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Working Party on Communication Infrastructures and Services Policy

BRIDGING THE DIGITAL RURAL DIVIDE

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1. Foreword

This report was prepared by the Working Party on Communication Infrastructure and Services Policy (WPCISP). This document examines recent policy and technology approaches to bridging the digital divide in rural and remote areas in OECD countries. It includes a summary of common challenges and good practices.

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2. Main Points

Ensuring that digital divides are bridged and that broadband networks and services attain the greatest national coverage and use is a priority for OECD governments. Policies to promote competition and private investment, as well as independent and evidence based regulation, have been tremendously effective in extending coverage. In doing so, they reduce the size of that segment of the market that requires alternative approaches to meet policy goals. In areas where market forces have not proven to be able to fulfil all policy objectives, such as in rural and remote areas, however, a range of further approaches are being used in OECD countries.

Policies to increase access are sometimes addressed, within regulatory frameworks or national broadband plans, using specific funds that are created for this purpose. In these cases, the funds are often an evolution of mechanisms originally put in place for meeting "universal service" objectives in telecommunication services (OECD, 2012). These approaches can involve imposing legal obligations on operators, such as using spectrum licences that have coverage requirements or through mandating contributions to funds used for expanding broadband coverage. Even here, the market may play a role. The use of tools such as public tenders for competitive bidding to find a provider best able to deliver the infrastructure and services required is one example. Others include the development of new technologies or participating in public private partnerships.

Furthermore, OECD countries have developed an increasing range of tools and approaches to assist in both setting goals and timelines, as well as in monitoring plans and programmes for expanding both broadband access and use. Examples include approaches to assess gaps, estimate costs, mapping available passive infrastructure or network reach and so forth, as well as benchmarking developments. Over recent years there has been, however, a widening divergence between national broadband targets and the minimum speeds embedded in some legal instruments or measurement definitions. While the introduction of tiers for measuring broadband subscription data by speed goes much of the way to providing comparable statistics, the divergence between the lower tiers and the expectations of stakeholders in what constitutes broadband is an open question. Some OECD countries have reformed their legal instruments to include new thresholds for minimum speeds and others simply adjusted their goals to reflect the changing nature of what people expect from broadband.

Almost all OECD countries have established broadband access targets, and somewhat less commonly, usage targets. National targets differ in elements such as end-dates, speed and proportion of population or premises to be covered and so forth. These national objectives are frequently defined in national broadband plans, digital agendas, innovation plans or national budgets and sometimes follow regional objectives such as those set for example by the European Union. The experience of the broadband era demonstrates that such targets evolve over time and, given the rapid changes in technology, are sometimes superseded by the date of meeting their original objective. Targets are also evolving in terms of format, recently encompassing coverage not only in terms of households and businesses, but also in terms of roads covered, and in terms of the availability of offers by providers of unlimited data for fixed broadband services. Undoubtedly, the exercise of establishing and measuring targets plays an important role for people living in underserved areas and as a means to assess progress.

OECD countries use several policy instruments to promote the deployment of infrastructure in rural and remote areas. Within their national plans for broadband, the majority of OECD countries have specific components to expand broadband in rural and remote areas. Several good practices based on OECD countries experience and outcomes in terms of promoting connectivity to rural populations exist. In order to improve access, they can choose to subsidise national and rural broadband networks, promote municipal networks and design competitive tenders for private sector network deployment and management or implement open access arrangements. They can also carry out initiatives to reduce deployment costs, such as by improving access to information on infrastructure availability and establishing guidelines such as those for “dig once” practices. Meanwhile, in terms of uptake, some other key barriers can include the affordability of services, lack of trust and digital literacy.

New technologies have always played a critical role in bringing improved communication services to people and communities in rural and remote areas. They have been deployed first and foremost by the private sector in commercially addressable markets but also used in public private partnership programmes or by communities on their own initiative to address unmet demand for broadband services. There is no single best way to expand broadband access not least because the technologies keep evolving – as do the demands people have for these technologies – and because countries have differing inherited circumstances. As such this document also aims to promote discussion and share experience from countries with different circumstances in terms of factors such as rural and remote population densities as well as the potential for technologies currently being deployed and those on the horizon.

While assessing the experiences of OECD countries in expanding availability and adoption of broadband access in rural and remote areas, several common challenges were found:

- *Measurement:* Collecting and making available standardised and comparable data on actual broadband gaps, in terms not only of advertised speeds, but also the actual quality of service of download and upload streams.
- *Coherence*: Challenges of co-ordination between different government levels and public agencies involved in broadband deployment or related urban planning and consequent high levels of administrative burdens for network operators.
- *Efficiency:* Reducing duplications and where applicable stimulating the sharing of infrastructure and investment in underserved areas.
- *Take-up:* Bridging the adoption gap in rural and remote areas.
- *Forward-looking policies:* Keeping national policies flexible to deal with evolving demand and technology options (i.e. technological neutrality).

In addressing the challenges related to bridging the broadband gap between urban and remote areas, some good practices have also been identified:

- *Understanding the existing broadband gaps*: In order to close broadband gaps, it is necessary to measure the different availability and adoption gaps through indicators and maps. In this sense, given the different capabilities within each speed threshold, a technology-neutral approach, or a speed-based approach is desirable, as it allows measuring the accessibility gaps in terms of quality of service offered for each area and type of user. Moreover, promoting ex-ante and ex-post analysis of costs and benefits of broadband deployment and use can further inform policy making.

- Making information on connectivity available for consumers and operators: several regulators in OECD countries facilitate consumer portals which include overviews of broadband coverage, relevant local service providers, and, when possible, price and capacity offerings to improve consumer choice and empowerment. Likewise, providing online maps that have information on coverage can be key for assessing broadband gaps, not only to improve consumers' information and inform network operators on the location of existing infrastructure and on planned construction work; but also for making sure consumers have accurate and easy-to-use information, to help them choose the best providers, placing pressure on networks to improve coverage.
- Updating broadband definitions: Broadband definitions should be updated to keep pace with the evolving technologies, along with the speed thresholds of data collected. The standardisation of terms used as prefixes to broadband, such as “very-high” or “ultra” will also contribute to a common policy vocabulary.
- *Harmonising national targets:* Setting national targets and establishing strategies are fundamental to complement private efforts to expand access and use. Currently, however, national broadband targets within OECD countries differ widely in format chosen for their own purposes in terms of accountability, which can limit comparability. To the extent possible, OECD countries should endeavour to use the speed tiers, recommended by a series of broadband metrics workshops, for percentage coverage for 10 Mbps, 30 Mbps, 50 Mbps, 100 Mbps, 1 Gbps downstream and 2 Mbps, 10 Mbps, 100 Mbps upstream, by end 2020, end 2025, and end 2030. Where this data is not supplied for these speeds and dates, extrapolation could be used to produce a comparative visualisation of expected broadband availability for each OECD country on a common basis. Beyond measurable headline download/upload speeds, addressing the overall quality experience of the user (e.g. jitter, latency, usage allowance, if applicable, and contention ratio) and exercising aspirational targets for more challenging geographies should also be considered.
- *Considering different evolving demands:* Differing requirements according to the user should be taken into account when establishing targets and supply- and demand-side policies. Business and anchor institutions, such as schools and hospitals, require specific needs. Evolving demands, together with changing data consumption and production patterns, also mean that policy makers need to consider including upload speed targets and connectivity targets beyond household and businesses, such as roads and connected objects.
- *Fostering sound regulatory frameworks and public policies*: Regulatory frameworks that are based on defining clear and general rules for all market actors involved in the broadband-services value chain, based on competition principles, spur competition and investment. Ensuring consistency, legal certainty and effectiveness of public and regulatory policies allows for stability and predictability for investors and operators and is crucial to facilitate healthy, sustainable competition in the broadband market, which enhances further deployment of networks and innovation in services.
- *Streamlining administrative procedures:* Improved co-ordination of different levels of government, thereby aiming to eliminate administrative redundancies, is one-way to reduce deployment costs. The establishment of an entity to co-ordinate the often many state agencies involved can contribute to broadband utilisation and expansion.

Developing and implementing common regulations for laying cables along municipal and regional roads, with a view to establishing as uniform a practice as possible, may further reduce costs. Likewise, adopting a state "dig once" policy to leverage non-broadband infrastructure projects is advisable as it reduces considerably the costs of broadband expansion.

- *Enhancing access to resources for network operators:* Removing existing barriers to accessing passive infrastructure, such as restrictive rights of way, limitations of access to poles, ducts and so forth, is of extreme importance to encourage investment by new entrants and facilitate network deployment in rural and remote areas. Eliminating bottlenecks for accessing local access and backhaul fibre infrastructures is crucial for cutting the deployment costs for both mobile and fixed broadband networks. Moreover, sufficient spectrum should be made available for mobile broadband.
- *Promoting open access networks if they involve public funding*: Implementing open access arrangements, where public funding is involved in rural areas, is an increasingly common approach to avoid duplication of resources and focus on the timely expansion of service to reach the widest level of network coverage through optimised roll-out and investment plans. By creating the environment for effective and non-discriminatory access to network elements by multiple retail providers, open access networks potentially promote an environment of affordable prices and volume gains.
- *Improving dialogue between private and public sectors:* Governments and regulatory authorities should engage in dialogue with market actors to reach a common understanding of how best to improve coverage in sparsely populated areas, including indoors, and in other areas frequented by people. Improving dialogue can also yield strengthened public-private partnerships and the effective use of public infrastructure to expand broadband access without creating anti-competitive conditions. Any broadband investment fund to finance infrastructure put in place to reach un-served populations should contemplate this dialogue and the complementarity between private and public sectors and be based on a cost-benefit analysis of using different technologies.
- *Stimulating local and municipality level initiatives*: Implementing bottom-up models to finance and deploy high-speed networks, such as those of municipal or community networks has been a mechanism assisting under-served areas, including in rural and remote areas, cope with unmet or continuously growing demand for higher broadband capacity. Promoting the development of local government policies and community-led initiatives can potentially facilitate and reduce costs of last-mile broadband provision in the absence of sufficient private supply.
- *Reusing existing infrastructure:* Initiatives that contribute to increasing the reuse of existing infrastructure and to co-ordinating construction work between different infrastructure owners should be adopted to further reduce costs and redundancies. Moreover, ensuring that public buildings and property are placed at the disposal of service providers on reasonable terms are easily-attainable "low-hanging fruit" that could be put into effect by governments to expand broadband availability.
- *Fostering demand and adoption of broadband services:* The availability of broadband coverage, through fixed or wireless networks, does not automatically equate to broadband service adoption. Issues related to use of broadband-services, such as awareness, affordability, digital literacy, relevant content and trust, should receive attention. The public sector has a role in understanding and bridging these gaps, but also as a driver of increased demand, since public administrations tend to

be major procurers of broadband services. Moreover, initiatives exposing non-users to the benefits of broadband-based services should be encouraged.

- *Establishing a consumer-centric approach to technological solutions:* Today, different types of technologies can provide next generation connectivity, from fixed line broadband, to mobile, wireless, and satellite connections. In addition, new technological solutions on the horizon are being developed and have the potential to close digital gaps in rural areas. For consumers, what is most important is the quality of connections, or more fundamentally having a connection at all, and not necessarily the means of delivery. Policy makers should focus on that end goal, which is, making broadband access available for households and businesses in both urban, but also rural and remote areas and sparsely populated areas.

3. Introduction

The majority of OECD countries have specific components to close digital divides and expand high-speed connectivity in rural and remote areas in their national broadband plans. These initiatives are also forming a more central part of more general regional development strategies. This is not only to ensure that people and communities living in these areas can participate in day to day activities, taken for granted in more densely populated areas. It also reflects the recognition that their exclusion otherwise undermines policy objectives in areas such as health and education, as well as broader economic and social development. At the same time, exclusion may contribute to a reduction of population in rural areas while promoting increases in urban areas. This could contribute to a decrease in the quality of life in both areas and an increasing inequality between communities.

The OECD *Territorial Review on Northern Sparsely Populated Areas*, for example, concluded that rural areas are places of unique opportunity and that improving broadband infrastructure is essential to better tap the productivity growth potential of these locations (OECD, 2017a). This report and related territorial reviews, recommended implementing "smart specialization" strategies, improving infrastructure and connectivity, promoting service delivery innovation and extending broadband, to increase productivity and to lift workforce participation. The case made is for broadband to be used as a critical tool to address the higher unit costs of delivering public services, including in sometimes challenging environments, as well as dealing with longer distances to markets.

All OECD countries are well aware of the benefits that stem from high-speed broadband networks and have made tremendous progress in recent years in fostering their deployment. Nevertheless, many challenges remain. First, that of making improved broadband readily accessible in areas with low population densities and for disadvantaged groups, and second, continuing to enhance these networks so users can take full advantage of the opportunities they offer. High-speed broadband networks are one of the building blocks for the digital economy and, therefore, as part of the OECD "Going Digital" Project, they are recognised as key enablers for the digital transformation of interactions between individuals, businesses and governments including in underserved areas (OECD, 2017b).

While the digital divide is by no means an issue related solely to rural and remote areas, they generally have a unique set of issues associated with their distance to core network facilities. At the same time, some aspects of digital divides are, of course, common to most geographical areas such as income disparities or lack of skills. A common point made by rural and remote communities, however, is that without broadband access they do not have the opportunities it creates to improve existing outcomes. This could be increasing productivity in an existing industry, such as agriculture, or attracting individuals and new firms to locate in a small town or region with all the attendant benefits in areas such as employment. The potential for telework or home learning outside urban areas is one example of how improved connectivity can potentially benefit rural communities.

