REGENERIS

The Economic Impact of Full Fibre Infrastructure in 100 UK Towns and Cities

A Report by Regeneris Consulting for CityFibre

March 2018

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Foreword from Greg Mesch,

Chief Executive of CityFibre

CityFibre's ambition is to build and operate metropolitan full fibre networks across 100 towns and cities in the UK. It's an ambition founded on two truths – first, that digital infrastructure is the cornerstone of any successful modern economy; second, that although the UK has succeeded in becoming a leading digital economy over the past decade, rising demand for fast and reliable connectivity means that today's copper network will not be fit to support tomorrow's digital economy. The UK needs to upgrade to full fibre as a matter of urgency if we are to maintain our competitive advantage in an increasingly digital world.

For this reason, we are strong supporters of the Government's full fibre goals – over the next decade, to have at least 10 million premises connected to full fibre, with a clear path to national coverage – as well as the Government initiatives aimed at stimulating commercial deployment, such as the Local Full Fibre Networks programme.

As Government and local authorities consider what role they can play in building full fibre Britain, there is a need to understand how these networks might impact national and local economies. We are therefore pleased to present this study of "The Economic Impact of Full Fibre Infrastructure in 100 UK Towns and Cities", by consultants Regeneris, as our contribution to the discussion.

We commissioned the study aware of the challenges inherent in measuring what is undeniably a moving picture. Full fibre is now being rolled out at pace across many of the UK's international competitors, leaving us trailing behind. But these networks are relatively new and studies analysing their economic impact are only now starting to come through. Similarly, many of the future applications and technologies that we know will depend on highly reliable gigabit connectivity – such as smart cities and 5G – have yet to be deployed or reach mass consumption. And finally, as well as the "known unknowns", as with all new technologies, there will be many uses of full fibre that we simply cannot yet predict.

For these reasons, rather than attempting to calculate one single figure capturing the 'total' economic impact of full fibre, we asked Regeneris to select 10 areas where full fibre is likely to

generate benefits – and where sufficiently robust research and data already exists – and to analyse those benefits across 100 towns and cities in the UK. These 10 estimates sit alongside each other, rather than summing to create one hard and fast prediction.

The result is an illustration of the immense scale and scope of the potential economic impact of full fibre. For example, Regeneris predict that full fibre in 100 towns and cities will generate significant economic benefits for businesses, in particular SMEs – £2.2bn in business productivity; £2.3bn in innovation benefits; £1.9bn in flexible working benefits and £2.3bn from new business start-ups. The benefits to individual households will also be substantial – £7bn. In addition, full fibre is expected to unlock considerable economic value from wider technological developments: £1.1bn from future healthcare applications; £5bn from smart city infrastructure; and £10bn from the Internet of Things in the manufacturing sector alone. Finally, in a world where fixed and wireless networks will increasingly work together to deliver ubiquitous ultrafast connectivity, full fibre will be necessary to deliver £28bn in 5G benefits.

As evidence continues to emerge, it will be possible to add to and refine these 10 economic estimates. However, the picture that emerges from this study is already crystal clear: it's a picture of economic and social opportunity, with full fibre providing the springboard for increased productivity and business innovation, more efficient public services and business processes, and the "smart" transformation of our urban areas and infrastructure. It's a picture wholly in tune with the Government's Industrial Strategy goal of taking advantage of technology to spread opportunity across the UK. As Regeneris conclude:

> *"Full fibre will provide the core infrastructure required to kick start the next generation of digital technology and drive expansion of smart infrastructure in towns and cities where it is deployed. The result will be a modernised, more productive and innovative UK economy."*

1. Introduction

1.1 As part-fibre broadband networks (such as Fibre to the Cabinet (FTTC) and cable) reach 95% of the UK[1], eyes have shifted towards the deployment of full fibre broadband (or Fibre to the Premises (FTTP)). Full fibre is widely acknowledged to deliver superior connectivity which will open up the next generation of applications for residential and business users. It will also sit at the heart of much wider digital advances, underpin 5G mobile networks, power the smart cities of the future and drive smart technologies in healthcare and what is being described as a fourth industrial revolution (or Industry 4.0) in the manufacturing sector. This is expected to generate significant economic and social impacts.

1.2 Drawing on the latest data and published research, we explore the wide range of economic impacts that may emerge from the exploitation of full fibre broadband.

1.3 We have used this evidence to estimate the impact of full fibre across a sample of 10 categories. Our sample of impact areas is not exhaustive but clearly demonstrates the scale and scope of economic and social impacts that full fibre could support across 100 major UK towns and cities (ie to roughly 30% of the UK's total population). The locations are listed in Appendix A.

1.4 We assess 10 categories of impact in this two-part report, covering the **core and wider benefits** of full fibre.

Core Impacts

1.5 The impacts generated most directly by full fibre will be as a result of the network build itself followed by businesses and residents starting to take-up and exploit its capabilities. We look at how these core impacts will arise through five channels:

1) economic and employment impacts associated with the **network build**

2) existing businesses exploiting full fibre applications to generate **productivity improvements**

3) existing businesses exploiting full fibre applications to **innovate and open new markets**

[1] FTTC delivers broadband through older copper lines between street level cabinets and premises, ie across the so called last mile. As a result, a significantly reduced connectivity is achieved versus full fibre (FTTP).

4) **new business start-ups** capitalising on gigabit broadband to operate new digitally dependent business models at lower cost and more flexibly than established businesses

5) the rise in **flexible working practices**, enabled through gigabit cloud, file transfer and communications/conferencing applications and delivering additional productivity benefits

6) **private households benefits,** via increases in house price and housing wealth.

Unlocking Wider Impacts

1.6 The economic impacts generated as a result of full fibre deployment will extend well beyond the core benefits set out above, into a number of other sectors of the economy. We have reviewed a range of findings that point to full fibre's potential for generating wider economic benefits. We have selected five of these wider areas, those where robust evidence/research exists, to illustrate this potential:

1) the impact of **5G** mobile networks, which will require full fibre backhaul

2) **smart cities infrastructure** such as reductions in energy use, congestion and fuel costs stemming from smart energy and traffic systems

3) increased manufacturing productivity secured from the emerging digital revolution in manufacturing (**Industry 4.0)** and connected **Internet of Things (IoT)** devices

4) **healthcare benefits** through advances in connected health technologies

5) **environmental impacts** through carbon reduction.

Full Fibre Will Drive Productivity and Innovation

1.7 The role of full fibre in delivering increased productivity runs throughout our findings. Full fibre will provide the core infrastructure required to kick start the next generation of digital technology and drive expansion of smart infrastructure in towns and cities where it is deployed. The result will be modernised, more productive and innovative economies.

