use private transport, but buses, trains, and railway stations often involve steps to climb and uneven surfaces to traverse, which limit use by those who need them the most.

The Access for All programme, launched in 2006, provides funding to upgrade legacy infrastructure at stations and create step-free, accessible access from entrance to platforms through provision of lifts, ramps, and other refurbishments such as accessible ticket gates and toilets.[17]

In London, newer parts of the network such as the DLR and Crossrail have been designed to be step-free from the start, and the London Underground network is gradually being upgraded, though there is still work to do, particularly in western London. Across Great Britain, 75% of all passenger rail vehicles have been built or refurbished to modern access standards.[18] Where stations are fully accessible, opportunities for wheelchair users to access employment and leisure opportunities have been improved, potentially preventing isolation and economic inactivity. Without these improvements travel would either be impossible or significantly harder, as disabled passengers would need to arrive early and request assistance from station staff when getting on and off trains.

17. https://www.gov.uk/government/collections/access-for-all-programme

18. *Access to transport for disabled people*, Louise Butcher, House of Commons Library, March 2018

Fix missing links in transport connectivity

Where 'missing links' exist in the road and rail network, users either miss out on making journeys or will need to make excessively long round trips, raising emissions and generating congestion in the process. If the additional pressure results in congestion, the negative social impacts will be amplified as other users are adversely affected.

Prior to the opening of the Forth Bridge in 1890, the Firth of Forth between Edinburgh and Dunfermline could only be crossed by ferry, with an overland journey of approximately 40 miles between the two sides. The first bridge provided a rail connection, while the Forth Road Bridge, opened in 1964, provided motor vehicles, cyclists, and pedestrians with an alternative to roll-on roll-off ferries. The usage of this bridge came to significantly exceed its planned capacity – carrying 23 million vehicles in 2006 rather than the 11 million per year it was designed for – demonstrating both the value of the connection and the need for new investment.

Figure 20: (a) The Queensferry Crossing; (b) layout of the Forth Bridge as a public transport corridor

The new Queensferry Crossing opened in 2017, enabling all private vehicular traffic to be removed from the Forth Road Bridge. Like the older bridge, it provides two lanes in each direction. However, the Forth Road Bridge has been kept open for use by pedestrians, cyclists, and public transport, providing vastly improved conditions for these sustainable modes.

The connectivity across the Firth of Forth afforded by the new road crossing and the repurposing of the old crossing will deliver a range of benefits:

- Improved attractiveness of active modes of transport such as cycling. The risk of accidents and air pollution exposure may have deterred those travelling over the crossing from cycling or walking. With the Forth Road Bridge now providing a route for pedestrians, cyclists, and public transport, active transport will become much more viable.
- This dedicated capacity will also make buses more reliable, increasing the attractiveness of public transport. The bridge could in future be adapted to also carry light rail or trams, increasing sustainable transportation options.
- The alternative to providing a new crossing was repair of the existing bridge to cope with the volumes of traffic it experienced. Transport Scotland estimates this would have taken seven to nine years with sustained traffic disruption and resulting harm to the Scottish economy.
- Maintaining the key benefits for road users of the original crossing; a shorter journey for those wishing to cross, thereby reducing air pollution and time spent driving, and relief to other routes around the Firth, preventing congestion there.

Figure 20 (c): The Queensferry Crossing under construction

New stations enhancing existing infrastructure

Though new train stations are usually constructed at the same time as entirely new rail lines, building them on existing networks can also deliver major new connectivity benefits and encourage a modal shift towards rail, thus delivering valuable economic and social benefits.

Worcestershire Parkway Regional Interchange is a station currently under construction at the intersection of the CrossCountry and Cotswold lines, expected to be completed in 2019.

This will allow Worcester residents to take a London-bound Cotswold line train and change at Worcestershire Parkway for trains towards Bristol or Birmingham, making rail a more convenient option for destinations along this line relative to driving. The eastern parts of the county will enjoy easier access to Oxford, Reading, and London as residents will no longer need to travel into Worcester to catch a train, reducing demand on city centre roads and car parking facilities.[19]

Figure 21: Cambridge North Station and Cambridge Science Park, whose growth it supports

As Cambridge's economic success has grown, so have the demands on its rail infrastructure. In response to this, Cambridge North station was completed in 2017, located on existing track running north from Cambridge towards Ely.

It helps to solve the acute congestion problems faced by Cambridge:

- Those travelling to and from Cambridge will have a choice of station, minimising distance of journey between it and their origin or destination, therefore reducing total miles travelled by car or bus. These journeys will also be split between the stations rather than concentrated at one.
- As Cambridge North expands choices for travelling into or out of Cambridge by rail, more people will do so rather than using cars.
- Destinations in the north of Cambridge can be reached without travelling via the city centre from the central station, relieving pressure on the roads there.

A key location which Cambridge North is close to is the Cambridge Science Park, an innovation centre which has existed since 1970 but has been expanding rapidly of late, creating high-skilled jobs in futuristic industries such as biomedical and communication. The new station supports that growth by mak-ing commuting and business journeys to and from it more convenient.

