Civil engineering insights on the roll-out of full-fibre broadband and alternative proposals

Overview

The UK is increasingly reliant on digital communications. By 2050, it is estimated that the population of the country will be 75 million, with an estimated top range GDP of £3.7 trillion.[1] An increase in population and economic activity will necessitate faster internet connections with greater capacity; this is in addition to the demand driven by new technologies and an increasingly connected world.

Even looking to immediate horizons, increased speed, reliability and capacity is highly desirable. There is an urban and rural divide, with average broadband speeds in rural settings slower because of less developed networks and copper cables having to carry data over longer distances, which degrades performance.[2] When the internet is increasingly used to interact with public authorities or services[3] or engage in economic activity, the potential for digital exclusion is significant.

Faster internet speeds also improve productivity and economic growth. A one-off increase in speed can increase employment by as much as 1.3%, increase productivity by up to 3.8% and increase the number of new businesses by between 0.4% and 3.2%.[4] Speeding up data flow is a sure way to boost the UK's competitiveness.

In the National Infrastructure Assessment (NIA), the National Infrastructure Commission (NIC) recommended that the UK should have nationwide full-fibre broadband by 2033.[5] The NIC determined that "while current digital connectivity is enough for current needs, demand for data is rapidly increasing" and so, in their judgement, the Government should act now to deliver full-fibre across the country, to avoid the risk of the UK being left behind.[6]

As demand for data increases and enables new technologies, social and economic changes will continue to occur. Working and socialising in a world with ultra-fast digital connectivity may reduce the need to travel, as work-based activities and entertainment experiences happen remotely in real-time.[7] In the future, smart, connected and autonomous transport networks will need uninterrupted digital connections between vehicles, remote devices and roadside infrastructure. This will transform how we travel, evolving the daily commute for many from an active to passive activity, increasing work and leisure time.[8]

The economy of the future, which will allow for remote collaborative working through a digital twin or boost connectivity through the internet of things, will mean a much greater reliance on internet-enabled economic activity and an always-on network. Boosting connectivity, speed, bandwidth and reliability is a necessary requirement to ensure that bottlenecks are eliminated.[9]

Purpose of this paper

This paper provides insights into the costs and benefits of the roll-out of full-fibre broadband in the UK, which is a significant infrastructure programme in its own right and a key enabler for the built environment sector more widely. It will also explore potential alternatives, combining insights from ICE Fellows, industry experts and available published evidence.

[1] ICE (2016) National Needs Assessment
[2] Gov.UK (2019) Rural Broadband Statistics
[3] Office for National Statistics (2019) Exploring the UK's Digital Divide
[4] Oxera (2019) Impact at a Local Level of Full-Fibre and 5G Investments
[5] National Infrastructure Commission (2018) National Infrastructure Assessment
[6] Ibid
[7] ICE (2016) National Needs Assessment
[8] WSP (2017) New Mobility Now
[9] Ibid

About the full-fibre programme

The ambition set out in the Future Telecoms Infrastructure Review[10] was to ensure a full-fibre-optic network from junctions and cabinets (most of which are already connected) directly to the home or business. This is known as fibre to the premises (FTTP). The review sought to have a full network in place by 2033,[11] supplementing, then replacing, the existing copper sections of the network. Since the 2019 election, the Conservative Government has modified the policy to ensure "full-fibre and gigabit-capable broadband to every home and business across the UK by 2025".[12]

In 2017, 95% coverage for superfast broadband was achieved across the UK.[13] Superfast is considered sufficient for today's average user and, as an upgrade to the existing copper network, was deliverable with negligible installation and time costs. Nonetheless, faster connection speeds are necessary to prevent bottlenecks appearing through to 2050.