1.8 Full fibre is vital to the UK government's policy focus on raising national productivity levels, as a driver of competitive advantage within an expanding globalised economy. The overarching focus of the government's Industrial Strategy White Paper is to "strengthen the five foundations of productivity: infrastructure, people, ideas and business environment and

places". It is clear from our research that full fibre can drive significant gains in all five of the Industrial Strategy's foundations of productivity:

- **Infrastructure:** in addition to boosting fixed connectivity speeds, full fibre infrastructure will drive the deployment of 5G mobile networks and smart city applications
- **People:** full fibre creates new opportunities for people to realise their potential in work and increase their earnings where they have the right skills to capitalise upon digital opportunities for work, learning and enterprise
- **Ideas:** full fibre is a future-proof platform for sharing knowledge and developing new innovative solutions which can secure economic growth for the UK
- **Business environment and places:** attracting and nurturing businesses to start-up and grow using new models of operation which exploit high speed resilient digital infrastructure.

1.9 The Industrial Strategy highlights four grand challenges – emerging technologies and industries where the UK should aim to be a world leader. The prospects for success in all four of the Industrial Strategy's grand challenges will be significantly enhanced in locations that have access to full fibre:

- **Artificial Intelligence:** the data flows and computing power needed to drive innovation and AI solutions demand access to high speed and reliable digital connectivity
- **Mobility:** full fibre has a vital role in underpinning the roll-out of wireless and 5G networks across the country which are a vital component of the innovation efforts in the transport arena
- **Clean Growth:** smart cities are a central plank of better energy management systems and they will rely on fast full fibre networks
- **Ageing Society:** digital health care will be a significant element of the solutions that emerge around care for our aging society and for sustaining people through longer working lives.

1.10 The National Infrastructure Commission further underlines the role of digital infrastructure at the heart of the upgrade of the UK's wider infrastructure:

"The UK's digital infrastructure needs to be ready to support new demands from other infrastructure sectors, as they become increasingly 'smart'. Smart infrastructure systems need to be resilient from the outset."

"The fibre spine laid in recent years will provide the foundations for digital networks for decades to come. This connectivity will be at the heart of a successful 21st century economy, just as electricity or railways were in earlier eras." [2]

Breadth and Scope of the Assessment

Using headline estimates and local data

1.11 We take the latest national and international research and evidence on the benefits of full fibre in each of our impacts areas. We use the headline evidence to build a picture of impact within each of our 100 sample cities using data on the size and composition of the resident and business population.

There is overlap between impact areas..

1.12 It is important to understand there are a number of overlaps between the areas we have looked at. For example, 5G (Element 1) networks will be required to unlock the full capabilities of smart cities (Element 2). Likewise, the productivity benefits secured through Industry 4.0 digital technology will overlap to some degree with the core productivity impacts estimated across the whole economy.

1.13 Given the breadth of potential impacts and scope for overlap, we have not sought to produce one overarching estimate of the economic impacts associated with full fibre.

Additional investment will be required..

1.14 It is important to view full fibre in the wider context of investment in technology and innovation. The impacts produced in this report will not arise without first investing in the widespread deployment of full fibre in urban areas. Full fibre will provide the underlying infrastructure on which these technologies, applications and end-user benefits are based but the full scale of benefits will not arise without additional investment in smart city technologies, IoT, 5G mobile networks and new telehealth technologies.

[2] The National Infrastructure Commission (2017). 'Priorities for National Infrastructure'.

There are areas we have not covered..

1.15 Some social and economic benefits of full fibre have not been covered in this report. It is important to bear these in mind when thinking about the full benefits associated with full fibre:

- **Growth in the tech sector:** the continued rise of the fintech and govtech industries will be powered by full fibre and make a significant contribution to growth in our future economy.
- **Public service delivery:** full fibre will allow residents and businesses to interact with local government and public services in a more seamless way as full fibre opens additional means of delivering public services. In 2015/16 alone, the government made £339 million of operational savings through digital transformation[3].
- **Digital and social inclusion**: reducing the digital divide between locations and people to ensure no one is left too far behind.
- **Access to education**: the education sector is already being transformed through digital technology. Full fibre will accelerate new more flexible ways for students to learn remotely and to use interactive e-learning tools.

Many of the impacts are not yet known..

1.16 While we can begin to predict the value that will be generated in some areas of the economy and society, there are likely to be many more areas where change is hard to predict. 5G and many smart and IoT technologies are yet to be rolled-out and we do not yet know the scale and breadth of benefits that will be generated.

1.17 Our assessment is based on conservative estimates and draws on an evolving research base. As time rolls on, the estimates of impact will need to be updated as new evidence emerges.

[3] Cabinet Office (2017). 'Government announces efficiency savings for 2015/16', Page 4.

Summary Across Ten Impact Areas

1.18 Our estimated impacts in the 10 areas we have chosen to analyse are summarised below. This provides a broad indication of a sample of the range of future benefits that may arise from full fibre. These figures are based on reliable lower range assumptions and should be viewed as conservative. We have not provided middle and upper range estimates.

Table 1.1 Headline Impacts over 15 Years

Impact Category		Impact Focus	Value, 50 Towns & Cities	Value, 100 Towns & Cities
Core Economic Impacts (Part 1)	Direct Employment	1. Network build	£1.4bn	£2.1bn
	Business Impacts	2. Productivity improvements	£1.5bn	£2.2bn
		3. Innovation	£1.6bn	£2.3bn
		4. Flexible working	£1.4bn	£1.9bn
		5. New business start-ups	£1.5bn	£2.3bn
	Private Benefit to Households	6. Housing wealth	£4bn	£7bn
Wider Impacts (Part 2)	5G	7. Total economic value	£20bn	£28bn
	Smart Cities Infrastructure	8. Energy use & congestion	£3.6bn	£5bn
	Industry 4.0 / IoT	9. Manufacturing productivity	£7bn	£10bn
	Health Care	10. Cost savings	£0.7bn	£1.1bn
	Environmental Impacts	CO2 reductions	1.5Mt CO2	2.3Mt CO2
		Value applying Shadow Price of Carbon	£100mn	£160mn

Source: Regeneris Consulting. Values over £5bn rounded to the nearest billion.

1.19 In addition to Gross Value Added (GVA) impacts, the number of people employed as a result of network construction would peak at **4,450** for the first 50 towns and cities and at **6,850** for the first 100.

Overarching Economic Impact

1.20 Although we have chosen not to produce a single overarching figure, the FTTH Council (2014) has generated an early overarching estimate of the impact of full fibre in the US, which suggests that providing full fibre to just half of all premises could result in a 1.1% rise in annual GDP. Applying this growth rate to the combined size of our 100 city and town economies suggests a total economic impact of up to **£85 billion** associated with 50 towns and cities over 15 years and up to **£120 billion** for 100 towns and cities. This underlines the conservative nature of our impact figures.