19. *Worcestershire County Council (Worcestershire Parkway Regional Interchange) Compulsory Purchase Order*, Worcestershire County Council, November 2014

Smart motorways - a technological solution to tackling congestion

Motorways are the UK's main road arteries, enabling vital longer distance freight and business travel as well as meeting more general transport needs e.g. orbital connections in city regions. Severe capacity constraints are evident in large parts of the network however, with congestion and unreliable journey times now the norm on many sections. Adding lanes to widen motorways is one solution, albeit an expensive and potentially disruptive one which can take years to complete.

A solution short of adding lanes is the 'smart motorway', a concept first seen in Britain on the M42, where a stretch of variable speed limits was used to moderate traffic flow. Since then, the concept has developed to include allowing drivers to use the hard shoulder at busy times or even its conversion into a regular lane. Where lanes need to be closed due to incidents or variable speed limits are used, information is signalled to drivers via overhead gantries, and on 'all lanes running' smart motorways, with no hard shoulder, regular emergency refuge areas are provided for drivers who need to stop. Since 2013 all lanes running has been the standard for new smart motorways. Highways England claims that smart motorways can be provided at a third of the cost of widening schemes.[20]

Smart motorways: key social advantages

1) Quicker to implement than widening schemes, which take around ten years. A smart upgrade can be constructed in under two, so capacity improvements are realised earlier and interim disruption for travellers from temporary lane closures is minimised.

2) Contrary to expectations, hard shoulder running has not been detrimental to safety; the Highways England two year after reports for the M25 J23-J27 scheme showed a small (not statistically significant) decrease in collisions and casualties.

3) Average journey time reductions are realised – by as much as 9% for the M25 scheme. Aside from the economic benefits, this makes travelling a more pleasant and reliable experience for commuters and leisure travellers.

The M6 between junctions 2 and 4, a 22km stretch between Birmingham and Coventry, is currently being converted into a smart motorway – part with all lanes running, part maintaining three lanes and a hard shoulder to tie in with the existing smart motorway between junctions 5 and 8. Construction began in March 2018 and the completed smart motorway is expected by the end of March 2020.[21] Improved capacity will help to expand Birmingham Airport's catchment area.[22]

Figure 22: A smart motorway section of the M60 with all lanes running

20. https://highwaysengland.citizenspace.com/he/m6-junctions-2-to-4-smart-motorway-public-informat/supporting_documents/BHM17_0363%20M6%20Junction%202%20to%204%20exhibition_FINAL.PDF

21. *Smart Motorways*, Ciara Walker and David Threlfall (Arcadis), April 2016

22. http://londonroadsafetycouncil.org.uk/m25-smart-motorways-are-having-no-adverse-effect-on-safety/

The digital and AI revolution in transportation

Roads investment must also account for new transportation technology such as autonomous vehicles, which could reduce or remove social costs inherent to existing transportation and widen the accessibility of private transport.[23]

For example:

- Elimination of many accidents due to the removal of human error.
- Potential for increased uptake of active modes such as cycling as collisions with cars become less of a risk.
- Improved use and allocation of capacity as connected autonomous vehicles (CAVs) 'talk' to each other – for instance co-ordinating braking and acceleration – reducing congestion and journey times, while increasing effective road capacity (and reducing the need for costly future road widening and junction capacity schemes).
- Fully autonomous vehicles will not require a qualified driver, opening up private transport to those who currently rely on public transport or on being driven by others such as the young, elderly, and disabled – thereby expanding their opportunities to access leisure, employment, friends and family.

The greater the degree of automation supported, the greater the inclusivity benefits – assistive automation only, which still requires a qualified driver at the wheel, does not expand access to the groups mentioned above; full automation, which does not require any human intervention, would bring the greatest inclusivity and social benefits.

Infrastructure requirements for connected, autonomous vehicles (CAVs)

These requirements will depend on exactly how autonomous the CAVs are and the extent of their ability to interact with existing road infrastructure.

Dedicated infrastructure, i.e. separate lanes or roads, is one option but would be difficult to implement in city centres where roads are full to capacity.

Fitting communications technologies such as beacons and antennae to existing signs and signals has been identified as a key step in making road systems CAV-friendly. These new pieces of infrastructure will of course require high-speed connectivity, i.e. full-fibre access.

Existing autonomous vehicle trials have encountered problems with poor road markings – therefore making these clearer and maintaining them well are also key.