The Government's aim is to ensure "that all parts of the country should enjoy the benefits of world-class connectivity",[14] with an early focus on rural areas, and a desire that all new-build homes have FTTP.[15] While internet penetration and superfast connectivity are reaching near totality, full FTTP coverage is low, at only 8% coverage, as of September 2019.[16]

Identified benefits to the economy of full-fibre

The "virtuous circle" of connectivity

Faster fibre connections have scaling benefits, particularly for small and medium enterprises (SMEs). A 2013 study determined that SMEs with fibre connectivity improved performance through more efficient and different ways of working in areas including business agility, flexibility and response time, increasing competitiveness.[17]

Increased connectivity allows for greater use of cloud-based systems. This is especially useful for rural areas where poor transport infrastructure could be mitigated by digital connectivity in the form of remote working, virtual meetings, increased customer connectivity or replacing courier services for large files.[18]

A full-fibre network would be expected to provide an economic boost, allowing for expanded commercial opportunities into a global customer base.[19] In a study, Regeneris estimated that SMEs would see benefits to productivity, flexible working, innovation and new enterprise worth £8.7 billion if 100 towns and cities in the UK were fully connected to full-fibre networks.[20]

More recent research for Openreach suggests that a full-fibre network could boost UK productivity "to the tune of £60 billion by 2025".[21] The same research also suggests that some 500,000 older and infirm individuals could re-enter the workforce, 400,000 more people could work from home and 270,000 people could choose to move to more rural areas.[22]

The NIC believes a full-fibre network would be "more reliable and cheaper to maintain" than the existing copper network.[23] It calculates that this would represent a saving of up to £5 billion in operating costs over 30 years, with five times fewer faults than copper connections.[24]

[10] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[11] Ibid
[12] The Conservative and Unionist Party (2019) Conservative Party Manifesto
[13] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[14] Hansard (2018) Broadband: Full-Fibre Coverage
[15] Gov.UK (2018) Forging a Full-Fibre Broadband and 5G Future for All
[16] Ofcom (2019) Connected Nations Update
[17] Dr Hazel Lacohée and Professor Andy Phippen on behalf of the Superfast Cornwall Project (2013) SME Benefits and Business Opportunities with Superfast Broadband: The Virtuous Circle of Connectivity
[18] Ibid
[19] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[20] Regeneris (2018) The Economic Impact of Full-fibre Infrastructure in 100 UK Towns and Cities
[21] Openreach (2019) The Blueprint for a Full-Fibre Future
[22] Ibid
[23] National Infrastructure Commission (2018) National Infrastructure Assessment
[24] Ibid

The impact of enhanced interconnectivity across infrastructure networks

Increased flexibility regarding remote working away from a business premises will have knock-on effects on other infrastructure sectors. A reduced need to work in situ or meet in person will, at scale, reduce the demand for transport infrastructure, easing congestion.

Fibre-optic connections could also allow for faster download and upload speeds, which are particularly important for emerging applications that perform remote management of infrastructure assets and dynamic structural health monitoring.[25] Remote smart monitoring of assets, particularly underground and in the geotechnical industry, could improve construction processes, deliver efficiencies or reduce over-specification.[26]

Building Information Modelling offers the ability to build and monitor assets virtually and in real-time in ways which reduce operational costs, lessen risks and enable design to be perfected before it is built.[27] Greater connectivity and wide-scale fibre-optic monitoring of infrastructure assets will also allow for innovation of the digital twin concept. This could take the form of new active monitoring applications making use of new sources and vastly increased volumes of data. Newer concepts, such as the National Digital Twin for infrastructure, might combine national scale modelling with real-time analysis.[28]

Fibre communication cables themselves, when embedded within existing infrastructure networks, have multiple applications beyond carrying data. They can be used to directly monitor infrastructure, especially for strain or temperature differentials, over long distances,[29] which could negate a need for additional monitoring equipment. Fibre-optic cables can also deliver intelligent traffic management by acting as Distributed Acoustic Sensors alongside their primary role.[30] This could be used to replace overhead sensors on roads, especially where this is prohibitive, and reduce maintenance and road closure costs when compared to the installation and maintenance of roadside sensor equipment.[31]