Part 1: Core Economic Impacts

The most direct impacts from full fibre will arise from the network build itself and from businesses and residents taking-up and exploiting its capabilities. In this first part of the report we look at how these core impacts will arise through five channels.

2. Direct Economic Impacts Associated with the Network Build

Employment Impacts

Phasing of Temporary Employment

2.1 To build full fibre networks across our 100 sample UK towns and cities, data from CityFibre allows us to estimate that employment associated with network construction will rise to around 150 jobs per town/city on average over a period of 11 quarters.

Estimating Peak Employment

2.2 The employment associated with network deployment will vary over time as investment into 100 UK cities begins and ends. The number of towns/cities in which network construction is taking place will peak at 50. On this basis the number of people employed as a result of network construction across 100 towns and cities will peak at **6,850**.

GVA Impacts

2.3 To estimate the GVA impact associated with the construction of full fibre networks in 50 and 100 towns and cities, we have applied GVA per employee per annum to employment as it rises and falls over the course of the roll-out. Broadly, three sectors are engaged in network deployment.

2.4 Table 2.1 shows the assumptions applied for employment in each of these sectors.

Table 2.1 Proportion of Direct Employment by Sector and GVA per employee

Sector	Construction	Civil Engineering	Professional Services
Employment, %[4]	63%	24%	13%
GVA per employee pa[5]	£67,700	£79,000	£67,000

Source: CityFibre Holdings; ONS Annual Business Survey, 2015.

Estimated Network Construction Impacts[6]

Over 15 years

GVA Created

50 towns & Cities: **£1.4bn**

100 towns & Cities: **£2.1bn**

Peak FTE Employment (Temporary)

50 towns & Cities: **4,450**

100 towns & Cities: **6,850**

[4] Proportion of employment by sector estimated by CityFibre Holdings based on full fibre roll-out to date.

[5] GVA per employee data taken from ONS Annual Business Survey, 2015. Rounded to the nearest £100.

[6] GVA and employment impacts have been disaggregated across the 100 towns and cities using CityFibre forecasts of the proportion of investment required to deliver to each location.

3. Business Productivity and Innovation

Productivity Impacts

3.1 Full fibre broadband will drive increased productivity in the workplace and throughout wider society. This is particularly pertinent given the UK government's policy focus on raising national productivity levels, as a driver of competitive advantage. Firms exploiting new business processes which are reliant on enhanced connectivity will secure economic gains from an increase in employee productivity.

3.2 Recent efforts to assess the productivity effects associated with enhanced broadband connectivity converge on a 0.3% uplift where a doubling in speed is achieved. This is applied in the Department for Community and Local Government (DCLG)'s 2017 assessment of the economic impacts associated with the Universal Service Obligation as well as in the 2013 Evaluation of the BDUK National Broadband Programme. This draws on 2012 research by Chalmers which found that a doubling of speed is associated with a 0.3 percentage point increase in Gross Domestic Product (GDP) growth for OECD countries[7].

3.3 We have used assumptions which estimate the economic uplifts associated with the transition from existing part fibre broadband technologies, to a full fibre network. This is informed by the transformational potential of full fibre, with the key differentiating characteristics being:

Faster speeds

- gigabit upload and download speeds as standard
- over 12 times faster than fibre to the cabinet and 3 times faster than DOCSIS 3.1.

Designed for business

- uncontended service and ultra-low latency
- superior resilience and reliability.

Future proof

- greater capacity
- provides the basis for future investment in 5G, wireless and smart cities
- positioned for upgrade to multi-gigabit speeds to adapt to exponential rises in computing power and data use and the emergence of new applications.

[7] Rohman, Ibrahim Kholilul, and Erik Bohlin. (2012). 'Does Broadband Speed Really Matter for Driving Economic Growth? Investigating OECD Countries.'

3.4 Given the transformative characteristics of full fibre networks, we have assumed the same level of benefits will be achieved again when businesses shift to full fibre as they did when they moved from first generation ADSL broadband to hybrid fibre connections. We believe the assumptions we have applied are conservative as full fibre delivers speeds many times quicker that the fastest services covered by the research.

GVA Impacts

3.5 We assume that on average, businesses taking up full fibre will generate productivity improvements in line with the 2017 DCMS assessment. We also assume that those impacts vary by sector and size.

3.6 We provide a description of the other detailed assumptions applied in estimating business productivity and innovation impacts (on impacts by industry type, take-up rates, the timing of impacts and technological change) in Appendix B.

Innovation Impacts

3.7 Through enhanced upload and download speeds, businesses will be able to develop and promote new and richer products and services online across wider geographical markets. They will be stimulated by greater exposure to innovation, information and an international online community and marketplace.

3.8 Innovation is informed by the rapid pace of technological change and can be difficult to forecast; some examples are:

- providing an interactive customer experience
- multi-media presentations
- online calculators or mapping services
- and, tailored products and services.

3.9 This increase in innovation sets the scene for a new ecosystem relying on applied digital technologies, smart data and increasing commercial returns from the Internet of Things.

3.10 We have assumed that productivity gains tested above are replicated through innovation and extended market reach. This suggests that a total of **£4.6bn** in GVA will be generated over 15 years, as a result of existing businesses making use of full fibre across 100 UK towns and cities to deliver productivity benefits, develop new products and services and open new markets.

Estimated Business Productivity & Innovation Impacts

Over 15 years

Productivity Improvements

50 towns & Cities: **£1.5bn**

100 towns & Cities: **£2.2bn**

Innovation & Opening New Markets

50 towns & Cities: **£1.6bn**

100 towns & Cities: **£2.3bn**

4. New Business Start-ups

4.1 Enhanced connectivity has been shown to make it easier and less expensive to start a business. Entrepreneurs are able to use increased computing and storage capabilities, more effectively to share data and work collaboratively. The shift to cloud and subscription services moves capital expenditure into operating costs, reduces the fixed costs of entry, and allows businesses to more cost effectively vary the scale of their activities.

4.2 The added flexibility provided through cloud computing is of particular benefit to smaller businesses and entrepreneurs. It allows small business owners to base their business at home without investing in servers or other expensive ICT equipment and overheads. Not only does it make it simpler to set up a business, fibre services are expected to make many of the next generation of businesses leaner and more productive.

Impact Assessment: New Business Starts-ups

4.3 We have estimated the number of business starts arising from reduced barriers to entry in certain sectors. Assumptions have been informed by a study which estimates levels of business creation due to increased cloud computing power[8]. This found increases in the businesses growth rate of the following magnitude: 1.2% across other manufacturing and construction and other services sectors and 1.5% for knowledge based industries.

We have assumed that the annual business growth rate builds up to its peak in year 5, then persists in years 6 to 8 before decreasing by 10% per year thereafter.