23. *Readiness of the road network for connected and autonomous vehicles*, Dr Charles Johnson, April 2017: https://www.racfoundation.org/wp-content/uploads/2017/11/CAS_Readiness_of_the_road_network_April_2017.pdf

Digital infrastructure connecting the UK's homes

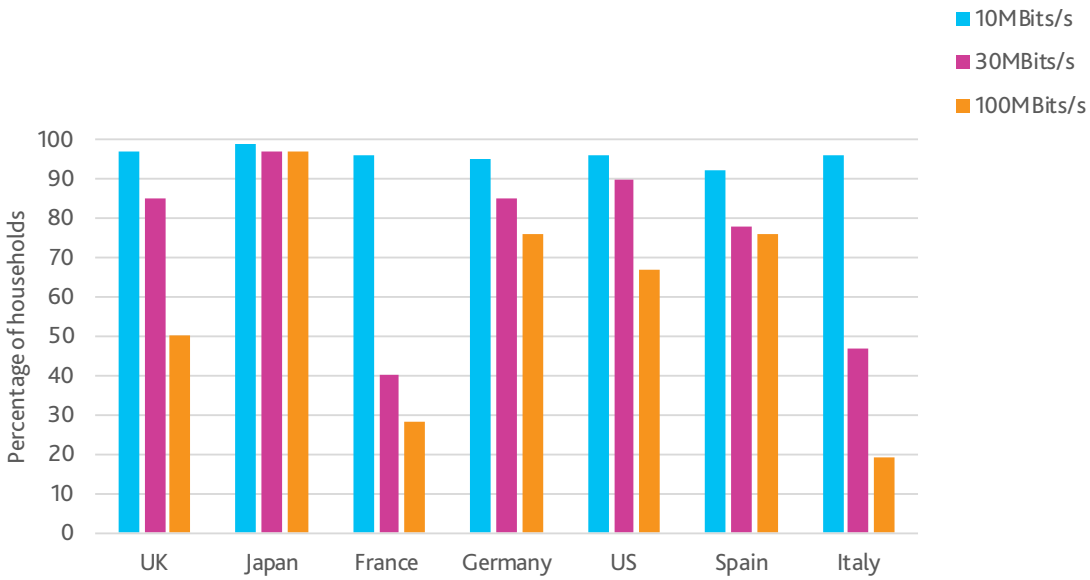

Figure 23: Availability of fixed broadband networks by advertised speeds, 2005. Source: Ofcom (2016) "The Communications Market Report: International"

For the last few decades, the connectivity provided by the Internet has been transforming global economies in the same way that canals and railways once did. The UK currently lags behind other developed countries in the provision of high-speed Internet to homes. It recently fell to 35th in a global league table of broadband speeds, behind France, Germany, most other European countries, the United States, and Canada.

On provision of full-fibre broadband, providing speeds as high as 1Gbps (gigabit per second), only 4% of UK premises have a link compared to 79% in Spain and 95% in Portugal. Figure 23 summarises the situation across the G7.

This may improve in coming years – under its *Future Telecoms Infrastructure Review* the Government intends to require full fibre as standard in all new homes and plans under the Industrial Strategy to invest in further roll-out.[24] There are clear quality of life benefits to faster Internet speeds, and these will be reflected in what consumers are willing to pay for them.

24. https://www.theguardian.com/technology/2018/jul/10/uk-slips-to-35th-in-global-table-of-broadband-speeds; https://www.bbc.co.uk/news/business-44921764.

Further social benefits also exist, for instance arising from the greater ability for employees or freelancers to work from home:

- Reduced travel to and from work eases pressure on the transport network – for instance freeing up some capacity on the rail network or reducing congestion and accidents on roads.
- Workers no longer required to live near an office may choose to be based in more pleasant (e.g. rural or coastal) locations than would otherwise be possible, improving their quality of life and easing affordability pressures on housing in and around cities. As skilled workers spend their earnings in less economically active areas, the boost to local economies could also be substantial. Therefore peripheral locations with a desirable quality of life could compete to attract these individuals through the provision of higher Internet speeds.
- The UK's ageing population presents serious fiscal challenges as taxes on workers need to cover the state pensions and care costs of proportionally more and more pensioners. One way of mitigating this – identified in the Government Office for Science's report *Future of an ageing population* – is to make it easier for employees to remain in the workforce later in life.

    1. The report suggests that home-working is likely to become more common, as older people are already particularly likely to work from home – supporting this with digital infrastruc-ture could encourage those workers to defer retirement.
    2. There is evidence that staying in work supports improved cognitive function – this is intrin-sically good, and may also reduce care costs by preventing conditions such as Alzheimer's.
    3. Those with caring responsibilities towards elderly family members could also be supported to stay in work through improved digital infrastructure – carers are less likely to work full-time and more likely to be economically inactive than the general population. Allowing greater flexibility through home-working could reduce this issue and promote the inclusion of carers in the workforce.

High-speed Internet developing new and innovative industries

Cebr research describes the 'Flat White Economy', i.e. the formation of local ecosystems in particular locations where small scale digital and creative businesses thrive in symbiotic relationships with one another and the local economy more generally.[25] This creates skilled, productive employment and stimulates the development of cultural and other amenities. The nature of 'Flat White' industries is such that quality digital infrastructure is vital to them, and as such they are currently centred on East London.