Many rural and remote communities are actively seeking new opportunities to drive economic growth but face constraints without adequate broadband access and without the necessary skills. For example, businesses need fast and reliable connection speeds to process payments and orders, participate in online commerce, and stay competitive in an increasingly digital economy. At the same time, anchor institutions, such as schools and hospitals, are unable to efficiently move and manage information as well as providing public services as efficiently as possible without broadband connectivity. Thus, assisting rural and remote communities to bridge the broadband access and uptake gaps is critical to strengthening the overall economic and social development.

Although private investment has been the overwhelming source of finance for high-speed networks in most OECD countries, connectivity and usage gaps still exist. Approaches to meet policy goals in areas not served by the private sector have varied across countries. Some initiatives, in addition to promoting market forces, involve efforts to reduce deployment costs, subsidising national and rural broadband networks using general revenues or specific funds as well as using community or national broadband networks or carrying out competitive tenders (e.g. through the use of reverse auctions).

Meanwhile, new technological developments will likely influence positively the provision of services in underserved areas, bringing improved communication services to individuals and communities in rural and remote areas. Experience in fibre optics, coaxial cable, copper, fixed and mobile wireless, satellites and hybrid approaches illustrate some technological trends discussed in this document. Potential innovations and new approaches using different technologies will play an important role in connecting underserved areas. Some of these technologies are available today, some in the near future and others on the horizon.

4. The Digital Divide

The term "digital divide" is commonly used to refer to different levels of access and use of information and communication technologies (ICTs) and, more specifically, to the gaps in access and use of Internet-based digital services. Broadband access provides the physical means for using these services, with availability gaps continuing to be a challenge in many rural and remote locations.

In recent years, the increased role broadband connectivity plays in economic and social interaction has made this aspect of the digital divide a key matter for public policy. In this respect, an increased body of work seeks to examine the effects of broadband provision to inform these discussions. They tend to be related to firm productivity, number of businesses, and local labour market outcomes (such as employment, income and wages). Using data for OECD countries, Czernich *et al.* (2011), for example, reported evidence that increased broadband Internet penetration has had large positive effects on economic growth rates. Kolko (2012) found significant effects on local economic growth in the United States, while in an earlier work Gillet *et al.* (2004) used zip code level data on broadband access in the United States and found 1 to 1.4% growth of local employment relative to the counterfactual of no access.

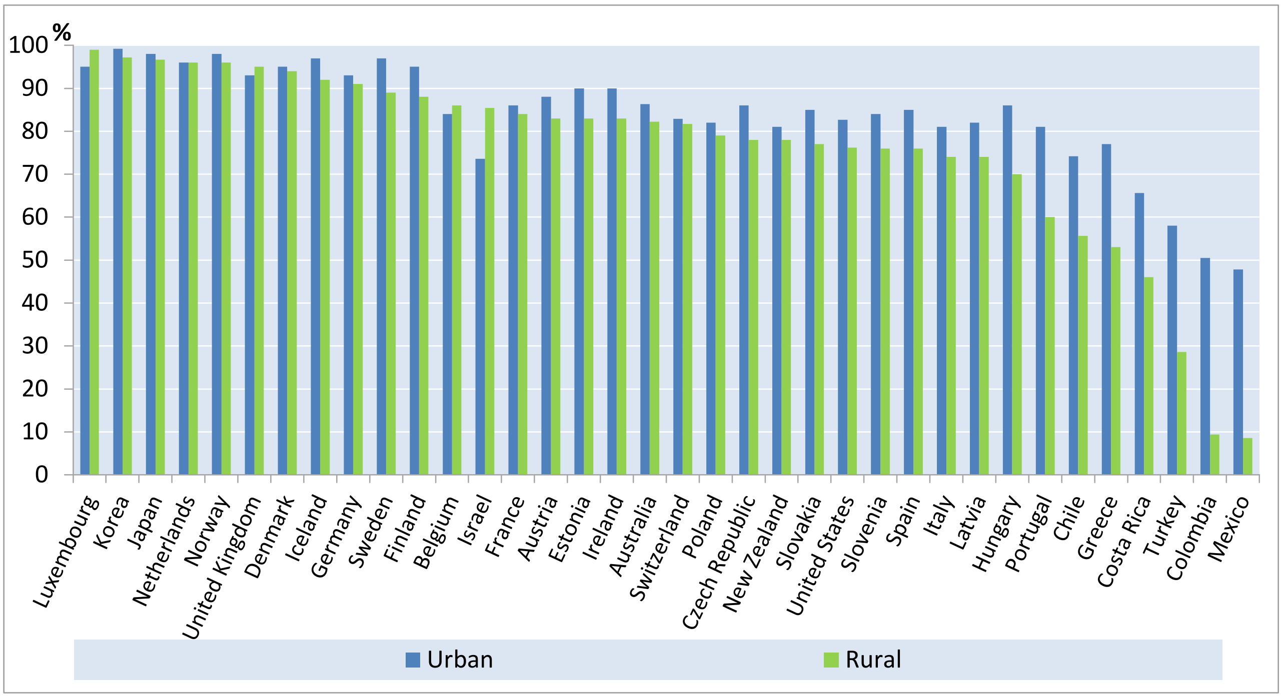
The effects on broadband provision and use may differ between urban and rural areas. Some economic research indicates that broadband expansion produces positive economic effects in certain rural areas, specifically in more populated rural locations neighbouring metropolitan areas. On the other hand, for low skilled and low population areas; research has found that that broadband expansion can sometimes result in job loss (What Works Centre for Local Economic Growth, 2015). Policy makers should be aware of these potential effects and couple such policies with broader economic development strategies supporting complementary elements such as entrepreneurship and skills development.

While demonstrating causality remains a challenge in relation to broader spillover effects, across local area broadband provision, it is undeniable that high-speed broadband is a foundational building block for digital economies and a key enabler for the digital transformation of interactions between individuals, businesses and governments. Accordingly, the task remains to address digital divides in rural and remote areas that stem from their distance to core networks. This is not to disregard aspects that have been highlighted as contributing to digital divides, such as income, education, gender, age, skills, and awareness of potential benefits. Rather the goal in this document is to examine geographical gaps and how they are being addressed in OECD countries.

4.1. The rural broadband divide

Despite advances in recent years, gaps between urban and rural areas remain considerable in many OECD countries. In 31 OECD and partner countries, the most recent data show the proportion of households in rural areas with Internet services was smaller than the equivalent proportion of households in urban areas, with the divide between rural and urban areas being particularly strong in Chile, Colombia, Costa Rica, Greece, Hungary, Mexico, Portugal and Turkey (Figure 1). By way of contrast, in Belgium, Israel, Luxembourg and the United Kingdom, the proportion of households with Internet in rural areas is higher than in urban areas. Population distribution patterns, both in terms of density and dispersion, geography (difficulty of terrain) and the existence of legacy communication infrastructure are among the most important factors affecting the availability, and consequent take-up of broadband services.

Figure 1. Household adoption of the Internet by urban/rural location



Notes: For European countries, data on Internet uptake by "households living in densely-populated area" was used for the "urban" category and on "households living in sparsely populated area" was used for the "rural" category, and correspond to 2016, with exception to Iceland (2014); while data on "households living in intermediate urbanized area" was disregarded. ITU data was used for non-European countries and corresponds to 2014-2015, and national household surveys were used for Chile (2015), New Zealand (2012), Turkey (2013) and the United States (2015)

Source: EUROSTAT (2017), ITU (2016) and national household surveys.

Scarcely populated areas, such as rural areas, may be more challenging in terms of profitability for market players. In these cases, the cost of deploying some types of infrastructure may be high compared to the expected return on investment. Historically, it is also in rural areas where public switched telephone network (PSTN) loop length has been a particular factor affecting the delivery of broadband services.

Nonetheless, population density in isolation cannot be used to assess the difficulty in deploying broadband and other variables, such as population dispersion and geography, need to be taken into account. Iceland, for example, has one of the lowest population densities across OECD countries, with 50% of its population living in just 1.4% of its territory, which means that broadband networks can reach a very high proportion of households with relatively low investment. Moreover, countries with flat terrains, such as Belgium and the Netherlands, certainly have an advantage, in addition to their high population densities, in comparison to countries like Greece, Norway and Switzerland with more challenging terrain (OECD, 2009).

That being said, although these indicators offer some insight regarding the difficulty of network deployment, bridging the digital divide in rural areas refers to the costs and benefits of extending broadband networks to the proportion of the population living in those under-served areas. Furthermore, even though individuals might be capable of accessing broadband services, they may not necessarily be able to take-up these services. Beyond issues of access, many are individuals and businesses that are thwarted by barriers to adoption such as lack of choice in terms of affordable broadband services or the inability to use or appreciate the benefits of Internet-based services. In addition, consumers and policymakers may not be aware of all the potential solutions available in the geographical areas concerned.

4.2. Assessing the gaps

Assessing both access and usage gaps is a precondition for informing policies aimed at maximising the benefits of broadband networks. The availability of access indicators on fixed broadband (in terms of household coverage, population coverage, percentage of homes passed) and on wireless broadband (population coverage, area coverage or use of maps), as well as use indicators (number of fixed and mobile subscriptions) are fundamental for setting appropriate broadband objectives and preparing plans for expanding broadband access in underserved areas.

Some OECD countries measure broadband availability by collecting metrics on coverage. Most often, these access indicators are collected using a technology-based approach. That is, through data provided by operators on the availability, based on a percentage of households/population, of xDSL, FTTx, cable TV networks, cable modem enabled networks, 3G and 4G mobile network coverage and the number of km of fibre deployed. In addition to availability, speed and quality of service are also important for broadband access, as low speeds or poor quality may make it difficult or impossible to use certain Internet applications and services (Table 1).

Table 1. Ranges of download speeds and services enabled

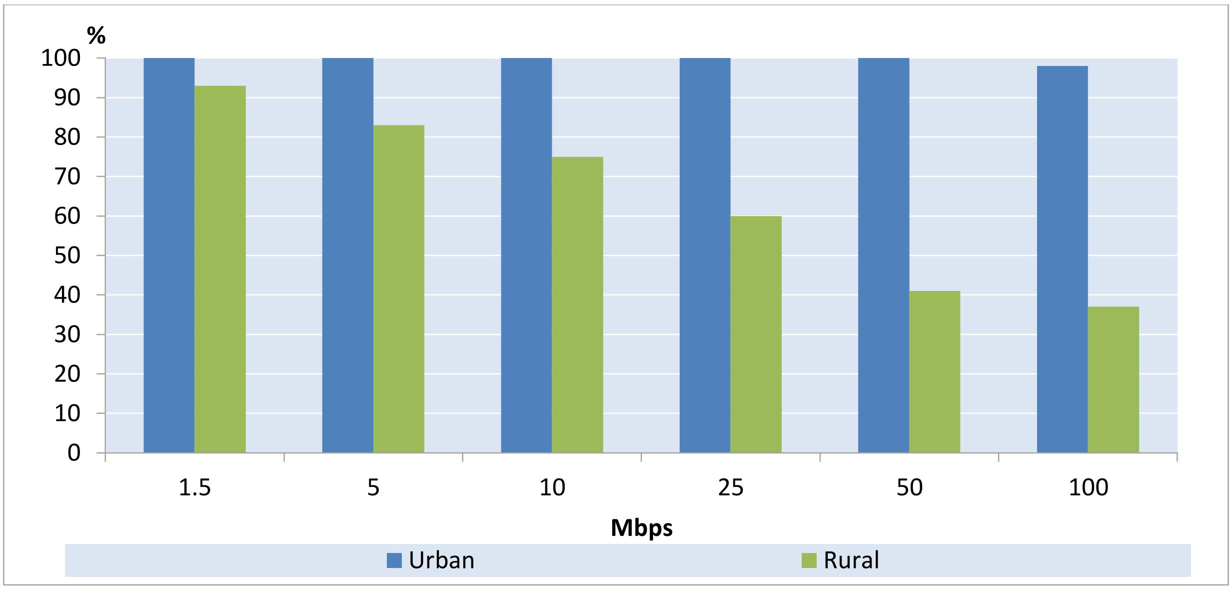
Average Download Bit Rate	Description of service
> 0.5 Mbps	Web browsing, email, streaming audio, mobile-quality video streaming, voice and Standard-Definition (SD) video calling
0.5 – 2.0 Mbps	SD video streaming (360p), High-Definition (HD) video calling
2.0 – 3.5 Mbps	Low bit rate HD streaming video (480p/720p)
3.5 – 5.0 Mbps	High bit rate HD streaming video (720p/1080p)
5.0 – 10.0 Mbps	Very high bit rate HD video streaming
10.0 – 20.0 Mbps	Ultra HD (UHD) video streaming
> 20.0 Mbps	High frame rate UHD video streaming, augmented reality, advanced telemedicine

Some countries have also moved to collecting data on coverage using a technology-neutral approach, or a service-based method, splitting the access indicators not by technology, but by speeds of connections announced. Given the different capabilities within each speed threshold, this technology-neutral approach is desirable since it allows measuring the accessibility gaps in terms of quality of service offered for each area. Japan, Canada and the United States are examples of countries using this speed-threshold method. Canada, for example, provides an overview of the urban/rural broadband divide in several thresholds of broadband speed (Figure 2). The United States measures access also in terms of upload speeds, coupled with download speeds (25 Mbps for download and 3 Mbps for upload). For this threshold, 39% of the rural population in the United States (23 million people) lack broadband access at these speeds, by contrast with only 4% of the urban population (FCC, 2016).