In the water and flood-defence sectors, enhanced digital connectivity could support continuous monitoring and adaptive control (CMAC); “utilising weather data, real-time monitoring and situational infrastructure adaptations, CMAC allows us to use existing infrastructure more efficiently, both to improve flood response and to boost supply of non-potable water.”[32]

Maintaining the United Kingdom at the forefront of the world economy

The UK is a leading digital economy, with 7.1% of economic output by GVA, or £130.5 billion, attributable to the Digital Sector.[33] This compares favourably to economies such as China, where the digital economy contributes 6% of GDP.[34]

According to the European Commission’s Digital Economy and Society Index, the UK ranks fifth overall in Europe, with a notably high take-up and regular use of internet services. It is held back by connectivity, particularly on ultra-fast broadband.[35] The UK is the fourth leading location when it comes to scaleup investment, behind the US, China and India, with a total investment in technology of £6.3 billion.[36]

[25] ICE (2016) 5G Consultation – Call for Evidence
[26] ICE Publishing (2016) Distributed Fibre Optic Strain Sensing for Monitoring Civil Infrastructure: A Practical Guide
[27] ICE (2015) Innovation: Stepping Up the Industry
[28] ICE (2019) The National Digital Twin Sounds Exciting – But we Need to do the Hard Stuff
[29] ICE Publishing (2016) Distributed Fibre Optic Strain Sensing for Monitoring Civil Infrastructure: A Practical Guide
[30] ICE (2019) Using Fibre Optic Cables to Deliver Intelligent Traffic Management in Smart Cities
[31] Ibid
[32] ICE (2017) A Revolutionary Approach to Managing Water using IoT Technology. Webinar
[33] Department for Digital, Culture, Media and Sport (2018) DCMS Sectors Economic Estimates 2017 (Provisional): Gross Value Added
[34] IMF (2019) IMF Working Paper: China’s Digital Economy: Opportunities and Risks
[35] European Commission (2019) Digital Economy and Society Index: United Kingdom 2019 Country Report
[36] Technation (2019) UK Tech on the Global Stage

International comparators

While end-to-end fibre networks are relatively scarce in the UK, other developed and developing nations are putting significant investment into full-fibre networks.

Several European countries have greater fibre coverage than the UK, with ambitious roll-out plans:

- Portugal currently has 89% coverage of fibre-optic services[37] and aims to reach coverage of at least 30 megabytes per second (mbps) for 100% of the population and at least 100 mbps for 50% of all households by 2020.[38]
- Spain currently has 71% coverage of fibre-optic services[39] and, like Portugal, aims to reach coverage of at least 30 mbps for 100% of the population and at least 100 mbps for 50% of all households by 2020.[40]
- France currently has 28% coverage of fibre-optic services,[41] with an ambition to ensure nationwide coverage of "very high speed" broadband, above 30 mbps, by the end of 2022.[42]

In Asia, South Korea (99%) and Japan (97%) have near complete ultra-fast coverage.[43] However these countries are far in advance of most of the rest of the world, having begun converting to fibre-optics in the last century.

The UK falls behind in international competitiveness on average speeds. The average download speed in the UK is 22.37 mbps. This places the UK 34th when it comes to connectivity and speed, behind France, which has an average download speed of 30.44 mbps, and Taiwan, with 85.02 mbps.[44]

As standards, policy objectives, population densities and demographic trends are very different between countries, direct comparisons of roll-out costs and challenges are difficult. Two thirds of Spaniards live in flats, whereas 60% of Britons live in semi-detached houses.[45] Meanwhile, South Korea's population density (530 people per sq km) is almost twice as high as the UK's (275 people per sq km), with fewer remote areas.[46]