Where the best digital infrastructure has been provided outside London, the results suggest there are significant benefits to be realised. Colchester, Essex has installed an ultra-fast broadband network in its town centre, allowing businesses there to access speeds as high as 1Gbps. These speeds are not found elsewhere in Essex (apart from in Southend), and help attract digital, knowledge-intensive industries to the area. This helps to explain the success of a creative incubator in the town, forming part of a rapidly-growing creative cluster.[26]

Modern infrastructure for electric cars

Changes are underway not just in how cars are controlled but also in how they are powered, with the growth of hybrid and electric cars. At present, electric vehicles (EVs) account for less than 1% of new registrations in the UK, but sales are growing quickly.

Ownership of electric vehicles would be much less feasible were it not for the growing network of charging points – there are now well over 10,000 around the UK.[27] Though increasingly operated on a commercial basis, this infrastructure was launched with financial support from the government and manufacturers, and charging infrastructure continues to receive government subsidies. Given the social benefits of electric vehicle usage and the disbenefits of the petrol and diesel alternatives, this looks to be money well spent.

Reduced usage of petrol- and diesel- driven internal combustion engines and increased prominence of electric power will reduce emissions. These include greenhouse gases like carbon dioxide and those which damage local air quality, mainly nitrogen oxides and particulates. Air quality issues are to the detriment of cyclists and pedestrians using the same route – they may cause health issues particularly in the young, elderly, and asthmatic and could deter people from choosing to use active transport. Electric vehicles still produce some particulates through wear and tear on tyres and brakes, but their effect on both climate change and local air quality is much less than petrol and diesel cars.

There are wider economic benefits which greater electric vehicle uptake could deliver but which are less widely appreciated. Like most western countries, the UK is profoundly affected by unpredictable oil price fluctuations. This is likely to remain the case for some time but as fewer vehicles are powered by petrol or diesel this will diminish. The Hyperbat site in Coventry is already the largest EV battery plant in Europe, and the Nissan Leaf is manufactured in Sunderland.[28] A large domestic market, supported by quality charging infrastructure, is one way of ensuring that these industries stay in the UK and continue to grow and innovate, creating skilled jobs and high-value exports.

25. Described in a book of the same name by Cebr founder and Deputy Chairman Douglas McWilliams.
26. https://colchesterultraready.co.uk/colchester-a-great-place-for-business/ultrafast-connectivity/
27. https://www.autoexpress.co.uk/car-tech/electric-cars/96638/electric-car-charging-in-the-uk-prices-networks-charger-types-and-top
28. https://www.autocar.co.uk/car-news/industry/new-coventry-based-firm-be-largest-ev-battery-maker-uk

Railway stations as development nodes

There are further differences in the social impacts of different modes of transport, such as in relation to their effects on the places surrounding them. In the past, while major stations such as London King's Cross have always played an important role as transport nodes, they were also associated with negative 'externalities' for the areas around them. The noise, dirt, and air pollution associated with steam and diesel trains are unpleasant, and this has led to a cycle of areas around these stations becoming associated with crime and other antisocial factors.

Electrification of the railways, visionary urban planning of the areas around stations, and their heritage characteristics have changed this and allowed major stations to act as catalysts of urban regeneration, building on their fundamental function of providing connectivity to a wider labour catchment area and other business locations. Stations and the facilities they support enable people to meet more easily. Large footfall makes them ideal locations for businesses that depend on throughput of people like restaurants and retail. Latent value is unlocked as people and firms derive value from close proximity (taking advantage of the mobility benefits they provide). Provision around stations of public and active transport for the 'last mile' of connectivity for those disembarking from trains can help promote sustainable urban forms.

In recent years city centre economies have diversified. Financial services have become less prominent since the 2008 crisis while professional services have grown strongly along with clusters in the creative, technology and life sciences sectors. This has been accompanied by an evolution towards more 'lifestyle' oriented locations which are able to offer workers the more exciting and vibrant urban environments they seek. These combine a richer mixture of land uses and offer diverse spaces for residential, leisure, cultural and educational uses as well as offices and other commercial activities. The epitome of this phenomenon is the new urban quarter emerging on the former railway lands behind King's Cross which has been 'curated' to provide a carefully balanced diversity and mix of uses, facilitated by its position as an intersection of several London Underground lines and National Rail services.

Figure 24: HS2 Curzon Street and Interchange Station design options. Courtesy of HS2 Ltd, 2018

Connections to HS2 and the resulting footfall may spur similar developments around stations in our other major cities. Indeed, increased development already underway around Birmingham Curzon Street has been attributed to the future HS2 connection and there are locally led HS2 growth strategies along the line of route to realise the opportunities it will deliver.

In this context, the decision for for HS2 trains to serve Liverpool Lime Street via the existing route from Crewe, as opposed to extending the high speed line to Liverpool, could be a missed opportunity. However, Lime Street will become an 'integrated high speed station' with two services every hour to London when Phase 2a of HS2 opens in 2027.