This corresponds to data on speeds advertised by service providers and not actual speeds. As such regulators often complement the information of advertised speeds as these can be dependent on a number of factors such as distance. For that reason, several regulators in OECD countries undertake their own data gathering exercises.

In addition to access indicators, maps with information on coverage can be key tools for assessing broadband gaps, and also for making sure consumers have accurate and easy-to-use information, to help them choose the best providers, putting pressure on networks to improve coverage. Most OECD countries have these resources. In France, a mapping tool, the French High Speed Broadband Observatory (Observatoire France Très Haut Débit), developed by the High Speed Broadband Unit (francethd), allows users to view possible downstream speeds (DSL on copper, coaxial cable and fibre-optic) at household or organization levels. Moreover in 2017, ARCEP, the French regulator, launched a mapping tool so that users could compare coverage between mobile operators, the *Mon Reseau Mobile* platform (ARCEP, 2017a).

Figure 2. National broadband availability in urban and rural households per download speed, Canada (2015)



Source: CRTC (2017), *Communications Monitoring Report 2017*, http://crtc.gc.ca/eng/publications/reports/policymonitoring/2017.

In Spain the government publishes broadband coverage information by technology and speed, which is gathered from 150 operators at the level of the 62 000 population entities. This same information is used to identify the white areas not having 30 Mbps, eligible for public aid provided by national or regional administrations. In 2015, Ofcom created a comprehensive map of mobile coverage by postcode for the whole United Kingdom. This will soon be updated to include fixed broadband coverage and to offer data for individual addresses. To ensure comparability between these datasets, the European Commission has launched a mapping tool to collect, analyse and display all dimensions of broadband quality of service and quality of experience.[1] The OECD Broadband Portal aggregates online platforms from OECD countries that have developed interactive broadband coverage maps.[2]

In terms of penetration of services, the OECD collects fixed and mobile broadband subscriptions and weights these by population as well as data gathered by household and enterprise surveys. Complementary surveys also assess the uptake on public institutions, non-governmental organisation, schools, hospitals and cultural centres.

Establishing better tools for monitoring broadband access availability can enable evaluation of how a broadband plan affects targeted beneficiaries, determine resource allocations, improve planning, and provide input for decisions about future strategic directions. An approach measuring both connectivity and use is necessary to inform all stakeholders. The European Commission's Digital Economy and Society Index (DESI), for example, promotes such a measurement framework by structuring European Union member states digital competitiveness on connectivity, human capital, use of Internet, integration of digital technology and digital public services (European Commission, 2017).

4.3. Defining broadband speeds

A question that invariably arises when considering the measurement of high-speed network availability is the definition of broadband itself. This question was considered most recently in 2012 by the OECD in relation to work on improving broadband metrics (OECD, 2014). By way of background, the baseline speed for a service to be considered broadband for the purpose of collecting subscription data was established by the OECD in 2001 at 256 kbps (OECD, 2001). This threshold served the purpose of excluding ISDN and was, at that time, the lowest commonly offered commercially offered speed in OECD countries. Periodically, it is suggested that the threshold speed for data collection be raised. In 2012, there was not a consensus to raise this speed. Instead, tiers were introduced for the reporting of broadband subscriptions (e.g. 256 Kbps to 1.5/2 Mbps; 1.5/2 Mbps to 10 Mbps and so forth with increasing tiers of service to above 1 Gbps).

Since that time baseline speeds for what is considered to be broadband have continued to be raised in OECD and partner countries. In the United States, in 2015, the FCC determined that speeds of 4 Mbps to 25 Mbps for downloads, and 3 Mbps for upload would be an appropriate benchmark for evaluating whether a service constitute "advanced telecommunications capability" as defined under the Telecommunications Act. Likewise, Colombia has announced that starting from January 2019, broadband will be defined as Internet services of speeds superior to 25 Mbps (download) and 3 Mbps (upload).

In 2012, one reason there was no consensus to raise the threshold speed was that some countries had incorporated descriptions of broadband speeds into legal instruments, such that a change in the definition of broadband could have implications for the universal service frameworks in those countries. In 2017, however, there is a widening difference between national broadband targets and the minimum speeds embedded in some universal service legal instruments. Policy instruments may sometimes not refer to different broadband services in terms of speeds or technology, but more generally as “fast broadband”, “high-speed broadband”, “very-high speed broadband”, “ultra-high-speed broadband”, without necessarily defining the term. This makes such terms less comparable across countries.

While speed tiers ensure that harmonised comparisons can be made across countries, the total number of connections may increasingly seem removed from the expectations of all stakeholders, especially when assessing broadband gaps. An increased threshold speed for reporting broadband data could be considered by OECD countries or adding prefixes to broadband, such as “very-high” or “ultra” with a harmonised definition. Moreover, given the evolving consumer and business demands and commercial offers, adapting speed tiers could be examined (e.g. while 10 Gbps offers are still outliers they were not available for consumers in 2012).

4.4. Establishing national targets

All OECD countries, with the exception of Japan, have specific national goals for broadband availability. Japan, where 50% of households already have 100 Mbps and the other remaining 50% at least 30 Mbps, has chosen not to set additional connectivity goals. Instead, in their broadband strategy, they target the establishment of commercial 5G by 2020. In the majority of countries, however, goals for broadband deployment are set in terms of speed of service offered and percentage of coverage, penetration and specific groups contemplated (Table 2, Figure 3). These national objectives are usually defined in national broadband plans, digital agendas, innovation plans or national budgets, which contain a number of sub-targets and disaggregated goals (in terms of schools, public institutions, hospitals, main urban hubs, rural and urban or gender gaps).

Table 2. National broadband access targets

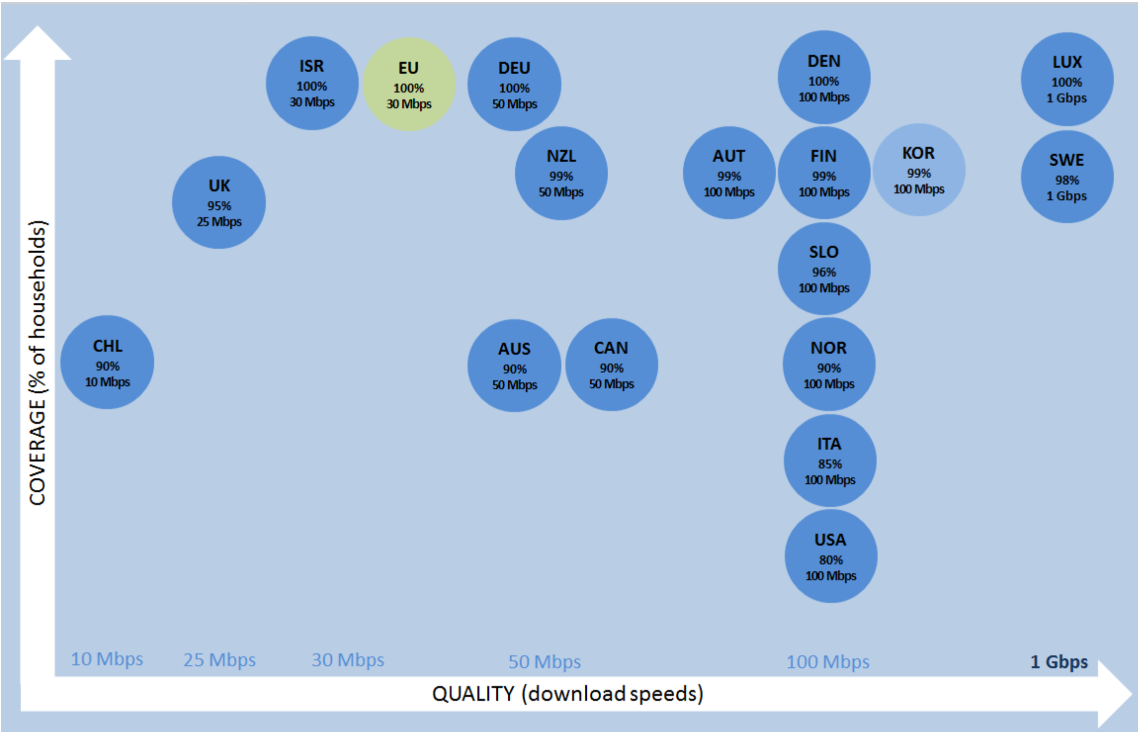
Country	Year	Coverage
Australia	2020	90% of households and businesses with 50 Mbps/5 Mbps (download/upload)
Austria	2020	99% of households with 100 Mbps
Belgium	2020	100% of households with 30 Mbps
Canada	2021[1]	90% of households and businesses with 50 Mbps/10 Mbps and latest mobile technology available to all households, businesses and major roads.
Chile	2020	90% of households with 10 Mbps
Czech Republic	2020	100% of households and businesses with 30 Mbps
Denmark	2020	100% of households and businesses with 100 Mbps/30 Mbps
Estonia	2020	100% of households with 30 Mbps
Finland	2015[2]	99% of households, businesses and public offices with 100 Mbps
France	2022	100% of households, businesses and public offices with 30 Mbps
Germany	2018	100% of households with 50 Mbps
Greece	2020	100% of households with 30 Mbps
Hungary	2018	100% of households with 30 Mbps
Iceland	2020	100% of households with 30 Mbps
Ireland	2020	100% of households with 30 Mbps
Israel	2022	100% of population with 30 Mbps
Italy	2020	100% of households with 30 Mbps; 100% of businesses and 85% of population with 100 Mbps
Korea	2017	90% of urban areas with 1 Gbps and 99% of households with 100 Mbps
Latvia	2020	100% of population with 30 Mbps mobile broadband and 100% of rural areas with optical backhaul
Luxembourg	2020	100% of households, businesses and public offices with 1 Gbps/500 Mbps
Netherlands	2020	100% of households with 30 Mbps
New Zealand	2025	99% of households with 50 Mbps and the remaining 1% with 10 Mbps
Norway	2020	90% of households with 100 Mbps
Poland	2020	100% of households and businesses with 30 Mbps
Portugal	2020	100% of households with 30 Mbps
Slovak Republic	2020	100% of households with 30 Mbps
Slovenia	2021	96% of households with 100 Mbps and the remaining 4% with 30 Mbps
Spain	2020	100% of households with 30 Mbps
Sweden	2025	98% of households and businesses with 1 Gbps
Switzerland	2020	100% of municipalities with 30 Mbps
United Kingdom	2020	95% of households and businesses with 25 Mbps
United States	2020	80% of households with 100 Mbps/50 Mbps

Notes: (1) The goal calls for 90% of households and businesses by end of 2021, with the remaining 10% to be achieved within 10 to 15 years. (2) A national broadband strategy being developed will define targets for the years 2025 and 2030

Among OECD countries, Luxembourg has the highest access target, in terms of percentage of households and speed contemplated, with a goal of offering 1 Gbps to 100% of households by 2020, followed by Sweden with the goal of connecting 98% of both households and businesses with 1 Gbps broadband. Korea has the goal of connecting 90% of urban areas with 1 Gbps by 2017 (Figure 3). Meanwhile, Belgium aims for 50% of its households to have that speed by 2020 and Sweden 98% by 2025. Australia, Israel and several European countries have set national goals in the range from 25 Mbps to 30 Mbps while Chile has a target of 10 Mbps.

In Australia, the government expects their national broadband network, aimed to be completed in 2020, will provide peak wholesale download data rates (and proportionate upload rates) of at least 25 Mbps to all premises, and at least 50 Mbps to 90% of fixed line premises as soon as possible. In the European Union area, countries follow or exceed the baseline of the commitments included in the "Europe 2020" strategy. In terms of access, the European Union commitment is that by 2020, there should be 30 Mbps to 100% of households (coverage) (European Commission, 2010). Austria, Denmark, Finland and Israel have a target of 100 Mbps to 99% or 100% of households. Meanwhile, Slovenia has a goal of 96% at this speed. For its part, the United States aims for 100 Mbps to 100 million homes, while Korea's goal is 1 Gbps to 90% of urban areas (85 cities) and 100 Mbps to 100% of households (including rural areas with 50 households).

Figure 3. Matrix of OECD national broadband targets per coverage and quality



Notes: Only the most ambitious access targets in terms of household or population coverage were included (urban area target such as the Korean one for 2017 was excluded for comparability purposes). Countries are represented by their ISO codes. All European Union (EU) countries, unless specified, follow the EU broadband access target. Target end dates differ between countries.

In terms of uptake, national targets among OECD countries are less common, but a number of countries, following the European Union commitments, have established specific goals in terms of broadband penetration of households and businesses. The target set by the European Union for usage by the "Digital Agenda for Europe" is 100 Mbps subscriptions to 50% of households (uptake). While some countries chose not to adopt this target, believing it to be unfeasible in their national contexts, others adhered to it. Belgium went beyond this target and set that 50% of its households should have subscriptions to services of 1 Gbps, while Estonia increased the proportion of households with 50 Mbps broadband services to 60%. Poland has added the target of 50% of businesses with 50 Mbps until 2020 to that of households. Latvia has set a goal for reducing to 8% the share of population who has never used the Internet.