Some developing economies are working to catch up in connectivity terms, especially as they recognise that poor connectivity exacerbates productivity and output gaps. If India were to be successful in increasing internet penetration from 12%, as it was in 2016, to 60%, this would translate to an increase of 5–6% of GDP or around US $135 billion.[47]

What the public needs from improved connectivity

The public expects to "order and forget" when it comes to home broadband. As long as the service is reliable, delivers on expected speed and is reasonably priced, the service "becomes invisible and forgotten in daily life".[48] Nationwide coverage has public support, with the NIC finding that 86% of people agree that all parts of the UK should have equal access.[49]

The public's perception about fibre-optic services fixates on speed. Beyond this, much of the public has little understanding of fibre optics or broadband technology.[50] As broadband speed is often a proxy measure for customer

[37] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[38] EU Commission (2020) Digital Single Market: Country Information – Portugal
[39] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[40] EU Commission (2020) Digital Single Market: Country Information – Spain
[41] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[42] République Française (2020) Garantir du Très Haut Débit Pour Tous en 2022
[43] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[44] PeakOptical (2019) The Countries with the Fastest Internet in the World
[45] Eurostat (2019) Housing Statistics
[46] World Bank (2018) Population Density (people per sq km of land area)
[47] Deloitte (2016) Broadband Infrastructure for Transforming India
[48] ASA (2017) Broadband Fibre Qualitative Research
[49] National Infrastructure Commission (2018) National Infrastructure Assessment
[50] ASA (2017) Broadband Fibre Qualitative Research

satisfaction with the quality of a broadband service, it should follow that a full-fibre network will increase customer satisfaction levels.[51]

Business users are much more demanding than residential users, reflecting a difference from more casual applications. The Institute of Directors (IoD) has set out a need to "force the shift to faster fibre broadband" so that full-fibre is implemented "as soon as possible".[52] This is a call echoed by the Confederation of British Industry (CBI).[53] Both organisations advocate for faster telecommunications networks which would allow companies to become more flexible, adopting and offering more cloud-based services, balancing regional economies and closing a digital divide.

Current status of the programme

Concerns around delivery of a full-fibre network revolve around cost, access for multiple companies to the existing copper network and its supporting infrastructure, and an enabling legal environment. An accelerated timescale to 2025 will create new impetus for these issues to be addressed.

Legislative changes necessary to ensure delivery

The Conservative Government's December 2019 Queen's Speech announced an intention to "accelerate the delivery of gigabit-capable broadband to 2025".[54] This will be supported through legislation aimed to make it easier for telecoms companies to install broadband infrastructure in blocks of flats and to ensure all new homes are built with reliable and fast internet speeds.

Specifically, a new bill will create powers for courts to order access to multiple-dwelling buildings, such as flats, where the owner has not responded to requests for access. This will allow for the installation of upgraded connections. This has been an issue in built-up areas where work has had to be repeated in an area to connect multiple buildings.

The bill will also mandate the installation of gigabit-capable connections in new-build developments. At present, the Universal Service Obligation[55] requires the installation of a 10 mbps download speed cable, which copper is easily capable of providing.

Budgetary concerns

The NIC believes that the construction and maintenance costs of a full-fibre network will amount to £33.4 billion over a 30-year period. Upgrading and expanding the current mix of copper and fibre cables would cost approximately £11.5 billion less. The Commission believes that investment in full-fibre is "a risk worth taking", citing previous roll-outs of broadband which resulted in increased annual per capita growth of between 0.9% and 1.5% for a 10% increase in broadband penetration.[56] These figures were, however, calculated prior to the timetable being brought forward from 2033 to 2025.