3. Ensuring balanced growth beyond the cities

An important aspect of regional rebalancing across the UK is the agglomeration in big regional cities discussed in the first chapter of this report: infrastructure as a means of unlocking housing and connecting large numbers of people to centres of employment. This is not however the whole story – there are also many more sparsely populated areas where a shortage of housing or constraints on its development are not issues, but a shortage of quality employment or a lack of connectivity to the rest of the country is. Certain kinds of infrastructure investment can deliver significant benefits to these areas and to the whole country. Geographically isolated areas, typically rural and/or coastal locations, are characterised by low population densities and challenges in accessing centres of economic activity and employment. Infrastructure investment can help to address some of the social and economic challenges faced by these areas. Many formerly vibrant seaside towns have suffered sharp declines in their fortunes as once-strong tourism or fishing industries have faded and relatively few high quality jobs have appeared in their place.

In much of Scotland, Wales and northern England in particular, there is an abundance of land protected from development through national park and AONB designation. Some communities surrounding these areas suffer from being comparatively isolated although there are valuable tourism opportunities. Transport infrastructure which connects these locations to centres of activity can have a transformative impact, for example in allowing local products to access wider markets and attracting tourists to scenic parts of the country, where their spending supports isolated settlements.

Investment in clean energy provision, building on natural assets, is another way of developing economic opportunity in the most isolated areas. It brings wider national benefits, for example by generating energy in a way that avoids the negative environmental impacts and potential high costs associated with fossil fuels and helps to meet the UK's renewable energy targets.

Another way in which infrastructure investment can help such areas is through supply chain effects. Investment can benefit places well beyond their user catchment area, creating opportunities in diverse locations across the country and helping to spur the development of new and innovative industries. We examine the example of Heathrow expansion below.

Therefore appropriate infrastructure investment can both deliver national objectives and ensure that there are high quality economic opportunities for residents living away from major population centres – it would be neither desirable nor appropriate for everyone to move to big cities.

A9 Dualling - enhancing a vital strategic link

The A9 traverses sparsely populated areas of the Scottish Highlands from Dunblane to Thurso. It is a well-used road with important economic and social functions, carrying over 40,000 vehicles (65,000 people) each day. The 177km main section of the road[29] shown in Figure 25, which the Scottish government plans to upgrade to dual carriageway standard, connects Perth and Inverness.[30]

It is used most intensively in the parts closest to these cities, owing to daily commuting. It also carries significant volumes of tourists and provides access to markets and inputs for key industries such as food and drink (i.e. whisky production, which is enjoying its biggest boom since the 1890s[31]) and life sciences (a strong sector in Inverness).

Figure 25: The main section of the A9 from Perth to Inverness

There are various issues experienced along the route which suggest the need for an upgrade. They include:

- A relatively high proportion of slower moving vehicles (i.e. HGVs) and lack of opportunities for overtaking leading to 'platooning' of vehicles and slow movement;
- Long delays when incidents or closures due to weather or landslips occur;
- High incidence of fatal and other serious accidents.

Transport Scotland estimates that the dualling programme will reduce journey times between Perth and Inverness by 18 to 20 minutes – a 14 to 16 percent reduction – which will translate into a 10 to 12 percent reduction between Inverness and the Central Belt. Businesses across the route should benefit from this, with the North of Scotland brought within closer reach of the Central Belt and the Cairngorms National Park easier to access for day trips. Reliability, even in the event of incidents, will be improved, as it will be easier to keep at least one lane open in each direction. The Scottish Government's analysis indicates that in the first decade after dualling, 61 fatalities and 37 serious casualties are expected to be avoided relative to today's baseline through higher quality road and improved vehicle segregation.[32]

29. Perth and Inverness contain one quarter of the population but one half of the jobs within the Highways and Perth and Kinross local authorities.

30. Of which 48km is dual carriageway at present.

31. 126 Scotch whisky distilleries are currently in operation more than 40 new distillery projects are in development, and 12 new operations are expected to have been set up in 2018.

32. This will be achieved through 'grade separation' of the levels of roads crossing each other and a reduced number of junctions with C class, unclassified, and access roads.

Offshore wind supporting coastal areas

By its nature, offshore wind energy can only take place away from land. Onshore generation has some cost advantages, however offshore wind benefits from larger turbines and higher wind speeds without raising concerns about noise pollution or damage to the countryside. Government policy is highly supportive, with the Industrial Strategy identifying offshore wind as an area where it will work with business to grow the industry. The UK already has the largest installed capacity of any country[33] and built more than half of Europe's new capacity in 2017.[34] Competition and innovation have helped cut the cost of offshore wind by half since 2015.[35]

Substantial offshore wind investment has benefitted many areas facing significant economic and social challenges:

- The borough of Tendring in northeast Essex, centred on the towns of Harwich and Clacton-on-Sea, is one of the most deprived in the UK. The once-strong seaside tourism industry has declined, leaving major challenges of unemployment and inactivity, with the economy dominated by low-skill, low-wage employment. The recent development of the 353MW **Galloper Offshore Wind Farm** – an addition to substantial existing capacity – created 700 jobs during construction with the Operations and Maintenance Base planned in Harwich International Port to create a further 60 in the long term.[36]