In an effort to produce broader targets and policies, in September 2016, the European Commission adopted its “Connectivity for a European Gigabit Society” (EGS), which sets a vision where availability and take-up of very high capacity networks enable the widespread use of products, services and applications in the Digital Single Market. It confirms and builds upon the previous broadband objectives set by 2020, and it adds that by 2025 all schools, transport hubs and main providers of public services as well as digitally intensive enterprises should have access to Internet connections with download/upload speeds of 1 Gbps. In addition, all European households, rural or urban, should have access to networks offering a download speed of at least 100 Mbps, which can be upgraded to 1 Gbps. In addition, by 2025, all urban areas as well as major roads and railways should have uninterrupted 5G wireless broadband coverage, starting with fully-fledged commercial service in at least one major city in each European Union State by 2020 (European Commission, 2017). In Europe, both the Digital Single Market (2015) and EGS strategies reinforced the need to close the digital gap between urban and rural areas. Moreover, the EGS strategy called on for countries to review and update their NBPs by the end of 2017. The goal is to enable them to reposition their timeline for connectivity objectives by 2025, and take into account the deployment of 5G in accordance with the European Commission’s Action Plan.

Following this update, Sweden revised its national broadband plan with a vision towards a totally connected Sweden where, by 2020, 100 Mbps should be ensured to 95% of their households and workplaces, and by 2025, 98% of households and workplaces should have access to 1 Gbps, with the remaining 1.9% with access to at least 100 Mbps and 0.1% with at least 30 Mbps. In 2014, Germany launched its “Digitale Agenda 2014-2017”, including measures on stimulating broadband take up and usage in different sectors. The new German broadband strategy suggests the use of synergies for cost-effective expansion of broadband infrastructure, a supportive frequency policy, market-friendly and growth-orientated regulation and financial aid programmes wherever necessary as a means of stimulating the expansion of broadband networks primarily carried out by private operators. In doing so, Germany has opted for a technology-mix in realising its targets.

In its most recent review, Canada has set a 50 Mbps/10 Mbps goal to 100% of households and businesses. Canada aims to reach this target for 90% of households and businesses by end of 2021, with the remaining 10% to achieve them within 10 to 15 years. Internet service providers must also offer the option of unlimited data for fixed broadband services. Canada’s national goal also includes a mobile component, which calls for the latest mobile wireless technology available not only to all homes and businesses, but also along major Canadian roads.

In the United Kingdom, the government has announced that efforts were underway to ensure there is reliable connection across major roads, not only so that consumers can make a call while on the move or in an emergency, but also as a means of enabling applications from real-time traffic alerts to emerging technologies such as connected and autonomous vehicles and smart motorways. Moreover, in new rail franchises, train operators are being required to tackle “not-spots” on their routes and to deliver high-speed connectivity to ensure fast and reliable Wi-Fi across routes serving the majority of their passengers, so they can send emails or make calls using VoIP.

4.5. Evolving targets for going digital

While broadband plans understandably focus on business and residences or aim at extending mobile broadband coverage in areas with little or no coverage, the mention of railways, highways and roads in Canada, the United Kingdom, and European Union goals is significant. Many people in rural areas live close to highways and roads even if their businesses and residences are distant to towns or cellular towers. They are also major users of these roads and improved coverage may be of benefit in terms of traditional concerns, such as safety. In Canada, municipalities with rural or sparse populations expressed their concerns about reliable mobile wireless coverage and public safety. Nearly all rural residents described feeling vulnerable in the event of emergencies occurring on a road where mobile coverage is limited (CRTC, 2016).

Beyond emergency and security in roads, there are also developments in the areas on M2M and IoT. To the extent to which future developments such as autonomous vehicles require improved communication along highways may also benefit people that live near to these roads. As precision agriculture and smart farming becomes a reality, access to high speed broadband is likely to offer even greater benefits to rural areas. Helping these communities bridge the broadband gap and take advantage of more efficient supply chains is critical to strengthening the region's economy. Targets that address these needs could be considered in national policy frameworks.

Taking into account connectivity targets for increasingly digital rural areas, requires also treating its residents not only as consumers, but also as producers of content. Preparing rural areas for being included in global value chains means identifying targets not only for higher download speeds, but also higher upload speeds, so they can share and create content online and benefit from developments such as cloud computing and big data.

Finally, within and outside rural areas, policy makers should examine the differing capacity requirements within each community (typically moderate for residents, mixed for business, higher for community anchor institutions). Businesses, homeworkers and SMEs, for example, may need upstream projections to be planned, given their use of more data-intense services, such as collaborative residential video-based applications covering value added activities as well as current usage such as online gaming. Anchor institutions, such as schools and hospitals, often require even more intense capacity in terms of bandwidth and reliability, given the sensitivity of the activities performed (such as telemedicine) and the number of users serviced. Therefore, for each group – residential, business and anchor institutions – tailored broadband availability targets should developed.

In the United States, for example, efforts have been made specifically to identify barriers and incentives to deploying broadband-enabled healthcare tools and strengthening telehealth infrastructure. The FCC's Connect2Health Task Force is leading the project, which is tasked with charting the future of broadband and its role in healthcare. To enable data-driven decision making at the intersection of broadband and health, the FCC has developed an interactive mapping platform that allows users to overlay and analyse broadband and health data at the national, state and county levels (The Mapping Broadband Health in America.)[3]

In addition to considering the differing requirements in terms of policy priority and type of use, to the extent possible OECD countries should also endeavour to use the speed tiers recommended by the Broadband Metrics workshops for percentage coverage for 30 Mbps, 50 Mbps, 100 Mbps, 1 Gbps downstream and 2 Mbps, 10 Mbps, 100 Mbps upstream, by end 2020, end 2025, end 2030. Where this data is not supplied for these speeds and dates, extrapolation could be used to produce a comparative visualisation of expected broadband availability for each OECD country on a common basis.

5. Policies for bridging the gaps in access to and use of broadband Networks and services in rural and remote areas

This section examines the role of competition for expanding broadband services in rural areas and of different policy tools being used to deliver the expansion of services in underserved areas. First, it contains a discussion on regulatory frameworks, through universal service and minimum speed requirements. As part of this discussion it addresses the issue of assessing connectivity gaps and benchmarking progress. It also describes the different national targets set by OECD countries to connect their populations and the mechanisms used to fund these broadband programs. Finally, it examines the policy instruments used to deploy infrastructure, through publically subsidised national and rural broadband programmes; municipal networks; competitive tenders for private sector deployment of both backhaul and local access networks; open access policies; and efforts to reduce deployment costs.

5.1. Improving access to broadband

5.1.1. Ensuring competition in broadband provision

To improve access to broadband and meet national broadband coverage objectives one of the key tools available to governments is to promote the role of the private sector. The more geographical areas that are served by market forces the less demands will be made on scarce public resources that need to be allocated to meet policy objectives in underserved areas. In this manner, policies that promote competition, private investment and the role of independent regulation have been tremendously effective in extending coverage.

In order to promote competition OECD countries have implemented policies to lower barriers for investment and to increase regulatory certainty. These policies include simplifying licensing requirements, lifting foreign investment restrictions, ensuring effective and efficient interconnection among the different actors, simplifying and harmonising rights-of-way acquisition and encouraging network sharing and co-investment. Alongside these approaches, policy makers and regulators have increasingly used market mechanisms wherever possible to make the use of scarce public funds more effective in terms of meeting objectives in geographical areas that are underserved by broadband access, such as using competitive tenders and reverse auctions.

5.1.2. The changing nature of universal service

One of the traditional policy approaches to expand telecommunication services, to areas not adequately addressed by the market, is that of implementing universal service frameworks for certain geographic regions. To that effect, universal service policies aim to provide telecommunication access when the costs may exceed likely commercial returns and, therefore, decrease the attractiveness of the market meeting these requirements without intervention. This can be the case, for example, in geographical areas with low population densities.

Universal service frameworks may also address specific needs targeted by policy makers relating to factors such as income levels or disabilities. Traditionally, elements covered under universal service obligation, when applied to a network operator, were a telephone-related service (e.g. connection at a fixed location or related to public payphones). Overtime, however, the expectations or objectives for universal service policies have changed considerably. The use of some services has decreased, such as payphones, while demand for Internet access has grown leading to some countries including broadband access as part of their universal service requirements. This does not mean, of course, that countries without such requirements embedded in universal service frameworks have different goals in terms of expanding broadband. Rather it means they have chosen other tools from building national broadband networks to public-private partnerships and a myriad of other approaches to expand high-speed network availability. In 2012, an OECD report discussed the expansion of the scope of universal service frameworks and proposed set of criteria to determine the basis for inclusion of these broadband services within universal service policies (OECD, 2012).

The term universal service framework or similar is commonly use to encompass both the measures of universal service obligation (USO) or universal service fund (USF). While USO often specifies that a designated service provider is required to provide a particular service on request, USF typically refers to a fund that any type of network access providers are required to contribute to and that is then used to support service expansion. The experience with USF has been successful in some countries in expanding broadband access, while in others less so, with funds remaining unallocated or being used to meet unrelated priorities.

Some OECD countries have changed their legal frameworks to include broadband as part of the universal service frameworks. Switzerland was the first country, in 2008, to include broadband in their USO, followed then by Spain, Finland, Belgium and Sweden. In Canada, a recent 2016 decision declaring broadband Internet a basic service means that broadband is now recognized as part of the country's universal service framework. Carriers are required to contribute towards a USF to support service expansion, but will be able to apply for funding through a competitive application process rather than being mandated to provide service.

Israel includes functional Internet services in their obligations and Latvia includes an obligation to offer a reduction in basic broadband prices to users with disabilities. Since 2011, the United States has moved in a similar direction in its four universal service programmes: the Connect America Fund (CAF), which reduces costs of rural providers to deploy and provide service to homes and small businesses; the Lifeline program, which reduces costs for low-income consumers; the Rural Health Care Program, which reduces costs for rural health care providers; and the E-rate Program, which reduces costs for schools and libraries. Discussions to reform universal service frameworks are currently under way in Australia, Chile, the United Kingdom and the United States. In the European Union, the on-going review of the EU electronic communications regulatory framework (European Commission, 2016) focuses on ensuring the affordability of available basic broadband access and voice communications services in the revised universal service provisions. In this context, the basic universal service broadband shall be capable of supporting dynamically defined basic online services.

The majority of OECD countries do not tie universal service frameworks to specific technology platforms. These countries promote technology neutrality and future proof frameworks by recognising that a variety of technologies, including wireless, are capable of delivering high-speed download speeds. By doing so, they encourage the deployment of the most appropriate technology for different local circumstances so as to achieve policy goals in the most efficient manner. Only Israel and Latvia, among the countries that have included broadband in their universal service frameworks, tied obligations to fixed technologies (Table 3).

Table 3. Universal service frameworks and broadband

Country	Broadband included in the universal service framework	Universal service framework tied to a certain technological platform
Australia	No*	No
Austria	No	No
Belgium	Yes	No
Canada	Yes	No
Chile	No*	No
Czech Republic	No	No
Denmark	No	No
Estonia	No	No
Finland	Yes	No
France	Yes	No
Germany	No	No
Greece	No	No
Hungary	No	No
Ireland	No	No
Israel	Yes**	Yes, fixed
Italy	No	No
Japan	No	No
Korea	No	No
Latvia	Yes***	Yes, fixed
Netherlands	No	Yes, fixed
New Zealand	No	Yes, fixed
Portugal	No	No
Slovakia	No	No
Slovenia	No	No
Spain	Yes	No
Sweden	Yes	No
Switzerland	Yes	No
United Kingdom	No*	No
United States	Yes	No

Notes: (*) Countries considering change in the universal service framework to include broadband; (**) Not broadband, but 'functional Internet access' included in the universal service framework; (***) Applicable for specific groups only, such as people with disabilities.

5.1.3. Setting minimum speeds

Frequently countries that include broadband in their universal service provisions have also defined minimum data speeds related to this obligation. Among the OECD countries that have included broadband in their universal service obligations, the highest threshold is

Switzerland, who recently updated their minimum download speeds of 2 Mbps to 3 Mbps, with minimum upload speeds of 300 kbps, to be implemented from January 2018 onwards. That threshold is followed by Finland, with minimum download speeds of 2 Mbps and an average of 1.5 Mbps. Belgium, Spain and Sweden have set their minimum broadband USO at 1 Mbps (Table 4).

Some countries use other regulatory mechanisms to set minimum data speeds, such as by including minimum speeds in their general universal service framework, as in Canada, or as part of their quality of service requirements. Examples of countries using general QoS frameworks to set minimum Internet speeds are Denmark, Hungary, Latvia and New Zealand.

Table 4. Minimum broadband speeds in OECD Countries

Country	Is there a set minimum data speed for Internet services?	Legal framework	Minimum data speed (download, /upload and //average)
Australia	No*		
Austria	No		
Belgium	Yes	USO	1 Mbps
Canada	Yes	General	50 Mbps download/ 10 Mbps upload
Chile	No*		
Czech Republic	No		
Denmark	Yes	QoS	128 kbps
Estonia	No		
Finland	Yes	USO	2 Mbps (download);1.5 Mbps (avg speed over 24hr); 1 Mbps (avg speed over 4hr)
France	No		
Germany	No		
Greece	No		
Hungary	Yes	QoS	30 kbps /8 kbps
Ireland	No		
Israel	Yes	USO	128 kbps
Italy	Yes	USO	56 kbps
Japan	No		
Korea	Yes	QoS	2 to 50 Mbps, depending on the technology
Latvia	Yes**	QoS	At least 20% of the maximum download and upload speeds specified in consumer contracts
Mexico	No*		
Netherlands	No		
New Zealand	Yes	QoS	14.4 kbps
Portugal	Yes	QoS	56 kbps
Slovakia	No		
Slovenia	No		
Spain	Yes	USO	1 Mbps
Sweden	Yes	USO	1 Mbps
Switzerland	Yes	USO	3 Mbps/300 kbps
United Kingdom	Yes*	QoS	28 kbps
United States	Yes	USO	10/1 Mbps (in some instances 4/1 Mbps)

Notes: General= general universal service framework; USO = universal service obligations; QoS = quality of service standards; (*) Countries considering change in minimum broadband speeds; (**) Applicable for specific groups only, such as people with disabilities.