4.4 Survival rates are applied across two broad sectors (Knowledge Based Industries and Other[9]) based on ONS business counts data. We have assumed that survival rates decline at around 5% per annum.

4.5 It is assumed that 99% of start-ups are established as micro businesses (1-10 employees), but that by year 15, the size composition of surviving firms mirrors the national average. Note that although some businesses will grow significantly, 95% of businesses will remain micro firms. Average employee numbers for each area are applied across micro, small and

[8] New Business Estimates from The Economic Impact of Cloud Computing on Business Creation, Employment and Output in Europe, 2009, Federico Etro, Review of Business and Economics

[9] Knowledge Based Industries include all professional, scientific, technical, financial and information & communications sectors.

medium sizes and large businesses for each sector drawing on the 2008 Annual Business Inquiry.

4.6 GVA estimates have been generated by applying GVA per worker figures across knowledge based industries, manufacturing and construction and other services. The proportion of GVA created by new businesses that is attributed to the full fibre network is programmed to fall over a five year period.

Estimated Economic Impact Associated with New Business Start-ups

Over 15 years

50 Towns & Cities: **£1.5bn**	100 towns & Cities: **£2.3bn**

5. Flexible Working Practices

5.1 Research shows that flexible working practices are 21% higher amongst firms with some form of fibre broadband versus basic broadband[10], and that employee productivity rises significantly as a result[11].

5.2 The widespread availability of full fibre broadband in homes and businesses can be expected to fuel continued growth in the use of fibre-enabled human resources, VoIP and other such systems. These applications will enable more employers and employees to communicate and work flexibly. Flexible working can yield the following benefits:

- enable employers to access a wider labour pool when recruiting
- reduce overheads associated with business premises
- reduce business and commuter travel costs and lower carbon emissions
- improve employees' work-life balance which in turn improves motivation and retention
- reduce barriers to work for carers, single mothers and disabled people.

Impact Assessment: Flexible Working

5.3 In our modelling, rates of teleworking are programmed to increase at roughly the same rate that has been achieved during the move from basic to part-fibre broadband. This assumes that increases will occur at the following rates:

- 3% pa in the financial and professional services sector (the sectors most likely to utilise these technologies)
- 1% per annum in all other sectors.

5.4 Baseline GVA estimates have been generated by applying GVA per worker figures across knowledge based industries, manufacturing and construction and other services.

[10] Strategic Networks Group (2013). Data refers to a survey of 16,000 firms in the US.

[11] Rockbridge Associates Inc. "2005/2006 National Technology Readiness Survey estimates that employees working flexibly are 25% more productive than other employees. 20% has been applied in estimating impacts here allowing for some levelling off in the increase in worker flexibility and productivity gains over time.

5.5 We assume that productivity will be 20% higher for tele-workers versus other employees. This compares to a 25% suggested by the research, allowing for some levelling off in the increase in worker flexibility and productivity gains over time.

Estimated Impact Associated with Flexible Working

Over 15 years

50 Towns & Cities: **£1.4bn**

100 Towns & Cities: **£1.9bn**

6. Private Household Benefits

6.1 In this section we focus on the private benefits that may accrue to residential consumers through access to full fibre through increases in the value of housing. This is just one of the means through which households will secure private economic benefits and the area in which there is currently the strongest emerging evidence base. Other benefits will be secured, as a result of new and enhanced services and applications available to residents but are not assessed here.

6.2 Full fibre is expected to push up house prices where it is available. Research undertaken by leading price comparison sites highlights the importance placed on broadband connectivity when purchasing a new home:

- A GoCompare survey of 2,000 house buyers found that 43% prioritised a good, reliable broadband connection strong enough to stream TV and films.[12]
- A survey by Rightmove, of over 3,000 users found that information on broadband connectivity was ranked as a more important feature when searching for property than transport links and nearby schools.[13]

6.3 Housing markets where only basic broadband is available appear to have suffered. Savills conducted a survey which found that nearly 70% of respondents reported that slow broadband was a constraint on letting properties in rural locations.[14] The Rightmove survey highlighted above suggests slow broadband could reduce the value of a home by up to 20%.

6.4 An analysis of broadband coverage and local house prices in the US by the Fibre to the Home (FTTH) Council Americas found that gigabit connectivity boosts the price of a house by 4% on average.[15]

[12] After a good neighbourhood (66%), low crime rate (59%), proximity to shops (51%) and a good GP or dentist (44%). moneywise.co.uk July 2017.

[13] rightmove.co.uk August 2016.

[14] Savills (2015). 'Estate Benchmarking Survey'.

[15] FTTH Council Americas (2015). White Paper.

Impact Assessment: Private Household Benefits

6.5 The estimated average house price across the 100 towns and cities is £204,000[16]. We apply a conservative 0.5% rise in prices to test the incremental rise in value resulting from a full fibre connection (compared with 2.8% suggested by the FTTH Council for homes with gigabit access). This suggests prices would rise by just over £1,000, on average.

Estimated Private Household Impacts

Over 15 years

50 Towns & Cities: **£4.4bn**

100 Towns & Cities: **£6.9bn**

[16] Based on district level average house price data from CLG, 2017.

Part 2: Wider Economic Impacts

The economic impacts generated as a result of full fibre deployment will extend well beyond the core benefits set out in Part 1, into a number of other sectors of the economy.

We have reviewed a range of findings that point to full fibre's potential for generating wider economic benefits and focus on the five areas where robust evidence/research has been produced to date.

These provide a sample of the types of impacts that are expected and illustrate the breadth and broad scale of wider economic, social and environmental benefits. There are likely to be many more areas where change is harder to predict. The range of applications developed using full fibre will continue to grow and we cannot yet predict how other areas of the economy and wider society might benefit.

7. 5G

7.1 Extensive full fibre backhaul will be required to ensure fifth generation mobile networks can be deployed in earnest. 5G will provide the basis for ultra-reliable and low latency mobile services. Once deployed across UK towns and cities, 5G networks will support:

- an exponential rise in mobile data traffic and expectations about the reliability and quality of mobile services and applications
- increased use of high definition video and communication applications for business and recreation
- greater integration between fixed full fibre, mobile and wireless networks
- wider deployment of the Internet of Things, machine to machine communication and smart city applications.

7.2 5G networks are widely expected to further enable all sectors of the economy to operate more flexibly using new business models, to develop new products and services and to boost productivity. From transport and logistics sectors to finance, health and social care, manufacturing and retail, 5G will open the door to a new generation of digital services, applications and technologies.

7.3 A 2017 report by the Future Communications Challenge Group (FCCG) suggests investment in 5G mobile networks, enabled by core full fibre infrastructure, will deliver £173bn in GDP growth between 2020 and 2030[17]. O2, also in 2017, estimate impacts from 5G would total £10 billion per annum by 2026[18].