Most of the network is expected to be commercially viable. Concerns exist around costs for some rural and hard-to-reach areas, with individual properties costing above £45,000 to connect.[57] There is public subsidy available for rural areas amounting up to £5 billion to allow simultaneous delivery with commercial investment elsewhere.[58]

[51] Ibid
[52] Institute of Directors (2018) Business Calls for Faster Shift to Fibre Broadband to Unleash Flexible Economy
[53] CBI (2019) Supercharge Broadband and 5G to Stop UK Economy from Buffering
[54] Prime Minister's Office (Gov.UK) (2019) The Queen's Speech 2019: Background Briefing Notes
[55] Ofcom (2019) Your Right to Request a Decent Broadband Service: What You Need to Know
[56] National Infrastructure Commission (2018) National Infrastructure Assessment
[57] Ibid
[58] Gov.UK (2019) Forging a Full-Fibre Broadband and 5G Future for All

Delivery companies, ducts and poles

Owing to its legacy network, when British Telecom (BT) held a monopoly position prior to privatisation, Openreach is the most significant delivery body and has a full-spectrum network of ducts and poles carrying copper and fibre cables. Other private companies have been laying their own cable, notably Virgin, which is transitioning to fibre optics. New entrants like CityFibre and Hyperoptic are building their own fibre networks from the ground up.

BT agreed to regulator demands to legally separate from Openreach in 2017.[59] This was, in large part, to ensure equal treatment for all "downstream" customers competing with BT and to prevent BT being able to enforce a monopoly position.

Ofcom's enhanced access regulations, implemented in 2019, are hoped to deliver "positive changes on investment in full-fibre infrastructure".[60] Unrestricted access to Openreach's network to allow any company to install its own internet infrastructure is expected to reduce costs.[61] However, there are concerns that delivery companies might find difficulty in accessing the ducts and poles network. ICE Fellows and other experts have highlighted that steps may be needed to ensure ducts and poles can be requested at scale, with availability being made far enough in advance to synchronise with the delivery timescales for other companies.

Minimisation of disruption

Delivering fibre-optic cables to every community in the UK is a substantial challenge. The scale of the delivery challenge will inevitably cause significant disruption. Roadworks, in particular, will likely increase congestion, disrupting productivity and economic output and increasing public frustration with the roll-out programme.

The Government has previously suggested and trialled methods to reduce roadwork disruption, including permit systems, lane rental, strict standards and better data management and communication to manage the impact of roadworks.[62]

Learning lessons from other sectors, such as rail, could also help to minimise disruption to local communities during upgrade work. Network Rail has sought to reduce the length of works through the Delivering Works Within Possessions process. This process sets out a structured set of actions and checklists to ensure that engineers are ready to deliver work, and that risks to "right-time handback" have been considered prior to work commencing.[63]

Companies could further be incentivised to operate at night, as happens in Japan, if innovation can reduce the noise of these works overnight. Alternatively, non-disruptive technology, like pipe jacking, could avoid the need for extensive surface-level works altogether.[64]

Some companies, such as Anglian Water, are investigating technological solutions to embed fibre-optic cables into their water-pipe assets for the purpose of infrastructure monitoring and leak detection.[65] If trials demonstrate this can be achieved without widespread surface-level disruption, this could accelerate and minimise the disruptive impacts of FTTP delivery.

Multiple companies delivering in the same areas in an uncoordinated way will likely mean significant localised disruption, with some areas being disrupted multiple times. This could lead to increased costs, an inefficient roll-out and reduced commercial viability, especially on a compressed delivery window to 2025. However, a reorganisation from private-led delivery to a more coordinated model, such as New Zealand's Ultra-Fast Broadband initiative,[66] which has seen roll-out delivered through a public-private partnership with four private companies delivering with the Government directly, would be unsuitable given the timescales.