However, due to advanced applications that demand higher speeds and given the fact that there are increasingly several simultaneous uses of broadband in a home at any one time, authorities have been substantially updating their minimum speed benchmarks. Between 2015 and 2016, the Canadian Radio-television and Telecommunication Commission (CRTC) undertook a review of basic telecommunication services including in rural and remote areas. It examined which telecommunications services Canadians required to participate meaningfully in the digital economy and the CRTC's role in ensuring the availability of affordable basic telecommunication services to all Canadians (CRTC, 2015). Following the review the CRTC established a universal service objective that Canadians – in rural and remote areas as well as in urban centres – should have access to voice services and broadband access services on fixed and mobile wireless networks. In addition to setting minimum speeds, the CRTC also set the target of having an unlimited data option for fixed broadband services in Canada.

In the United Kingdom, while there is no minimum speed which must be provided at present, in the preliminary considerations of Ofcom's Digital Communications Review, it was said that 10 Mbps would be an appropriate level for a broadband USO, or of "a decent broadband service", should one be implemented. However, it is expected that other factors will also effect broadband connections for business and consumers, including upload speed, latency, jitter, contention and capacity. In July 2016, the United Kingdom consulted on a proposed specification for a broadband USO that provides a minimum download speed of 10 Mbps, upload speed of 1 Mbps, minimum standards of latency, a maximum contention ratio of 50:1, and a data cap of at least 100 GB per month.

Instead of using the universal service or quality of service frameworks, other countries choose to use instead their broadband programmes to guarantee a minimum speed, such as the United States for the Lifeline program, which reduces costs for low-income consumers. In Australia, while there is no minimum speed related to broadband in terms of universal service, in practice the country's national broadband network (NBN) performs this role. In rural and remote areas, for example, the NBN satellites provide a baseline advertised speed of 12 Mbps across its entire land mass as do other technologies used in more closely settled areas beyond the reach of fixed broadband networks, such as fixed wireless.

5.1.4. Competitive tenders

A policy tool being used in OECD countries to expand broadband to rural and remote areas is that of competitive tendering. A transparent, open and competitive process can be implemented when a variety of operators compete for a particular incentive provided by the public sector. This could be a partial or total tax exemption, lower or no fees for spectrum licenses, loans at a reduced interest rate or direct or total subsidisation of rural deployments. OECD countries have carried out tenders that are varied in speeds, quality of service, operational support, future upgrading of a network, open access obligations and coverage associated with the obligations of the selected operators.

The competitive tender process can either be designed to be technologically neutral, or prescribe a particular technology to be used. The former is preferable as it allows countries to weigh up the costs and benefits of different technological solutions, including those that make use of hybrid solutions based on multiple technologies. It should also be noted that while public authorities often intend tenders to be technologically neutral, wording in tender contracts that could de facto exclude certain technologies. For instance, a tender may be worded as being for the "building of" or "deployment of infrastructure" rather than for "providing access to infrastructure". Satellite technology, for example, can often be a valid option but one that does not require the building of substantial new infrastructure when they are already operating in space.

Competitive tender processes can be used for national broadband deployment programmes, such as in the case of Australia and Mexico, or in local networks, such as in Portugal. Depending on the context, breaking up the scope of the broadband deployment project to cover smaller areas may provide an opportunity for smaller operators to take part in the bid, increasing competition and allowing for diversification with different models and technologies for broadband deployment. Conversely, in nationwide fixed or mobile broadband networks, management and implementation, and economic scale may call for one single operator, that usually provides wholesale services only. Competitive tenders can be linked to other initiatives that aim to reduce costs of broadband deployment and service.

In Portugal, in the context of the Digital Agenda, once market failures had been identified, five public competitive tenders were launched in 2009, for the deployment, management, operation and maintenance of electronic high-speed communications networks in rural areas of the North, Centre, Alentejo and Algarve, Madeira and Azores islands. Under the contracts, the successful operators were obliged to ensure covering at least 50% of the population of each of the municipalities with a minimum speed of 40 Mbps (downstream) to each end user; provide a wholesale offer to ensure access to the network to all operators and service providers; and provide through subcontracting, a retail offer to all users who require it.

In the United Kingdom, the main government scheme for extending and improving broadband in rural and remote areas is the Superfast Broadband Programme, managed by the Broadband Delivery for the United Kingdom (BDUK) in the Department for Culture, Media and Sport. This programme is based on a competitive tender model for public funding to make investments viable to the private sector (DCMS, 2013). Initially, all the contracts were won by BT, but once demand was proved to be higher than expected, start-up companies emerged with different technological approaches and networks. These are now up and running in rural areas with surprising results. The United Kingdom is one of several OECD countries where some small villages and rural areas have fibre to the home (Box 1).

Box 1. United Kingdom's BDUK Programme

The Broadband Delivery UK (BDUK) aims to provide superfast broadband (speeds of 24Mbps or more) for at least 95% of premises in the United Kingdom and, at the time of launch in 2013, universal access to basic broadband (defined as speeds of at least 2Mbps). This baseline speed target has since been increased to 10 Mbps.

In the first round of contracts, all the initial BDUK contracts were won by BT, the incumbent telecommunication carrier and consisted of upgrading backhaul networks and installing FTTN facilities with the aim of providing 30 Mbps. BT received grants under the BDUK scheme, additional funding from some local governments as well as investing its own capital. The goal was to improve access in areas where commercial returns were not assessed to be adequate to attract purely commercial investment.

BT's success in winning all contracts, for the first stage of the BDUK project, reflected in part its ability to scale from its existing facilities. In contrast, other infrastructure based competitors were predominantly urban based (e.g. Virgin Media a cable company) or likely did not have networks in those locations from which they could scale to meet the requirements with a competitive tender. Worthy of note, is that the government specified in its contracts that some of the money granted would be returned by BT if demand exceeded a 20% take up rate. This has resulted in USD 161 million already being returned to the government and available for further broadband expansion as a result of the target being exceeded. BT has set aside a total of USD 613 million in its accounts to provide for future funding returns over the life of the projects.

By the time the second round of contracts were awarded several things had changed in the rural and remote broadband market. One was changing perceptions about demand, which had proven higher than expected, and start-up companies emerging with different technological approaches and networks that were by then up and running in rural areas with surprising results. In 2011, for example, a company called Gigaclear built its first FTTP network in the town of Hambleton, which had a population of 203 people in that year. By the close of 2016, Gigaclear FTTP operated networks across 13 counties in the United Kingdom. By that stage the company had 20 000 subscribers and passed 50 000 premises.

Gigaclear, a privately owned company, has yet to turn a profit and says at present it prefers to reinvest revenue in extending its FTTP network. It has, however attracted substantial investment as well as winning contracts under the BDUK programme. By 2016, this had resulted in some small towns and rural communities having speeds that exceed those in most urban areas in OECD countries. Gigaclear's current offers range from 50 Mbps to 1 Gbps at monthly prices from USD 52 to USD 96. Subscribers also pay an activation fee of USD 125 (GDP 100) and an installation fee starting at USD 157 (GDP 125), though customers can opt to pay the cost of joining the network if there premises would not otherwise be covered due to higher costs. In the latter case, Gigaclear provides the example of a 500 premises network in the village of Appleton (population 915) where it concluded four residences could not be economically covered. In that case three of the four householders shared the USD 15 000 cost between them. By mid-2016, Gigaclear said it had an average take up rate of 36% of homes passed.

A further example of competitive processes is the use of reverse auctions. The strength of such an approach, in a market with multiple potential suppliers, is to draw on the information often uniquely available to private firms. The market players then bid using attributes such as the amount of coverage and service they can provide for a certain amount of funding or for a defined service level at the lowest cost. This approach is used in some parts of the United States. In May 2016, the FCC adopted rules that will allocate up to USD 1.98 billion over the next decade for fixed broadband service in certain unserved high-cost (primarily rural) areas. The auction seeks to expand service to areas currently lacking broadband delivering at least 10 Mbps download/1Mbps upload. It provides robust but flexible standards for broadband deployment. To encourage a broad range of bidders, the FCC established technology-neutral performance tiers with varying levels of speed, usage allowances, and latency (Box 2). The rules set reporting obligations to enable the FCC to monitor progress in deployment. In August 2017, the FCC sought public comment on proposed procedures for the auction, which it intends to conduct in 2018. Additionally, in February 2017, it adopted a budget of up to USD 4.53 billion for ongoing support to be awarded in a separate reverse auction to expand mobile broadband service to certain unserved high-cost areas currently lacking reliable 4G LTE service. The FCC has also created a framework for a Remote Areas Fund auction to address those areas that receive no winning bids in the reverse auction.

In January 2015, New York launched the New NY Broadband Program, a public-private initiative created to speed the deployment of broadband in the state. New York budgeted USD 500 million for its Broadband Program to be disbursed through a competitive bidding process, which New York is conducting in phases. Participants are also required to contribute funds towards their projects to better leverage state funds. In the first two phases of the program, recipients were required to offer broadband at download speeds of at least 100 Mbps in most areas. If no "qualifying, commercially reasonable" application was submitted to offer download speeds at 100 Mbps in unserved areas, New York would consider applications that propose to offer download speeds below 100 Mbps. However, all applications were required to offer download speeds of 25 Mbps at a minimum. All build out for the first two phases must be completed by 31st December 2018. New York support is disbursed as frequently as quarterly to reimburse eligible expenses, provided that New York awardees are in compliance with the terms and conditions of the program, and that they submit the required status reports and documentation of their eligible expenses. New York awardees are limited to using New York support for capital expenses. For New York's Phase 3, the FCC allocated federal universal service support to augment New York's program, with the winning bidders eligible for Connect America support up to the total reserve prices of all the census blocks that are included in a winning bid, provided that New York has committed, at a minimum, the same dollar amount of New York support to the Connect America-eligible areas in that bid. Phase 3 recipients will be subject to the same level of oversight and non-compliance measures as all other Connect America Phase II recipients.

Box 2. Tiers for rural broadband competitive bidding in the United States

In the United States, the FCC new rules adopted in 2016 to allocate funds for fixed broadband deployment through a reverse auction, setting performance tiers with different levels of speed, usage allowances and latency. Bidders can also choose to provide either high or low latency in each tier. The FCC gives more weight to bids that offer better performance. The tiers are:

- minimum performance tier providing broadband speeds of at least 10 Mbps download/1 Mbps upload and offering at least 150 gigabytes (GB) of monthly usage
- a baseline performance tier providing at least 25 Mbps download/3 Mbps upload and offering at least a 150 GB monthly usage allowance, or that reflects the average usage of a majority of fixed broadband customers nationwide, whichever is higher
- an above-baseline performance tier providing at least 100 Mbps download/20 Mbps upload and offering an unlimited monthly usage allowance
- a Gigabit performance tier providing at least 1 Gbps download/500 Mbps upload and offering an unlimited monthly usage allowance.

5.1.5. Coverage obligations

In principle, any auction can incorporate restrictions and obligations. Some of the most common ones are coverage obligations. Fixed broadband access has not been traditionally subjected to coverage obligations, while they have been widely implemented for mobile operators being awarded spectrum. This mechanism has been used by most OECD countries to provide some certainty about the future coverage of networks. For rural areas, the inclusion of coverage obligations in spectrum licences has historically been crucial to ensure availability of mobile telephony. With time, mobile broadband services have also been incorporated to enable a certain percentage of the population to have mobile broadband access. In some OECD countries, for example, mobile operators partner with satellite operators who provide the backhaul connection to the Internet backbone in the absence of other fixed infrastructure.

In some cases, countries have included conditions to provide connectivity to specific premises, such as schools, and to apply special rates, provide free services for low-income citizens or to provide terminals for schools within spectrum licences. However, setting coverage obligations demands careful analysis. Lax coverage obligations may waste the opportunities to ensure mobile broadband access in areas where there are not enough economic incentives to deploy network infrastructure. On the other hand, obligations that provide for extensive geographical coverage in too short a time may impose an excessive burden on an operator. The usual practice is to impose the same obligations for all the MNOs in a country with similar licenses, while possibly allowing any new entrants, more time to fulfil obligations. A careful assessment of regulation, some of which may no longer be required, and more flexibility in meeting obligations) for the underserved areas could also serve as an enabler to attract investment by reducing costs attached to service provision.

In Portugal, following the 2012 800 MHz Multiband Auction (4G), mobile operators were required to extend coverage to 480 parishes which "tended to lack mobile broadband coverage” at speeds between 7.2 Mbps and 43.2 Mbps. In 2017, following the renewal of the 1920-1980 MHz / 2110-2170 MHz mobile licenses for a further 15 years, operators were required to extend mobile coverage to an extra 588 parishes where coverage would be difficult to achieve if operators were left to act based purely on their own commercial interests. The reference download speed in this case was 30 Mbps (ANACOM, 2016).