7.4 International research also points to the vital role of full fibre in enabling 5G networks and supports the broad scale of the FCCG and O2 impact projections for the UK:

- The European Commission (2016): member countries are expected to generate an annual total of €113 billion in socio-economic benefits from 5G in 2025[19].

[17] FCCG (2017). 'UK Strategy and Plan for 5G & Digitisation – Driving Economic Growth and Productivity'. GCCG estimates are based on global contribution of 5G from GSMA (2017). 'The Mobile Economy' and the net benefit of investment in 5G in the UK.

[18] O2 Tech-onomy (2017). 'Measuring the impact of 5G on the nation's economic growth'.

[19] European Commission (2016). 'Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe.'

- IHS Economics and Technology (2017): 5G could enable about 4.6% of global real output in 2035, with the 5G value chain alone driving $3.5 trillion of economic output and supporting 22 million jobs[20].
- Teece & Qualcomm Technologies (2017): by 2035, 5G will enable more than $2.4 trillion in total economic output across the global automotive sector alone, its supply chain and customers[21].

Impact Assessment: 5G

7.5 We have disaggregated the headline GDP estimates of impact produced by the FCCG and O2 in the UK using local GVA data to estimate the impacts across our 50 and 100 towns and cities. This suggests that over a 15-year horizon between **£20 and £37 billion** could be generated from full fibre supported 5G networks across 50 towns and cities and rising to somewhere between **£28 and £53 billion** for 100 towns and cities. Below we present the lower end value of these two assessments to give a conservative estimate of anticipated economic benefit.

Estimated 5G Impact (lower end estimate)

Over 15 years

50 Towns & Cities: **£20bn** 100 Towns & Cities: **£28bn**

[20] IHS Economics & IHS Technology (2017). 'How 5G technology will contribute to the global economy.'

[21] Teece & Qualcomm Technologies (2017). '5G Mobile: Disrupting the Automotive Sector.'

8. Smart Cities Infrastructure

8.1 Full fibre gigabit broadband will provide the UK's core infrastructure, including its energy, transport and utilities networks, with the digital speed, capacity and resilience needed to develop smart city solutions. That is, it will enable the roll-out of connected and interactive technologies and data to make a wide range of services and urban infrastructure better adapted to user needs and more efficient.

8.2 For now, the evidence on economic impact is strongest in the areas of energy, transport and technologies in the home:

- Smart energy: data communication networks integrated with electric grids, smart meters and IoT devices to collect and analyse real-time data and enable better energy management in homes, businesses and public spaces.
- Smart transport and logistic solutions: connected networks of sensors enabling smart roads/parking management and street lighting, leading to reduced congestion and energy use.
- Smart homes: including enabled Internet of Things (IoT) devices used to monitor and control energy and household devices remotely.

8.3 Two studies have provided an indication of future economic benefits that could arise from a series of smart city applications:

- £19 billion of savings could be achieved in the energy sector by upgrading the UK's network to a smart grid (Ernst & Young, 2012[22]).
- Smart city solutions applied to vehicle traffic management and electrical grids could produce $160 billion in benefits and savings through reductions in energy use, traffic congestion and fuel costs across the US (Accenture, 2017[23]).

Impact Assessment: Smart Cities Infrastructure

8.4 We have applied the Accenture impact estimate to each of our towns and cities. This gives a broad indicative and conservative estimate of the benefits that may arise from smart energy and traffic management systems[24]. In focussing our estimate on a sample of just two areas

[22] Ernst & Young (2012). 'Smart Grid: a race worth winning? A report on the economic benefits of smart grid'.

[23] Accenture (2017). 'How 5G can help municipalities become vibrant smart cities'.

[24] 2015 local authority level GVA from ONS Regional GVA data; 2017 US GDP [removing net trade to give GDP]. Applying the US dollar: £ exchange rate from October 2017 ($1:£0.74).

of smart cities infrastructure, we have again sought to produce a conservative picture around economic impact.

8.5 Not all the impact estimated here can be attributed wholly to full fibre as additional investment in 5G mobile networks, wireless broadband and IoT will be required. Plus, there will be some cross-over with the impacts estimated for 5G in the previous section.

8.6 Nonetheless, it is investment in full fibre that will unlock the development of new mobile and wireless networks themselves, and of smart systems and technologies and associated economic impact:

> *"The [government's] focus on connectivity, and the development and deployment of new infrastructure technologies is critical in ensuring our infrastructure network is future-proofed… encouraging the uptake of smart infrastructure now as well as preparing it for the impacts of new technologies on our infrastructure systems"* **Institute for Civil Engineers, 'State of the Nation 2017: Digital Transformation'.**

Estimated Smart Cities Infrastructure Impact

Over 15 years

50 Towns & Cities: **£3.6bn**	100 Towns & Cities: **£5bn**

9. Industry 4.0 and the Internet of Things

9.1 The emerging use of a wide set of digital technologies in the manufacturing sector is set to revolutionise the way the sector operates globally. The scope for applying technology in manufacturing is wide. The Boston Consulting Group (BCG) present eight technology drivers of Industry 4.0: industrial robots, networked machinery, data simulation, 3D printing, big data and analytics, horizontal/vertical integration, augmented reality and cloud computing[25].

9.2 Industry 4.0 technology is gathering pace. BCG surveyed more than 1,500 senior executive and managers of manufacturing in Germany, the UK, China, the US and France. It found that 40% of UK manufacturers expect to make progress across these areas within two years, increasing to 65% within 5 years. Almost three quarters of manufacturers (72%) expect to have fully digitised their supply chains by 2021 (PwC, 2016[26]).

9.3 Full fibre infrastructure is recognised as a critical ingredient in making this technological change. Almost two thirds (61%) of companies surveyed by BCG saw missing network infrastructure and sufficient bandwidth, as an intermediate, big or very big challenge for the implementation of industry 4.0. The UK manufacturers association, EEF, says that for Industry 4.0 to deliver £350bn to the UK economy by 2030, a high speed, secure and reliable digital infrastructure is required[27]. EEF infographic: Secure and reliable digital infrastructure underpins modern manufacturing, eef.org"

9.4 IoT devices are expected to play an important role in future smart city applications but the deployment of connected devices, or 'the internet of things' (IoT) in manufacturing is also proving to be the major driver of Industry 4.0 in the short-term. Although Industry 4.0 extends well beyond IoT, current developments present an early opportunity to gauge potential impacts. The disruptive effect of IoT, in terms of operational and productivity improvements is thought to be marked:

- 44% of UK manufacturers are currently investing in the IoT, 46% in 3D printing and 49% in advanced robotics (KPMG, 2017)[28]
- More than half of major new business processes and systems expect to incorporate some element of the IoT by 2020[29].