- Grimsby in North East Lincolnshire faces similar social and economic challenges, following a sharp decline in the once-dominant fishing industry. **Hornsea**, which will be the world's largest offshore wind farm, is currently being built off its coast by Ørsted. Once all proposed stages are completed by 2025, generation capacity will be upwards of 6GW. The Danish company has sited its main east coast maintenance base in Grimsby and is providing training and apprenticeships to construction workers.[37]

The scale of deprivation issues facing these areas is illustrated clearly in Figure 26, which shows the 2015 Index of Multiple Deprivation (IMD) across England, zoomed in to areas of interest – Grimsby, Clacton, and Harwich stand out as pockets of high deprivation.

33. Industrial Strategy, p. 32.
34. https://www.theguardian.com/environment/2018/feb/06/uk-built-half-of-europes-offshore-wind-power-in-2017
35. Industrial Strategy, p. 160.
36. http://www.galloperwindfarm.com/
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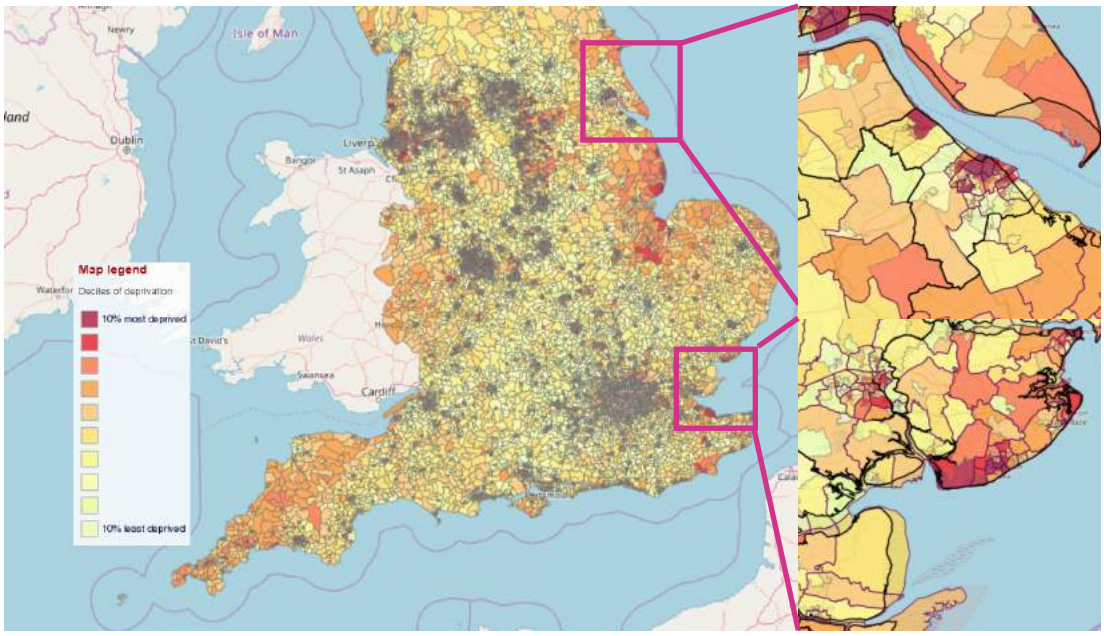

Figure 26: Index of Multiple Deprivation Map, focus on North East Lincolnshire, North Essex

Remote generation of onshore wind

Whilst offshore wind generation has recently expanded and received significant government support for the reasons mentioned above – greater efficiency and reduced environmental concerns – onshore wind in the UK's most remote areas may also see growth. A recent change in government rules will allow onshore wind projects on remote islands to compete in clean energy auctions to win Contracts for Difference – i.e. a guaranteed strike price for their output.

Improving energy security in remote areas through new renewables

New energy generation on Scottish islands will also require the provision of new interconnectors between them and the mainland, delivering improved energy security.

Shetland, for instance, currently operates as an island system with no connection to Great Britain's grid. It is reliant on the Lerwick Power Station, an ageing 67 MW oil-fired station, for security of supply. The interconnector would allow transmission of some power from the mainland, reducing the strain on the station and potentially enabling its replacement. For instance, a cheaper diesel facility could be used instead, saving electricity consumers money.

The Western Isles, Orkney, and Shetland are all areas in which there is potential for remote island wind projects – a 2013 report for the UK and Scottish governments concluded that such projects could meet 3% of the UK's total electricity demand.[38] Direct employment and supply chain opportunities would also be created. In areas lacking the knowledge-intensive jobs associated with city centre economies, these would be particularly valuable opportunities for residents to develop skills and work in well-paid jobs.