5.1.6. Open access policies

Following the global financial crisis, a number of OECD governments provided grants for public - private partnerships to develop fibre networks in underserved areas. Some of these initiatives were designed to be of an "open access" nature so as not to strengthen monopoly power in underserved areas. Although there is no single definition of open access policies in OECD countries and are seen in a variety of contexts, from fixed and mobile access networks, backhaul and backbone, to undersea cables and Internet exchange points, they share some common features. Open access arrangements usually refer to wholesale access to network infrastructure or services provided effectively on fair and reasonable terms, for which there is some degree of transparency and non-discrimination (OECD, 2013).

Once it has been determined that there was insufficient competition to meet policy objectives, some OECD countries have tackled market failures through open access policies in fixed broadband networks, backhaul, backbone and more recently mobile networks such as in Mexico. Mandating open access to ducts of the incumbent has proved extremely useful in some countries such as Spain, fostering the deployment of FTTH by alternative operators and saving costs from civil works. Voluntary open access agreements remain relatively rare but the separation between wholesale and retail operations by the telecommunication incumbent in the Czech Republic provides one example.

Many open access arrangements are a result of direct public funding of broadband networks. In this case, certain open access conditions can be imposed once operators are awarded public funding (*e.g.* preferential loans, subsidies), for broadband infrastructure deployment. These conditions need to be complied with if companies are to be recipients of public awards or competitive tenders and are widely used in regional and rural areas such as in New Zealand. The rationale is to try to ensure that such public funding promotes the emergence of some degree of competition in a given area.

One of the largest projects currently for fixed and wireless broadband services is that of the Australian National Broadband Network (NBN). In Australia, to meet a goal of providing broadband to all its population, the government established in 2009 a company to commence building a national broadband network, based on the commissioning of two national broadband satellites to ensure total coverage. The goal is to deliver Australia's first national wholesale-only, open access broadband network to all Australians, regardless of where they live. The expectation is that the NBN will be completed in 2020.

With its *Red Compartida* project, Mexico offers OECD's first wholesale-only national wireless network. The goal of this model is to promote a more efficient and equitable use of spectrum infrastructure, by having *Red Compartida* be operated by a new concessionary, instead of an active player in the market of providing services to final consumers, with its services sold to retailers such as Mobile Virtual Network Operators (MVNOs), Mobile Network Operators (MNOs) and Fixed Network Operators (FNOs) offering quadruple play services, amongst others.

In Mexico and the United Kingdom open access remedies for fixed networks are also being imposed in the context of regulation in the functional separation of the incumbent. The Czech Republic and New Zealand has structurally separated incumbents based on voluntary decisions taken by private companies. In other OECD countries, such as in the Netherlands, regulators and competition authorities have imposed open access obligations in the context of mergers or acquisitions. Denmark has opened the access to its incumbent's, TDC, broadband network since 2009.

Local and municipal broadband networks funded by public authorities in the United States and in the European Union have also been using open access arrangements, especially in the context of the so-called "middle mile" connectivity for local access (last mile) facilities.

In the United States, one example was the creation of the Maine Fibre Company (MFC).[4] The MFC is a dark-fibre leasing company, formed in 2010, using public and private funds. The company oversees the construction, maintenance, leasing and operations of a 1 100-mile, high-capacity fibre optic network, including in some of the most rural areas in the state of Maine. The network is largely an open-access infrastructure and is available to all carriers and service providers on a non-discriminatory basis. Customers include national and international telecommunication carriers, local service providers, wireless providers, ISPs and business or public sector entities with a high demand for data transmission. At the same time, some capacity is reserved for the University of Maine and the State Government as a condition of the grant and their early involvement in the project. In Sweden, Stokab, owned by the city of Stockholm, runs a dark-fibre network and also acts as retail operator for the local government. All operators are granted access to Stokab's network on equal terms.

In Latvia, to increase broadband coverage in areas with lower population densities, the government has introduced a plan within the framework of the development of next generation electronic communications networks in rural areas project, supported partially by ERDF. The plan foresees the deployment of "middle mile" optical fibre networks in remote areas through broadband access points in municipalities across the country. Retail operators, in order to provide broadband for consumers, are then required to roll-out last-mile optical fibre or use wireless technology from the access points to reach consumer premises. Mobile operators, for example, will be able to lease dark fibre to connect base stations, which are central for deploying 4G and 5G. The aim is both to open wholesale access to the "middle mile" networks (i.e. dark fibre), in order to have wholesale services provided on fair terms and at competitive prices to all retail operators, and to enable competition in the last-mile. The diffusion of broadband services, as well as quality of service, are systematically monitored and evaluated by the government to define policy measures as appropriate.

5.1.7. Municipal networks

In addition to national broadband programmes, a number of OECD countries have been implementing bottom-up models to finance and deploy high-speed networks, such as that of municipal or community networks. Municipal networks are understood as high speed networks that have been fully or partially facilitated, built, operated or financed by local governments, public bodies, utilities, organisations, or co-operatives that have some type of public involvement. Municipal networks have been used to fill the gaps or provide substantial service in a region, city or smaller town and the experience varies among OECD countries (OECD, 2015).

In the right circumstances municipalities and communities have a role to play in the development of new broadband networks and helping to cope with the continuously growing demand for higher capacity and in meeting policy objectives. Often, rural towns are prepared to get involved and contribute with voluntary work or their resources, such as machinery, in order to establish networks. This occurs when communities or co-operatives, contribute with time and money, if no other solutions are available.

When other providers are not meeting public policy objectives, municipal networks can become a welcome facilitator of competitive choice by providing an alternative infrastructure and opening the market to other providers through open access frameworks. The reason for responding to unmet demand is the most common one given for municipal networks though some feel they can build on their existing responsibilities and facilitate more cost efficient digital communication as well as promote economic and social growth in their cities and towns (OECD, 2015). There needs to be appropriate safeguards to limit unfair competition especially where public subsidies are used.

Sweden provides a successful example of municipal networks or the "village fibre" approach (Box 3). It should be noted though that in some countries business models that include collecting upfront payments and requiring subscribers to provide a part of the infrastructure (e.g. trenches), may not be permissible for commercial network providers. Other OECD countries such as Australia, Denmark, Japan, Netherlands, New Zealand, United Kingdom and the United States have also witnessed the deployment of different types of municipal networks. In Germany, the government-owned development bank KfW offers a loan at reduced rates to municipalities to support investments in infrastructure including broadband infrastructure, which can also be complemented with public funding.

In the United Kingdom, the Department for Digital, Culture Media and Sport, maintains a list of case studies of successful community-led schemes to improve local broadband. The case studies are listed in order of models, from model 2 (buy into existing commercial rollout) to model 6 (community owned and operated) (DCMS, 2017). By way of example, B4RN is a professional fibre to the premises broadband network, registered as a non-profit community benefit society, and run by a dedicated local team with the support of landowners and volunteers.[5] The basic offer is 1 Gbps symmetrical FTTP broadband to every property in their coverage area within North West England, cost USD 200 to connect and USD 40 per month. B4RN says, however, 10 Gbps is also available to all properties, a speed normally reserved for commercial offers in cities such as Singapore or Tokyo.

Box 3. The village fibre approach in Sweden

In the 1990s, the liberalisation of the telecommunication market in Sweden not only encouraged alternative operators to expand and the creation of municipal networks but also local communities to form co-operatives for the roll out of fibre networks. This could be called the "village fibre" approach. It is based on the premise of community involvement to plan, build, and operate local fibre networks in cooperation with municipalities and commercial operators. The Swedish Governmental Broadband Forum estimates that there are around 1 000 village fibre networks, which on average each connect 150 to 200 households.

Proponents say the village fibre approach facilitates fibre deployment at a considerably lower cost compared to those of commercial operators through a combination of three factors: handling of permissions; excavation work and trenching; and voluntary work in respect to aggregation of demand. Moreover, the deployment of fibre networks through village fibre as well as all other operators is facilitated by consumers' willingness to pay upfront fees of around USD 2 300 to connect single dwelling units and the possibility to apply for a subsidy from public funds.

In Sweden, the handling of permissions that are required to build broadband networks strives to reduce or eliminate costs. The involvement of landowners, who must give their consent for rights of way before network deployment, is a vital part of the village fibre approach as it facilitates a pragmatic means towards allowing rights of way at minimal or no cost. Deployment of fibre networks in conjunction with roads commonly require permission from the Swedish Transport Administration but, if that raises obstacles or leads to excessive costs, another option is to use alternative routes for fibre deployment along private roads (often owned by communities or private landowners), bridges and properties.

Given that excavation and trenching costs increase with distance it is necessary to take advantage of locally based contractors which can be hired at competitive tariffs or alternatively involve members of the communities themselves to carry out the work.

A cornerstone of the village fibre approach is that members of local communities make a significant contribution through voluntary work by, for example, communicating with residents in order to raise interest and aggregate demand. On average, the penetration rate for village fibre projects is around 80% compared to roughly 50% in commercial fibre network projects. Moreover, members of the communities are also reducing costs by handling documentation and internal control of the projects as well as solving practical issues like offering facilities for meetings.

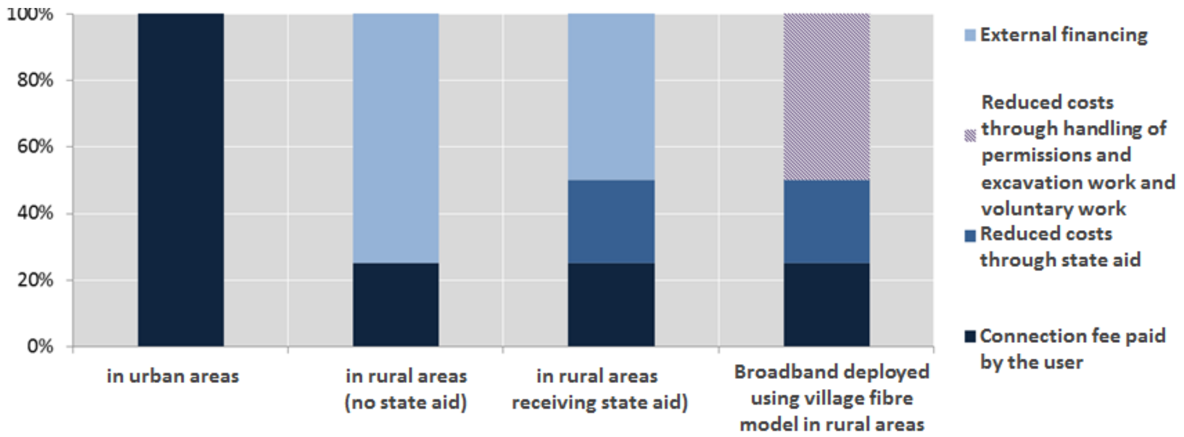
In addition to voluntary work, the individual household that participates in the construction of a village fibre network has to pay a connection fee. Typically the fee is around USD 2 300, roughly representing some 25% of the total cost of a rural broadband connection. Given that village networks are deployed in areas where no commercial operators are deploying fibre networks they meet the key criteria for state aid. A government grant scheme is available, which has dedicated funding and is included in the national rural development programme set up by the European Union.

The Swedish government regards broadband deployment as a way to strengthen resilience within rural communities. Roughly 25% of the total value of a village fibre project is attributed to financial support, making it a relatively small but, nevertheless, a significant contribution to the realisation of village fibre projects.

In total and compared to commercial broadband projects, this means that village fibre projects can achieve deployment cost savings of some 50% using an innovative handling of permissions as well as excavation and voluntary work. A further reduction of some 25% is achieved through state aid, making the connection fee equivalent to that of urban areas (Figure 4).

In Sweden, the first wave of village fibre networks set the process rolling but as the demand has continued to increase, attracting more operators to expand into rural areas, various combinations of village fibre solutions are being deployed to connect households all over the country to fibre networks. Proponents say this means someone can live anywhere in the country and participate in the digital economy on the same terms as people in urban areas.

Figure 4. Illustration of different funding models for broadband expansion in Sweden



Note: Index based on the commercial cost in rural areas.

Source: Swedish Post and Telecom Authority (PTS)

5.1.8. Reducing deployment costs

Construction of civil engineering infrastructure (such as ducts, subducts, manholes, and poles) constitutes a major part of the costs of deployment of broadband infrastructure, though some of these infrastructures are more used in some urban areas than in rural areas. Therefore, civil engineering infrastructure is the most difficult part of the network to replicate. Mandating access to it is an effective regulatory tool to promote competition, promote investment in fibre infrastructure, reduce deployment costs, reduce negative impact on the environment, and ultimately benefit end-users in terms of better choice, lower prices, higher speeds, and better quality of service. A number of studies have suggested that the main factor driving optical fibre deployment is infrastructure competition (BEREC, 2016). Evidence and some country cases show that first movers with regard to fibre investments are new entrants who are willing to build their own infrastructure. Incumbents react in response to competitive pressure exerted by new entrants and then upgrade their infrastructure. Access to civil engineering infrastructure could contribute to overall development of the telecommunication market both in urban and rural areas.

The level of competition in rural and remote areas is generally characterised by being lower compared to urban areas due to lower population density that can be reached by telecommunication providers. Access to civil engineering infrastructure might make market entry easier and optimize resources in rural and remote areas. With regard to the sharing of civil engineering infrastructure among fixed telecommunication providers, the provision of access to underground ducts, compared to over poles, tends to be more widespread. That being said, in a number of OECD countries (e.g. Lithuania and Portugal access to ducts play a significant role in ensuring competition.