[25] Boston Consulting Group (2017), 'Is the UK ready for Industry 4.0.' Survey of 322 UK manufacturers.

[26] PwC (2016). 'Industry 4.0: Building the digital enterprises.' Survey of 2,000 manufacturing firms in 26 countries.

[27] EEF (2016). 'EEF infographic: Secure and reliable digital infrastructure underpins modern manufacturing'. eef.org.uk

[28] KPMG (2014). 'Rethink manufacturing: designing a UK industrial strategy for the age of industry 4.0.'

[29] Gartner (2016). 'Unexpected Implications Arising from the Internet of Things'.

Impact Assessment: IoT for Industry 4.0

9.5 The benefits to the manufacturing sector from IoT alone are predicted to generate a fundamental upward shift over and above the productivity impacts assessed for manufacturing businesses in Section 3.

9.6 Three studies have looked to quantify the economic benefits that could come about through IoT and what is widely termed the fourth industrial revolution or Industry 4.0, i.e. the transformation of the manufacturing processes and operations through internet enabled technologies and systems:

- The McKinsey Global Institute (2013) suggests that 80% of global manufacturers will use IoT technologies by 2025, leading to a potential global economic uplift of $2.3 trillion in manufacturing alone[30].
- Full adoption of SMART manufacturing processes, such as robotics and use of ICT, could result in a 22% increase in productivity in the UK sector (Manufacturing Technology Centre, 2016[31]).
- The introduction of RFID chips to improve inventory management in the UK retail sector could save UK businesses £3 billion (Morgan Stanley, 2014[32]).

9.7 We attribute the forecast global economic uplift from McKinsey GI, to each of our 100 towns and cities based on the proportion of global manufacturing output accounted for by the UK and the relative size of the economy for each town/city[33].

Estimated Industry 4.0 / IoT Impact

Over 15 years

50 Towns & Cities: **£7bn** 100 Towns & Cities: **£10bn**

[30] McKinsey Global Institute (2013). Disruptive technologies: advances that will transform life, business, and the global economy.

[31] Manufacturing Technology Centre (2016). 'From Industry 4.0 to Digitising Manufacturing'.

[32] Morgan Stanley (2014), 'The Internet of Things is Now'.

[33] 2015 local authority level GVA from ONS Regional GVA data; 2017 Global GVA from statisticstimes.com. Global and UK manufacturing output from World Bank statistics. Applying the US dollar: £ exchange rate from October 2017 ($1: £0.74).

10. Healthcare Benefits

10.1 Part fibre networks are already assisting the healthcare sector to develop and deploy transformative technologies and improve access to healthcare. New forms of outreach, remote diagnosis and patient monitoring are becoming increasingly commonplace and deliverable.

10.2 The UK government is investing £4.2 billion over the next five years in areas such as electronic patient records, apps and wearable devices, telehealth and assistive technologies[34]. It is estimated that 10% of patients in every general practice will book appointments and order repeat prescriptions online by March 2018[35].

10.3 Full fibre will enable the larger scale deployment of connected healthcare technologies[36]. It will increase network capacity and reliability of service, allowing better real-time access to patient monitoring data and stimulating new technology development.

10.4 These technologies will enable significant cost savings and a more agile health service that is better placed to cope with the pressures of an ageing population.

Improved Health Outcomes

10.5 The development of new applications in the field of healthcare has been facilitated by high speed connectivity. It is also borne out of the need to respond to an ageing population and the growing number of people with long term conditions (LTCs), such as chronic obstructive pulmonary disease (COPD), heart failure and diabetes.

10.6 The Nuffield Trust ran a whole-system telehealth demonstrator trial for 3,100 patients diagnosed with COPD, heart failure or diabetes. It found that telehealth services delivered a 45% reduction in mortality, reduced emergency admissions by 20%, led to 14% fewer elective admissions and 14% fewer bed days[37]. The trial found that overall costs of hospital care were £1,888 lower among telehealth users with COPD, heart disease or diabetes, than for control patients.

[34] DCMS (2017). 'UK Digital Strategy'.

[35] *ibid*

[36] See for example, Arthur D. Little for Vodafone (2016), 'Creating a Gigabit Society' p12-15.

[37] Nuffield Trust (2012). ''The Impact of Telehealth on the use of Hospital Care and Mortality'.

10.7 Connected IoT devices will play an important role in delivering the impacts from full fibre in healthcare. A 2015 report by ISACA identifies a number of IoT healthcare innovations, including foetal, heart, temperature and blood glucose level monitors in addition to robotic mental health assistants and that the use of IoT could save $63bn in healthcare costs over 15 years with a 15 per cent to 30 per cent reduction in hospital equipment costs and a 15 to 20 per cent increase in patient communications (original estimate from the Atlantic Council, 2017[38]).

10.8 We have applied the lower end impact estimate from the Atlantic Council (2017) to our 100 cities based on average impact per head of population.

Estimated Healthcare / IoT Impact

Over 15 years

50 Towns & Cities: **£0.7bn** 100 Towns & Cities: **£1.1bn**

[38] Atlantic Council (2017). 'The Healthcare Internet of Things: Rewards and Risks'.

11. Environmental Impacts

11.1 On top of economic benefits, full fibre broadband is expected to reduce business and commuter travel and energy use, resulting in CO^2 reductions through a range of mechanisms:

- Dematerialisation: part fibre broadband is already fuelling a shift in production and consumption of news, books, music and films to digital platforms. This reduces the need to manufacture, publish, print and ship a range of physical products and results in reduced carbon emissions. The capability of full fibre will expand the range of physical products that can be provided digitally and further reduce CO2 emissions from manufacturing.
- E-commerce: gigabit broadband will provide a more seamless online shopping experience and drive increased e-commerce, both business to consumer (B2C) and business to business (B2B). E-commerce reduces the need for commercial, retail and wholesale floorspace and associated energy requirements.
- Cloud computing: full fibre will make online file sharing and business process applications (e.g. CRM and HR systems) work seamlessly and reduce energy consumption associated with a range of digital interactions.
- Telecommuting: everyday use of cloud and video conferencing and the more general rise of online communications and commerce has opened the opportunity for many to work and do business remotely and from home (also reducing commuter travel and congestion). This is a trend that can be expected to continue with wider access to full fibre broadband which makes remote working more achievable and effective.

Impact Assessment: Carbon Abatement

11.2 PwC and Ecobilan for FTTH (2008) estimate the additional environmental benefits set to arise from full fibre. They estimate that over 15 years, the equivalent of 330 tonnes of carbon will be saved for every person with a full fibre connection. This is based only on teleworking, telemedicine and home assistance using high-end videoconferencing and represents only a portion of the total CO2 abatement that will be achieved[39]. The study looks at the whole life

[39] PwC and Ecobilan for FTTH (2008). 'Developing a generic approach for FTTH solutions using LCA methodology'.

cycle of a full fibre network, incorporating the environmental costs associated with the manufacture and deployment of optical fibre.