38. *Scottish Island Renewable Project: Final Report*, Department of Energy & Climate Change 2013

Potential transformative investment in tidal power

Tidal power is not widely used in the UK, however it could yet play a role and experience from abroad suggests that it may offer significant social benefits. The Northern Tidal Power Gateways Project (NTPGP) is an £8 billion investment, still at an early stage, proposed by Northern Tidal Power Gateways Limited. It would locate tidal gateways (barrages) across six estuaries along the coast of the North West. If it goes ahead, it could provide major energy generation capacity, improved transport links, and a variety of other benefits helping to meet environmental and regeneration objectives.

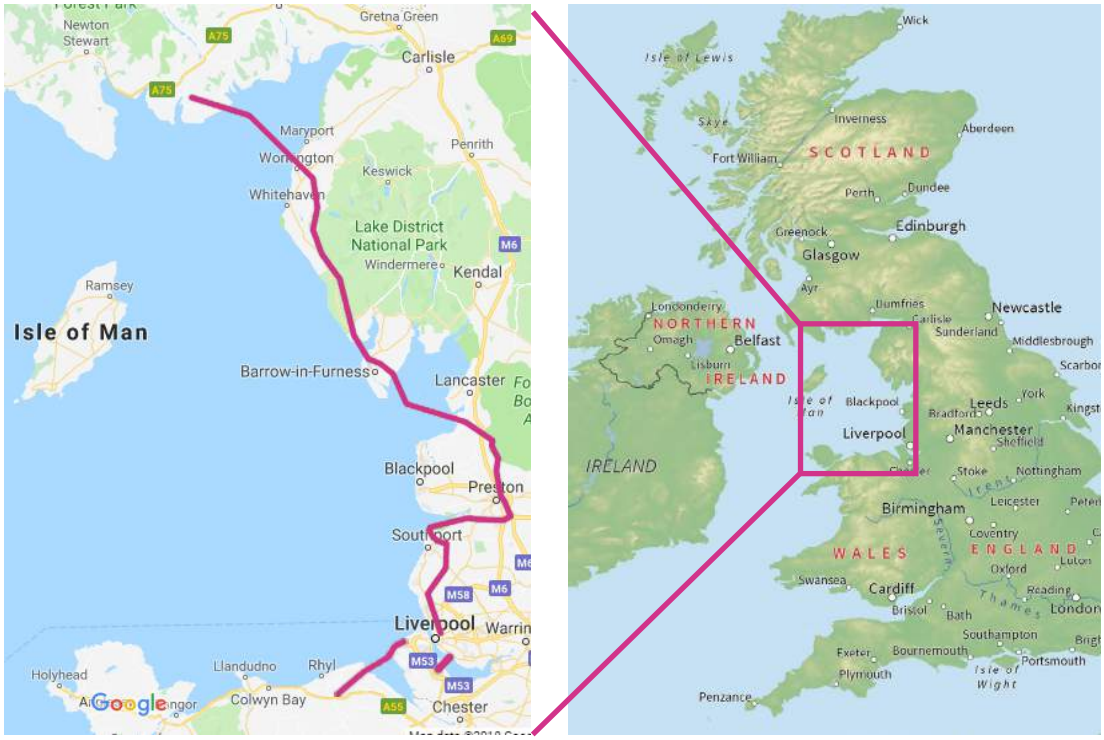

Figure 27: Potential scale of NTPGP, including new road connections

NTPG Limited's studies have identified that gateways at Morecambe Bay and the Duddon Estuary could produce 6,500GWh and 100GWh per annum of electricity respectively – enough for approximately 1.5 million homes (more than 5% of those in the UK). In the context of the UK's target to provide 15% of its energy (including 30% of electricity) from renewables by 2020 and 33% by 2030, this is a significant prospect. The company argues that tidal energy would be affordable relative to other renewables, with an estimated cost below £70 per MwH[39] and that it does not have the ongoing and decommissioning costs associated with nuclear. Compared to wind or solar, tidal generation is predictable. Finally, as gateways can be used to reduce tidal surges, they serve as flood protection.

Figure 27 shows the proposed locations of the barrages and existing roads along with associated roads that NTPG Ltd have suggested could be built across and around barrages. There is potential to improve connectivity between these locations, which are currently relatively isolated from one another.[40] Railways could presumably be provided as well or instead in some of these locations – for instance a MerseyRail extension into North Wales would expand the commuting radius of Liverpool and Manchester, supporting their growth and allowing workers to live in scenic, affordable locations.

NTPG Ltd cite La Rance in Brittany as a successful scheme along similar lines. It produces the cheapest electricity in France, has only shut down for routine maintenance during over 50 years in operation, and has cut the distance by road between St Malo and Dinard from 45km to 15km.[41]

The Northern Tidal Power Gateways Project faces significant challenges, such as demonstrating that any impacts on local wildlife or valuable landscapes will be acceptable, and if it comes to fruition construction will take many years. Nevertheless, the idea and the precedent set elsewhere show the potential for ambitious energy schemes to deliver jobs to remote areas, meet national objectives by providing clean, affordable electricity, and improve connectivity.