The provision of mobile broadband is increasingly important in rural and remote areas. While the quality of mobile broadband differs among OECD countries and in different locations, broadband customers whose households do not have a connection to a fixed network can consider using mobile broadband or other wireless technologies instead. The sharing of masts and sites is typical among mobile operators. Access to ducts is not only used by fixed operators but also by mobile operators to install fibre cables for connection of its base stations. The importance of access to ducts for mobile operators has been increasing and will increase in the future especially for the deployment of 5G. For mobile broadband, high spectrum costs could also act as a factor contributing to commercial assessment of coverage.

Sometimes other utilities (e.g. energy, gas, railway etc.) use their own physical infrastructure to install fibre for their own needs in order to ensure safe network operations, e.g. detection of problems, surveillance, monitoring and so forth. Other utilities might also operate as telecommunications providers and use their own physical infrastructure to install fibre for data communication. There are also cases in practice when other utilities give access to their physical infrastructure to telecommunication providers on commercial or regulated basis, which bring benefits to the telecommunication market increasing the coverage of broadband networks and promoting competition. In the majority of current infrastructure sharing cases, but not always, the physical infrastructure of other utilities is used for telecommunication operators' core networks and ultimately influence services available to end-users in both rural and urban areas. The physical infrastructure of other utilities can be used for national and also international telecommunication networks.

The following fibre installation projects exist in a number of OECD countries:

- on the aerial power lines (e.g. in Latvia), such as the more widely used Optical Fibre Ground Wire (OPGW) cable technology used in high voltage aerial power line networks or the power lines and optical fibre cables installed underground
- on gas infrastructure (e.g. the Baltic Highway from Tallin to Frankfurt uses optical fibre which is laid on high voltage lines, OPGW, and along gas pipelines)
- along railways, roads, tunnels and bridges and so forth.

The infrastructure sharing of other utilities, however, appears to be limited. The following reasons might influence the sharing:

- Telecommunication providers, especially new entrants do not necessarily have knowledge and experience on how to use the physical infrastructure of other utilities. Installation of optical fibre cables should be in compliance with national or international standards and/or national legislation.
- There is a scarcity of information about opportunities to share infrastructure (e.g. architecture of physical infrastructure, geographical location, infrastructure maps and so forth).
- The architecture of physical infrastructure of other utilities might change over time (e.g. energy companies move their aerial power lines underground. If optical fibre was used on the aerial power lines in high, middle, or low voltage networks and the particular segment of power lines is planned to be built underground, these changes will influence infrastructure sharing).
- Technical constraints may exist in sharing certain infrastructures (e.g. optical fibre cables are particularly suitable for the use on the aerial power lines in high voltage networks, however, if the cable fails it may not be repaired quickly) or when physical infrastructures are not easily reachable (e.g. if electrical power lines have been directly buried).
- There is a lack of commercial agreement (i.e. when parties are unable to successful negotiate a price for infrastructure sharing).
- Uncertain regulatory environment reducing incentives to share infrastructure (e.g. price regulation).

In order to increase coverage, especially in rural areas telecommunication providers (and energy companies) tend to use a technique of directly buried cables. Often it is done along the roads to avoid long and expensive procedures to gain permissions from landowners to construct the network. Policy makers and regulators should take into account that the method of directly buried cables is less expensive compared to building a duct network. However, there are some following risks involved:

- If there is a need to install additional cable, it is necessary to dig again.
- Older directly buried cables are usually left underground, which can have a negative outcome for the environment.
- Directly buried cables are relatively easy to damage, although less so today as they are armoured (e.g. from agricultural work).
- Infrastructure sharing in the future technically is not possible if this method was used.

An approach to install underground ducts along the roads if they are under construction (i.e. building new or upgrading existing) for installation fibre cables in the future would solve part of the problems related to directly buried fibre cables. However, that approach would increase costs of construction of the particular road. In this case, careful planning would be required if it is economically feasible and justified to do so.

To further spur competition in communication markets and reduce costs, some countries are increasingly working on infrastructure sharing provisions. In this respect, most European Union member states have recently enacted national legislation in order to transpose the European Union Broadband Cost Reduction Directive (2014/61/EU) into national law and the remaining ones are currently finalising the process of doing so (European Parliament and European Council, 2014). The directive addresses infrastructure sharing, information sharing and co-ordination of civil works between communication operators and other utility operators (energy, gas, heating, water and transport) to facilitate the roll-out of high speed broadband networks. It enables ISPs to get access to physical infrastructure of any network provider.

In several ways OECD countries are endeavouring to expand broadband in rural and remote areas are reforms aimed at reducing costs. In the United States, for example, the FCC has created a federal advisory committee to explore ways to accelerate deployment of broadband and, by so doing, act to close the digital divide (FCC, 2017a). In 2017, issues the Committee is addressing include further reforms to the FCC’s pole attachment rules; identifying unreasonable regulatory barriers to broadband deployment; and ways to encourage local governments to adopt policies conducive to broadband development. This includes drafting model codes, for both states and municipalities, covering such issues as rural deployment, local franchising, zoning, permitting, and rights-of-way regulation. One of the intended benefits of the municipal model code is to disseminate guidance to localities that want to enact deployment-friendly policies but have limited resources or expertise in this area. In this way, the model code ideally will mitigate disparities in resources among localities. Meanwhile policy makers in the United States continue to discuss the introduction of “dig once” initiatives (Brodkin, 2016), such as mandating the installation of fibre conduits during federally funded highway projects (FCC, 2017b).

In Mexico, initiatives to lower costs through improved regulation and practical policies in the area of rights of way and available infrastructure has also been a priority. The National Information System of Telecommunications Infrastructure that is currently being developed will include useful information pertaining to rights of way geared at allowing concessionaires to deploy telecommunication infrastructure within those assets. This inventory aims at revealing the availability and status of this infrastructure, in order to increase efficiency in deploying telecommunication networks. These initiatives are part of SCT's efforts to synchronize the involvement of local and state authorities through a passive infrastructure programme containing parallel projects with the intention of lowering the costs for infrastructure deployment and increasing coverage across the country. These programmes are considered in more detail in the OECD's implementation review of telecommunication reform in Mexico (2017) but two can be highlighted here:

- The SCT aims at developing co-ordination agreements between the different players. Under these agreements, local and municipal governments undertake to strictly implement a Model Statute that would apply to all requests submitted by operators and infrastructure developers in connection with the construction, installation, expansion and modification of telecommunication and broadcasting infrastructure in their territory. By doing this, the SCT seeks to simplify and standardize criteria, including requirements, procedures and fees, thus reducing bureaucratic barriers associated with the deployment of infrastructure.
- The SCT plans to issue an interagency agreement that will allow for close to 110 000 state-owned structures to be used and shared, by concessionaires (licensees), permission-holders and infrastructure developers, as passive infrastructure for telecommunication networks under non-discriminatory, equal-access and non-exclusive conditions. Information pertaining to the relevant properties, including geo-referenced location, as well as physical, economic, technical, safety and operational conditions and the market value are published on an on-line platform operated and managed by INDAABIN. Interested parties can use the platform as a search engine and indicate their interest in a particular building and INDAABIN will serve as a one-stop portal for all the requests. Apart from the 110 000 federal buildings, other interested public institutions, for instance at the municipal level can become a member of the portal and present their properties that fulfil the necessary technical conditions.

Slovenia has also developed a somewhat unique database relating to efforts to improve broadband availability. The so-called Consolidated Cadastre of Public Infrastructure (CCPI), includes data on the available connectivity and capacity (in Mbps) of the existing network for each building. Prior to publishing a call for co-financing the deployment of open broadband networks, the Ministry invites network operators to submit expressions of commercial interest. This provides a basis to precisely define and identify in the CCPI the households that lack broadband Internet access at a speed of at least 100 Mbps or 30 Mbps and for which the operators have no commercial interest in providing such access in the following three years. These data are then used to calculate the public funds required to meet policy objectives. Should the need arise, based on this assessment, Slovenia's NGN Development Plan–2020 will be revised by shifting the boundary between two geographic segments with high and low population densities. As a result, the number of households to be provided with 100 Mbps broadband will decrease, whereas the number of households to be provided with broadband infrastructure at a speed of at least 30 Mbps will increase. Authorities aim for this modification to result in a balance between investment requirements, commercial interests and private financial resources.

Belgium included in their NBP the action lines to reduce costs by creating a central electronic counter in each region for applying licences for rolling out infrastructure and for granting licenses swiftly, promoting access to existing infrastructure and publishing guidelines and issuing a "fibre ready" label for citizens that plan to build or renovate their residences. Based on the European Commission Directive, it also seeks to optimise the co-ordination of roadworks and the distribution of costs between network operators (telecom companies, cable companies, power grid operators, water companies, transport, etc) participating in the joint roadworks ("dig-once" policies) (Digital Belgium, 2015). In Germany, the DigiNetz Act adopted in November 2016 aims to reduce costs by the use of synergies and optimizing the entire deployment process. The government says that more transparency, sharing networks with more users and the obligation to deploy broadband within the framework of existing infrastructure and new construction projects can significantly reduce costs.

In the United Kingdom, Ofcom has announced that BT's Openreach must make it much easier for competitors to access its network, and provide comprehensive data on the nature and location of its ducts and poles. This information will be used for a new "digital map" of the United Kingdom, Ofcom says, to allow competing operators to invest, plan and lay advanced networks, giving people more choice over how they receive their telephone and broadband services (Ofcom, 2016a). At the same time, in France, the Government has also made public a list, which is continuously upgraded, including the network-roll-out projects initiated under the French Broadband Plan, in addition to publishing the specifications for network development project applications in its broadband strategy.

In Spain, as in many other OECD countries, one of the major problems that networks operators find when deploying high-speed broadband networks in the different territories is the wide variety of licenses and applicable procedures to be fulfilled in the different municipalities. A mechanism was established there to better coordinate different levels of government responsible with urban planning and broadband infrastructures (Box 4).

Box 4. Coordinating different levels of government in Spain

In Spain, in order to coordinate both public interests of having municipalities have a say on their own urban planning and at the same time reduce administrative burdens and additional costs for operators during deployment, while respecting homogenous spatial planning, a mechanism was established by the Spanish General Telecommunications Law of 2014. The Law considers in its text the use of co-ordination instruments allowing the competent telecommunications authorities to assess the urban management measures affecting electronic communication network infrastructures. These instruments rest on the need for municipalities to obtain a binding report from the Ministry of Energy, Tourism and Digital Agenda on their urban planning instruments: the Ministry must examine them with the purpose of verifying the accomplishment of the measures provided in the General Telecommunications Law. Once they have been examined, a report on the mentioned accomplishment has to be submitted within three months. In the case of there not being a favourable report, the municipality may correct those elements not complying with law or may submit allegations within one month. The Ministry shall study those corrections or allegations, submitting a final binding report within one month. In the case of this report not being favourable, the municipality shall not be allowed to approve its urban planning containing the articles affecting electronic communication networks deployment that do not comply with General Telecommunications Law. The municipality may start the process again with a new urban planning containing new wording for the articles that were not approved.

During the process, there exists an active communication between the Ministry and the municipality, where different agreements and understandings are met, respecting both General Telecommunications Law dispositions and municipalities' urban planning needs.

Since the entry into force of these coordination instruments in March 2014 more than 2 000 reports have been issued. Roughly one out of four have been unfavourable in the first round. After the second round, only eight unfavourable final reports have been submitted. This is indicative of the success of these co-ordination instruments, which help to harmonize the rules in the different municipalities when it comes to deploy electronic communications networks, providing greater simplicity for the operators by removing administrative burdens and fostering the investment in infrastructures with lower costs.

Establishing information on broadband availability, as well as creating the tools and mechanisms to inform all stakeholders, has been a key element promoting demand driven approaches to lowering costs. Demand aggregation approaches, for example, can benefit suppliers if they know that there are a certain number of committed users at a particular location. One of the first broadband network suppliers to use this approach was Reggefibre in the Netherlands.[6] Founded in 2005, and now owned by KPN, Reggefibre focuses on constructing and operating open fibre-optic networks, now passing more than two million residences. The company's approach, since adopted by others, was to initially target underserved villages and towns by setting up a marketing and registration process. Once 30% of the location said they would subscribe to a fibre to the residence network they started construction. Since that time Reggefibre created a similar company in Germany called Deutsche Glasfaser, where a target of 40% of residences is used (Attema, 2013). Deutsche Glasfaser is now a privately owned investor primarily for the networking of rural areas. The company is reported to have passed 275 000 residences and businesses with plans to invest USD 1.6 billion and to be present in about 200 municipalities in five federal states. Tariffs for fibre connections are priced by speeds: USD 50 for 100 Mbits/s, USD 56 for 200 Mbits/s and USD 89 for 500 Mbits/s (Mansmann, 2017). The company says the 40% approach makes expansions in less populated areas economic. In April 2017, for example, Beelen (population 6 300), Ostenfelde (population about 3 000) and Westkirchen (population about 3 000) were announced to have passed the 40% mark (Kreis Warendorf, 2017; Stadt Enningerloh, 2017).

5.1.9. Funding broadband programmes

In order to close access gaps, OECD countries have developed specific programmes to deploy broadband networks. These programmes can be funded through different financial models, using a wide range of possibilities for combining public and private resources. According to the European Commission, for example, broadband investment can take a number of different forms (Box 5).