11.3 We apply this, per user impact assessment over our 15-year timeframe to estimate the net environmental effect of fibre to our chosen cities and towns and have assumed, as with our other impact assessments, a conservative 35% take-up rate.

Estimated Environmental Impact

Over 15 years

50 Towns & Cities: **1.5m tonnes CO2**

100 Towns & Cities: **2.3m tonnes CO2**

11.4 This equates to the emissions created by 2% of all drivers across the 100 towns and cities over 15 years[40]. The government's latest Shadow Price for Carbon values this at **£100 million** across 50 towns and cities rising to **£160 million** across 100 towns and cities.

[40] Applying national data on the proportion of adults with a driver's license (License Bureau, 2017), average vehicle emissions (Department for Transport New Car Carbon Dioxide Emissions, 2013) and distance travelled per driver (National Travel Survey, 2016).

12. Summary of Total Impacts

12.1 Part 1 of this report provided estimates of the core economic impacts attributable to a full fibre rollout to 50 and 100 UK towns and cities. In part 2 we estimated a selection of the broader set of impacts that will be generated as full fibre unlocks the potential of 5G, smart cities infrastructure, Industry 4.0 and the Internet of Things and health care technologies.

12.2 We have drawn on a broad base of research to estimate impacts generated through a range of channels. In Part 1 we undertook detailed economic modelling to estimate core economic benefits arising as a direct result of full fibre infrastructure and as the transformative potential of full fibre is harnessed by new and existing businesses and residents.

12.3 In Part 2 we explored the wider economic, social and environmental benefits likely to arise from full fibre. This included early estimates of the broad scale of impacts likely to be created through two major trends that look set to transform the way UK cities and the manufacturing sector operate i.e. smart city and industry 4.0 technologies. The speed of technology change in each of these areas means that predicting future uses, let alone the scale of associated economic benefit, is naturally difficult. Despite this, we have generated some broad, indicative and cautious estimates of economic and environmental impact over a 15-year period, drawing on headline forecasts and evidence of specific impacts generated to date. Throughout we have used lower end figures in the ranges presented in research.

Table 12.1 Headline Impacts over 15 Years

Impact Category		Impact Focus	50 Towns & Cities	100 Towns & Cities
Core Economic Impacts (Part 1)	Direct Employment	1. Network build	£1.4bn	£2.1bn
	Business Impacts	2. Productivity improvements	£1.5bn	£2.2bn
		3. Innovation	£1.6bn	£2.3bn
		4. Flexible working	£1.4bn	£1.9bn
		5. New business start-ups	£1.5bn	£2.3bn
	Private Benefit to Households	6. Housing wealth	£4bn	£7bn
Wider Impacts (Part 2)	5G	7. Total economic value	£20bn	£28bn
	Smart Cities Infrastructure	8. Energy use & congestion	£3.6bn	£5bn
	Industry 4.0 / IoT	9. Manufacturing productivity	£7bn	£10bn
	Health Care	10. Cost savings	£0.7bn	£1.1bn
	Environmental Impacts	CO2 reductions	1.5Mt CO2	2.3Mt CO2
		Value applying Shadow Price of Carbon	£100mn	£160mn

Source: Regeneris Consulting. Values over £5bn rounded to the nearest billion.

12.4 In addition, the number of people employed as a result of network construction will peak at **4,450** for the first 50 towns and cities and at **6,850** for the first 100.

Overarching Economic Impact

12.5 Given the breadth of potential impacts and scope for overlap, we have not sought to produce one overarching estimate of the economic impacts associated with full fibre. There is cross-over between some of these areas and some of the wider impacts will require additional investment in technology to be realised.

12.6 While we have chosen not to provide one single economic impact figure, the FTTH Council (2014) does provide an early overarching estimate. Based on evidence from the US, it suggests that providing full fibre to just half of all premises could result in a 1.1% rise in annual GDP. If this growth rate is applied to our combined 100 city and town economies, it suggests a total economic impact of up to **£85 billion** associated with 50 towns and cities over 15 years and up to **£120 billion** for 100 towns and cities.

Conclusion

12.7 The findings within this report provide a powerful set of insights into the scale and scope of the economic contribution that the extensive availability of full fibre networks will make.

12.8 These impacts are critical to the UK government's focus on growing UK productivity and ensuring we have the right infrastructure to generate the greatest economic returns and help areas across the UK achieve their potential.

Appendix A - The 100 UK Towns and Cities

First 50 Towns and Cities	Peterborough	Chester
Liverpool	Dundee City	High Wycombe
Cardiff	Newport	Colchester
Brighton and Hove	Cambridge	Winchester
Swansea	Huddersfield, Dewsbury, Batley	Bolton
Gateshead	Slough	Cheltenham
Oxford	Doncaster	Chelmsford
Barnsley	Exeter	Mansfield
Inverness	Rotherham	Darlington
Birmingham	Bath	Blackburn
Manchester	Wakefield	Chesterfield
Leeds	Windsor and Maidenhead	Oldham
Glasgow City	Bracknell	Wolverhampton
Sheffield	Halifax	Eastbourne
Bradford	Ayr	Worcester
Edinburgh, City of	Stirling	Basildon
Bristol, City of		Margate, Ramsgate
Coventry	**Second 50 Towns & Cities**	
Leicester	Sunderland	Durham
Nottingham	Stoke-on-Trent	Hastings
Newcastle upon Tyne	Luton	Basingstoke and Deane
Plymouth	Norwich	Weston-Super-Mare
Milton Keynes	Solihull	Brentwood
Kingston upon Hull, City of	Warrington	Salford
Derby	Telford and Wrekin	Crewe
Southampton	Poole	Shrewsbury
Aberdeen City	Blackpool	Llanelli, Carmarthen
Northampton	Wirral	Wrexham
Swindon	Neath Port Talbot	Littlehampton, Bognor Regis
Portsmouth	Middlesbrough	Taunton
York	Wigan	Bury
Bournemouth	Stockport	Hereford
Southend-on-Sea	Lancaster, Morecambe	Scarborough
Reading	Preston	Clacton-on-Sea
Ipswich	Newcastle-under-Lyme	

Appendix B - Core Business Impact Method

Detailed Assumptions

Overarching Assumptions

B.1 We have applied the following:

- a 15-year assessment period consistent with European telecommunication infrastructure assessment guidance[41]
- a 3.5% discount rate consistent with HM Treasury's Green Book[42]
- where supply-chain and knock-on impacts associated with increased spending power are relevant, we apply a combined multiplier effect of 1.25. for the knock-on benefits generated due to increased employee/resident spending power (induced multiplier effects) and increased supply chain purchasing by businesses (indirect multiplier effects)[43].