39. Compared to the £92.50 agreed for Hinkley Point C, the highest strike price ever agreed.

40. https://www.mottmac.com/releases/mott-macdonald-appointed-on-proposed-northern-tidal-power-gateways-project-uk

41. http://www.supernorth.co.uk/wp-content/uploads/2016/11/SuperNorth-Nov16-online-4and5.pdf

Heathrow expansion - supporting innovation in construction across the UK

Heathrow Airport's new Northwest runway, which could be completed within the next eight years, represents one of the largest infrastructure projects currently planned in the UK, with potentially transformative impacts across the country. Leisure and business travellers will benefit from more frequent flights to a wider range of destinations including emerging markets which could gain importance post-Brexit. Meanwhile, increased capacity and competition is expected to lower fares. The UK's air freight capacity will also grow, driving greater exports of high-value, time-sensitive products – the know-how and highly-skilled industries nurtured in locations like the Oxford-Milton Keynes-Cambridge corridor will generate more and more of these.

Beyond these benefits, the decision by Heathrow Airport to use offsite construction for between 25% and 40 percent of the project[42] will spread the positive economic impact of construction far beyond London. Reducing construction activity at Heathrow itself will also minimise the disruption to neighbouring areas. Representatives of Heathrow Airport have now visited all 65 sites across the country longlisted to become offsite construction hubs. Of these, four will be chosen in time for construction to start in 2021. Heathrow will not directly operate these hubs, and once construction on the new runway is complete their legacy of skilled workers and modern facilities could be put to use in other major projects such as Hinkley Point C and in meeting the country's housing demands through offsite construction of new homes. This shows how infrastructure investment can trigger progress in the wider economy.

Offsite construction

The transformation of the UK construction industry towards an offsite model could be catalysed by Heathrow Airport's major investment in new construction hubs to support its expansion. This would be welcome for several reasons, both economic and social.

Offsite construction requires relatively fewer but more highly-skilled workers than traditional methods. Therefore it creates high-productivity, high-wage jobs which will deliver a higher standard of living and job fulfilment for workers, whilst also helping mitigate the impacts of emerging labour supply issues on the sector: The Farmer Review of the UK Construction Labour Market (2016) estimated that on current trends the available construction labour force will decline by 20-25% over the next decade, a trend which might be accelerated by future constraints on low-skilled labour from the EU27.

The greater precision allowed by factory construction improves energy efficiency of buildings: therefore they could reduce energy costs and carbon emissions. Indoor construction is also safer than onsite and cannot be disrupted by the weather.

Finally, and unlike traditional construction, offsite has significant export potential. Modular building components are suitable for transport abroad – perhaps utilising expanded freight capacity at Heathrow.

Rob Ewen, Heathrow Airport's expansion delivery director, has also identified an interesting and important benefit that could arise from greater use of offsite construction; lowering suicide rates. A 2017 ONS report found that the risk of suicide among low-skilled male labourers, particularly those working in construction roles, was 3 times higher than the male national average. Factors such as long periods of time away from home to be onsite may be behind this. Offsite construction would remove this issue by creating a higher proportion of skilled and semi-skilled jobs with better conditions.

42. This compares to an offshore share in the wider construction industry of approximately 10%.

Conclusions & Recommendations

The benefits of long-term infrastructure investment are clear. Not only is there a strong economic outcome – previous CECA / CEBR research has found that every £1 billion of infrastructure construction increases overall economic activity by £2.842 billion – but this publication demonstrates that there is also significant social benefit.

Well planned infrastructure investment can not only transform how we all live and work, but it has a notable benefit for those areas which have been left behind over the years.

The wider benefits infrastructure investment can bring are only starting to be recognised by governments and local authorities. CECA welcomes this wider approach, and has worked with its members to produce a series of recommendations to ensure the delivery of world class infrastructure for all.

Based on this report, the Civil Engineering Contractors Association makes the following recommendations:

- A cross-sector working group should be established to create and champion a new national framework for the measurement of social benefits. This group would advise Government departments on how to consistently appraise and evaluate the contribution of different types of infrastructure investment to social outcomes, with data resulting from this work supporting business cases for future investment.
- The planning of future infrastructure projects and programmes should consider opportunities to spread the social benefits across the UK. In particular, consideration should be given to establishing infrastructure logistics and manufacturing hubs in former industrial towns and cities, creating new industrial heartlands that support multiple projects, create jobs, and rebalance the UK economy.
- There is a need to move discussion away from an either/or approach to delivering much needed investment in London and across the rest of the UK. Instead there should be a recognition that investment outside the capital supports growth in London and vice versa.
- Northern English cities should move towards a 'Randstad'- style model of collaboration between interconnected cities, supporting increased global competitiveness.
- To support the UK's future infrastructure needs, the Government should maintain a commitment to gross public funding support for infrastructure that meets the 1.2 per cent of GDP fiscal remit set for the National Infrastructure Commission, while examining the case for higher social and economic outcomes if this ceiling was to be raised.

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