Instead, greater coordination between companies, through a more open environment for the sharing of expansion plans or incentives for companies to deliver in the same area at the same time, would help avoid overbuilding. Regional bodies,

[59] Ofcom (2017) BT Agrees to Legal Separation of Openreach
[60] Department for Digital, Culture, Media and Sport (2018) Future Telecoms Infrastructure Review
[61] Ofcom (2018) Wholesale Local Access Market Review: Statement – Volume 1
[62] ICE (2018) What More Can Be Done to Reduce Congestion Caused by Roadworks?
[63] Network Rail (2019) How We're Reducing Delay Minutes after Engineering Work
[64] Ibid
[65] Anglian Water (2020) Anglian Water to Trial Fibre-Optic Cables to Find Hidden Leaks in Water Mains
[66] ICE (2020) Ultra-Fast Broadband Roll-Out, New Zealand

such as the Northern Powerhouse Partnership, have called for the Government and Ofcom to create a "regulatory framework that takes a proactive approach to monitoring, investigating and cracking down on anti-competitive behaviour" that would undermine efficient investment or threaten competition.[67]

Alternatives

While 100% delivery of full-fibre networks would provide a step change in connectivity and speed, there are potential alternatives which could deliver these benefits in faster or more cost-effective ways.

Satellite coverage

Connecting rural or remote businesses and domestic users through a ground cable might not represent the best value-for-money solution. While the geographical challenges are far greater, Canada's connectivity strategy calls for multi-mode approaches, including CAN $1.7 billion (approximately £1 billion) of spending on infrastructure for fixed-ground assets and low-earth orbit (LEO) satellites.[68]

The LEO satellite network will be developed by Telesat Canada. It is designed to run as a constellation and can offer download speeds of above 50 mbps with continuous connection, which will be scalable in future to reach gigabit-capable capacity.[69] The Canadian Government signed a memorandum of understanding with Telesat Canada in 2019 with an expectation that this system would deliver broadband coverage to Canada's far north in 2022 and all of Canada from a constellation in mid-2023.[70] The constellation will thereafter offer global coverage, with the Government of Canada offering a contribution of CAN $1.2 billion over 10 years.[71]

The UK has an advanced space industry and the UK Space Agency works in close collaboration with international partners, announcing £374 million of investment in European Space Agency activities, including research into 5G and satellite broadband services, as recently as November 2019.[72] Were the UK to develop its own system, collaborate with others or utilise Telesat Canada's system when it comes online, to connect rural areas, the cost would likely compare favourably to the £5 billion cost envelope for rural and remote connections set out in July 2018.[73]

5G to the premises

A full-fibre network is expected to enable and greatly expand the capabilities of 5G mobile networks. The new set of technologies has already begun roll-out and is capable of speeds and bandwidth comparable to, or even exceeding, existing superfast and fibre broadband. 5G.co.UK suggests average speeds of around 150–250 mbps and peak speeds of over 1 gbps.[74] 5G in particular has the potential to provide access to far more machine-to-machine devices, in the internet of things, at low cost, providing ultra-reliable, ultra-low-latency networks for specific vertical applications.[75]

The need for FTTP could be negated in some areas by widespread adaptation of 5G to connect individual premises. This might reduce costs in remote areas where ground connection costs would be prohibitive, especially in the final-stage connection from cabinet to property. The National Infrastructure Commission for Wales is an advocate, stating that 4G and 5G mobile broadband "may be the lowest cost technology to provide superfast connections to some Welsh households".[76]

[67] The Northern Powerhouse Partnership (2019) Next Steps for the Northern Powerhouse
[68] Government of Canada (2019) High-Speed Access for All: Canada's Connectivity Strategy
[69] Telesat (2020) Telesat LEO – Why Leo?
[70] Government of Canada (2019) Memorandum of Understanding between Industry Canada and Telesat Canada
[71] Ibid
[72] Gov.UK (2019) UK Invests in European Space Agency Programmes
[73] Gov.UK (2018) Forging a Full Fibre Broadband and 5G Future for All
[74] 5G.co.UK (2019) 5G Broadband – Which Networks Offer 5G Broadband?
[75] Frontier Economics for the National Infrastructure Commission (2017) Future Benefits of Broadband Networks
[76] National Infrastructure Commission for Wales (2019) Annual Report

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