Business Productivity Improvements

B.2 A 2008 EC study estimated broadband productivity impacts for a range of industry types[44]:

- manufacturing and construction: 0.14% increase in GVA per firm per annum
- knowledge intensive[45]: 0.58% per annum
- other services: 0.32% per annum (productivity benefits only).

[41] In line with European guidance on the assessment of major telecommunications infrastructure; EU (2008). 'Guide to Cost Benefit Analysis of Investment Projects'. Table 2.2.

[42] HM Treasury Green Book Appraisal Guide. Indirect multiplier effects have not been factored into the assessment of private household benefits.

[43] HM Treasury Green Book Appraisal Guide. Only induced impacts applied in the assessment of private household benefits.

[44] Micus Management (2008). 'The Impact of Broadband on Growth and Productivity'. European Commission, DG Information Society and Media.

[45] These are the information and communication (Standard Industrial Classification J), financial (SIC K) and professional, scientific and technical (SIC M) sectors.

B.3 Varying broadband productivity impacts by industry type in line with the EC study, and business size, allows us to apply impacts to individual businesses and to be tailored to the business base in our sample town and cities.

Adoption

B.4 Based on early rates of adoption internationally, we conservatively assume that take-up of full fibre amongst businesses rises to an overall figure of 35% in those areas where it is available. We have assumed take-up would be higher among knowledge based businesses, lower among other manufacturing firms and lower still within other service sectors. It is also assumed that larger businesses would adopt at a faster rate. This is conservative given adoption trends to date:

- adoption of part fibre solutions has risen to over 30% within three years (BDUK Local Project Data for Q3 2016)[46]
- penetration of 100mbps+ broadband has already risen beyond 35% in Romania and Sweden and beyond 30% in the Netherlands, Belgium and Latvia[47]
- 100mbps+ connections represented 66% of contracted connections in South Korea at the end of 2015 with a similar proportion in Japan (62%) and Singapore (53%)[48].

Time Dependency

B.5 Our modelling of productivity and innovation impacts has assumed the following build-up periods:

- broadband services enabled: 1 year after the start of network build
- 35% adoption rate reached: after 5 years
- productivity benefits achieved: 1 year after adoption
- innovation benefits realised: 4 years after adoption.

[46] http://www.ispreview.co.uk/index.php/2016/12/q3-2016-take-figures-bduk-roll-superfast-broadband.html

[47] European Commission (2017). '2017 European Digital Progress Report'.

[48] Ofcom (2016). 'The Communications Market Report'. Page 107.

Technological Change and Metcalfe's Law

B.6 The benefit to businesses of full fibre will increase over time, as a result of two factors:

1) **Technological change:** new and improved applications will emerge in reaction to the enhanced capabilities offered by full fibre. As businesses make use of these applications they will be able to generate new impacts.

2) **Metcalfe's law:** the value of a telecommunications network is proportional to the square of the number of connected users of the system. For example, applications that require multiple users, significant data transfer between users or which foster collaboration can only begin to deliver their full potential once a critical mass of users adopt it. As it expands across UK towns and cities, the user value associated with the full fibre network will rise exponentially.

B.7 Based on available research, it is difficult to predict the exact scale of these effects and project the associated benefits in the future. To account for this, we have applied a conservative assumption that technological change and Metcalfe's law will lead to a 2.5% uplift on all productivity and innovation impacts in the short term (after 5 years), a 5% uplift in the medium term (after 10 years) and a 7.5% uplift in the long term (after 15 years).

Establishing Baseline Business Numbers and GVA

B.8 To produce estimates of economic growth (through Gross Value Added, or GVA), employment and private household impacts, a baseline position has been formed for our 100 urban areas. This draws on the following data:

- businesses: local authority and mid-level super output area (data) from ONS Business Counts (enterprise data)[49]
- households: ONS Mid-Year Population Estimates and average household size from the 2011 Census[50]
- GVA per business:
  - ONS Regional GVA data by sector

[49] We have assumed that where it is deployed, full fibre would be available to 90% of businesses and households.

[50] *Ibid.* There are 7,200 mid-level super output areas (MSOAs) across England and Wales. MSOAs are formed from a minimum population of 5,000 (and 7,500 on average). Intermediate Zones have been used for locations in Scotland (average 4,000 household residents).

- employee data from the ONS Business Register and Employment Survey (BRES)
- average employees per micro, small, medium and large business, by sector, from the Annual Business Inquiry (ABI).

Accounting for Existing Leased Line Connections to Business

B.9 Some larger businesses have already secured full fibre through uncontended leased line connections. There is a substantial price differential between the cheapest leased lines and business xDSL services. Most smaller businesses currently use the latter. It is this latter group that will benefit most from its full fibre roll-out.

B.10 Businesses with full fibre leased line connections will still benefit from the extension of full fibre because of the increased competition and choice resulting from a competitor provider with an alternative product in the market. These benefits are harder to model robustly than the obvious benefit to SMEs who currently are priced out of the leased line market.

B.11 We have used results from ONS Internet Data that show 5.9% of businesses in 2015 had purchased broadband connections delivering 100mbps and above. Removing all business connections of 100mbps+ from the analysis represents a conservative approach; many of these businesses will be connected services delivering significantly less than what full fibre provides and will still stand to benefit. As there is no way to disaggregate the data it is not possible to isolate the number of businesses that have gigabit services comparable to those provided through full fibre.

B.12 **Error! Reference source not found.** shows that the proportion of businesses with 100mbps+ connections varies considerably by business size; 5.4% of micro businesses were using 100mbps+ connections in 2015, rising towards 50% and above for the largest firms, which typically have greater data needs. These results are consistent with wider research findings that demonstrate micro and small business take-up of fibre broadband is often muted, affecting the realisation of benefits.

Table 12.2 100mbps+ Business Connections, UK	
0 to 9 employees	5.4%
10 to 49 employees	6.6%
50 to 249 employees	21.2%
250 to 999 employees	40.1%
1000 or more employees	56.3%
All businesses	**5.9%**

Source: ONS (2016). 'E-Commerce and ICT Activity, 2015'.

B.13 It is acknowledged that an increase in full fibre network coverage and the arrival of a third network infrastructure may provoke a competitive reaction from the leased line market and possibly Ofcom, in its regulatory capacity. This could have two significant impacts:

1) downwards pressure on pricing makes leased line connections more accessible to SMEs

2) the quality of leased line services improves as part of service level agreements, with associated benefits to end users.

B.14 The potential economic impacts associated with these effects are not explored in this report, but could be investigated in more detail, underpinned by robust research and assumptions. Our findings reflect a conservative view, with the potential for additional economic impacts to be gained by businesses with existing leased line provision.

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