Box 5. European Commission's Broadband Investment Models

- Bottom-up Model: based on an initiative by the local community and includes a group of end users who are organised into a commonly owned and democratically controlled group and are able to oversee the construction and operation of their own local networks.
- Private Design, Build and Operate (DBO) Model – this is built around the existence of a Managing Authority that issues means (often in the form of subsidies/public aid by grants or competitive tenders) to the private sector for the purpose of support during the expansion of their networks. The public sector does not have any specific role in the ownership or operation of the network, but may impose obligations determining access to financial resources.
- Public Outsourcing Model – within the framework of this model there is a single contract that covers all aspects of the construction and operation of the network. The main characteristic of this model is that the network is operated by the private sector, but the public sector retains the ownership and a certain level of control over the network.
- Joint Venture Model – a partnership between the public and private sector is the arrangement through which the ownership of the network is split between the public and private sector. The construction and operating obligations are as a rule carried out and secured by the private sector.
- Public Design, Build and Operate Model – in this model, the public sector owns and operates the network without participation from the private sector. All the aspects of the development of the network are managed by the public sector, which may operate the whole network or may provide wholesale access with private entities then offering retail services.

Source : European Commission (2014)

OECD countries widely vary in the models chosen to expand their broadband networks. The appropriateness of each model depends on the scope of the required infrastructure, the specific objectives, the circumstances of the government and the level of competition in the market. The public resources aimed to deploying broadband networks are circumscribed in a timeframe, in which connectivity targets are usually measured against, and are usually allocated through grants, competitive tenders or direct public investment. Some OECD countries, such as Belgium, Canada, Ireland, Portugal, Slovenia, Spain and the United States, have established universal service funds (USF) to collect resources to finance supply, and sometimes, demand side projects. However, some USF have never become operational (Table 5). Moreover, in some countries operators that are recipients of USF have historically not been permitted to employ certain business models, such as requesting advance sign-ups to deploy infrastructure.

Table 5. Extending and funding national broadband deployment

Country	USF	Means of allocation of funds
Australia	No	Tenders and grants
Austria	No	Tenders and subsidies
Belgium	Yes*	n.a.
Canada	Yes	Tenders
Chile	Yes	Tenders
Czech Republic	No	n.a.
Denmark	No	Grants
Estonia	No	Grants
Finland	No	Grants
France	Yes	Tenders and subsidies
Germany	No	Tenders
Greece	No	Tenders
Hungary	No	Tenders
Italy	Yes	Tenders and grants
Ireland	Yes	Tenders and grants
Israel	No	Grants
Korea	No	Bidding
Latvia	No	Grants
Netherlands	No	n.a.
New Zealand	No	Tenders and grants
Portugal	Yes	Tenders
Slovakia	No	Grants
Slovenia	Yes*	Tenders
Spain	Yes	Tenders
Sweden	No	Grants
United Kingdom	No	Tenders
United States	Yes	Ongoing subsidies (determined by model, competitive bidding or own costs)

Notes: (*) Not operational; (n.a.) Not available; for some countries investment amounts may include both national and regional funds.

USF is a revenue-based collection mechanism with contributions paid by telecommunication service providers, or groups of related market players. In Ireland the USF is funded solely by the incumbent operator. Meanwhile in Israel and Spain all major market players contribute to the USF, which is allocated through grants to underserved areas, or in the case of Spain, to finance the designated operator. In the United States, telecommunications carriers such as long distance companies, local telephone companies, wireless telephone companies, paging companies, payphone providers that are aggregators, and interconnected VoIP providers must contribute to the USF. Switzerland has a legal provision that foresees the constitution of an USF if necessary, but has never established one. In Latvia, a USF has also not been established. In areas where the incumbent operator incurs losses caused by the provision of the universal service obligations, they are compensated from the government budget.

OECD countries have chosen to source these funds for broadband projects through a number of different mechanisms. Government funding for broadband services is sometimes undertaken, for example, through contributions from general tax revenues. Funding for these programmes generally involves a national competitive application process. Applications are assessed against project selection criteria to identify projects that best fit with the program objectives. Funding for programs typically involves a contribution towards capital costs to support broadband deployment where the business case is uneconomical.

Some general infrastructure funds, for example, where broadband is sometimes an eligible funding category, can have different processes with regard to how finance is made available. European Union states, for example, are eligible for the European Structural and Investment Funds (ESIF), made up of the European Regional Development Fund (ERDF) and the EAFRD. Between 2014 and 2020, these funds, amounting to USD 6.1 billion and USD 1.1 billion, respectively, were the main sources of financing roll-out of broadband networks in areas where market-driven investment had not materialised. In Latvia, Estonia, Greece, Slovakia, Slovenia, and Sweden, for example, these funds are allocated only for building fibre backbone networks in rural and remote areas. In Estonia, these funds are used to finance major projects to support broadband developments in rural and remote area. The projects are selected in co-operation with telecommunication service providers and support is given only to NGOs that provide the wholesale service to operators. These market actors then provide the service to retail customers. In Latvia, public support is made available for the installation of access points for third party operators to connect rural and remote areas.

In Sweden, in addition to ERDF, national government funding can be used to procure technical solutions for telephony. One case in point is to ensure that individuals are not disadvantaged in terms of traditional services, such as telephony, if there is a change in the technology used to provide it (e.g. wired to wireless). In addition, the Swedish government has proposed further government funding for the procurement of broadband services at 10 Mbps, in areas where operators cannot supply a service at that speed. In Germany, in addition to federal funding, many states have their own funding for broadband programmes and co-funding with the Federal Broadband Program is also possible.

In the United Kingdom, the Government is investing over USD 1.1 billion in superfast broadband infrastructure in areas where there is no commercial incentive for communications providers to do so. In 2010 it allocated USD 716 million, and a further USD 338 million was made available in 2013. Local Authorities and Devolved Administrations are matching the Government’s investment from local and European Union funding. The Government has also made available up to USD 11 million to support pilot projects to explore ways to extend superfast broadband to beyond 95% of premises in the United Kingdom, with technologies such as satellite and wireless and new financing models. The public sector is investing in total over USD 2 billion in improving broadband through the United Kingdom’s Superfast Broadband Programme.

Further to the resources from USF, Ireland approved in 2016 an initial sum of USD 279 million with some estimates putting the total cost at around USD 527 million to finance the National Broadband Plan until 2020. In that year, the model chosen by the Government, entitled “Commercial Stimulus”, is for the private sector to finance, design, build, own and operate networks, with contractual obligations to the Department of Communications, Climate Action and Environment, in return for the public funding contribution (so called “Gap Funding”) (DCCAE, 2016a). In 2017, the Government will also decide on the ownership associated with the network after 25 years.

In Spain, government funding from broadband expansion is allocated through the SESIAD programme, which grants subsidies to operators through yearly competitive tenders. Some regions run programmes addressed to particular needs, which are complementary to the aid granted by SESIAD, which has a joint budget of around USD 600 million (2014-2020) (Box 6). There is also a universal service fund, which is funded by network communication operators. Korea is also implementing a joint venture model where government funding is allocated based on a bidding process, private resources and operation

In 2015, the government of Hungary allocated USD 241 million in non-refundable subsidies and HUF 10 billion in loans on preferential conditions (ca EUR 248 million) to reach goals of connecting households and in the country in specific regions..

Canada, through CRTC’s 2016 broadband decision, is setting up a new funding mechanism for projects in underserved areas of about USD 559 million. The funding mechanism will be managed at arm’s length from the CRTC, based on objective criteria, and administered in a manner that is transparent, fair and efficient and in line with the broader ecosystem of current and future funding and investment in the country. Under this new mechanism, applicants will be able to submit funding proposals to build or upgrade access and transport infrastructure for fixed and mobile wireless broadband Internet access service. For the first five years, up to 10% of annual funding will be allocated to satellite-dependent communities to cover operational costs and certain related capital costs. While CRTC’s new broadband fund will use a revenue-based collection mechanism with contributions paid by telecommunication service providers (e.g., industry-levy), Canada’s federal government initiatives are funded out of general tax revenues. The latest rural and remote broadband initiative is Connect to Innovate (Box 6). Funding has also been provided through a number of federal infrastructure and economic development funds.

Box 6. Regulatory and aid measures to reduce deployment costs in Spain

The Spanish Ministry of Energy, Tourism and Digital Agenda, through the Secretary of State for the Information Society and the Digital Agenda (SESIAD), is the body charged with telecommunication policy. To achieve the objectives set out in its Digital Agenda, Spain has approved a set of regulatory measures aimed at mitigating deployment costs faced by operators and the creation of an environment favourable to infrastructure investments. These measures were included in a new General Telecommunications Law which was approved in 2014. Coverage at 30 Mbps has reached 81 % of the population in 2016 with an important FTTH coverage of 63 % of the population (increase from 3.3 million FTTH access installed in 2012 to 31 million in 2016).

Complementary to commercial deployments by operators, SESIAD is managing an aid program at the national level to foster NGA coverage. This program seeks the maximization of the results in terms of number of underserved households covered, without undermining competition. It is based on the following:

- White areas for coverage extension are defined at the national level. As of 2017 more than 53 000 population centres encompassing 11 % of the Spanish population make up the eligible areas, which are mainly rural.
- Annual tenders addressed to private network operators, through funding of projects of up to € 4 mill investment
- Aid is provided as subsidies.
- Operators may present projects to provide partial or full coverage to population centres included in the white areas. There is not a list of areas that operators must compulsorily cover.
- Projects which require less aid are given priority (projects with the lowest level of aid per household covered)
- The whole budget for the 2017 tender is USD 120 million. To preserve an appropriate balance amongst regions, there is a budget initially allocated for each region.
- The intensity of aid is set according to the specific needs of each of the 19 regions. In the 2017 tender varies from 40 % to 80 %.
- Operators receiving aid are obliged to provide wholesale services
- European Regional Development Funds are used.

The approach followed by SESIAD allows operators to choose the specific areas in which to extend broadband coverage, funding those projects requiring less aid. The aim is to locate the projects in the areas closest to profitability, maximizing the use of public funding in terms of population covered. The aid granted from 2013 to 2016 was around USD 144 million, funding 305 projects, and providing NGA coverage mostly through FTTH to 3 million households and businesses, amounting to public investment per household of around USD 70. There were 74 operators participating with a slight underrepresentation of the major players: Telefonica, Orange and Vodafone have jointly 95 % of the broadband market share, whereas they only received 66 % of the aid.

Even when funding is available, the implementation of broadband projects has often proven to be complicated. In order to facilitate the process for public authorities, the European Commission launched in November 2017 a network of Broadband Competence Offices (BCOs). The BCOs main task is to exchange best practices and share information between public administrations, in particular those responsible for ESIF-funded broadband rollout. In addition, two-new funding schemes have been introduced in the European Union. The Connecting Europe Broadband Fund (CEBF), launched at the end of 2017 to support smaller-scale and higher-risk broadband projects (equity or quasi equity) and the the European Investment Advisory Hub (EIAH), which has a strong rural and/or cross-border dimension using blended financing (mixing grant and financial instruments).

5.1.10. National and rural broadband programs

Within their national broadband plans (NBP), the majority of OECD countries have specific components to expand broadband in rural and remote areas. Some OECD countries, however, have already reached such a high penetration of high-speed connectivity, that their NBPs have become a component in broader and more ambitious digital agendas to provide even faster broadband to all, irrespective of the location, such as the case of Sweden, or to deploy new generations of mobile networks, such as Japan with its plan for 5G. Israel, on the other hand, due to its dimensions and relatively high density of even its peripheral areas, does not have a national broadband plan as such, choosing instead to reach policy objectives through their two universal broadband operators (Bezeq and HOT).

At a first stage, rural programmes typically involve connecting rural sites such as schools, libraries, hospitals and public buildings, before turning attention to individual premises underserved areas (Table 6). These plans can be a standalone project for public subsidy of networks, either in the national or state-level, or one of the action lines within broader national broadband strategies. While in some countries these programmes are technology neutral, others choose to set the desired technology in advance. In some countries, for example, satellites play an important role in connecting remote locations, such as in Canada, Chile (Easter Island), Denmark (Greenland) and the United States. The French NBP, *France Très Haut Débit*, launched in 2013 and updated in 2015, which has an important rural component, opts predominantly for establishing and widening its broadband network infrastructure through FTTH technology.

Table 6. National and Rural Broadband Programmes

Country	National Broadband Plan/ Rural broadband project(s)
Australia	National Broadband Network (2009-2020)
Austria	Broadband Strategy 2020 (2014-2020)
Belgium	Digital Belgium – Plan for Ultrafast Internet in Belgium (2015-2020)
Canada	Connect to Innovate (CTI)
Chile	Agenda Digital Chile (2016-2020)
Colombia	Vive Digital (2010-2014)*
Czech Republic	National Plan for the Development of NGN (2016-2020)
Denmark	Better broadband and mobile coverage in Denmark (2013-2020)
Estonia	EstWin project
Finland	Broadband Implementation Plan (2016-2019)
France	France Très Haut Débit (2013-2022)
Germany	Digitale Agenda (2014-2017)
Greece	National Broadband Plan Next Generation (2014-2020)
Hungary	National Infocommunication Strategy (2014-2020)
Italy	Strategy for Next Generation Access Network (2015-2020)
Ireland	National Broadband Strategy (2012-2020)
Japan	Declaration of the Creation of the Most Advanced IT Nation in the World (2013-2021)
Korea	Plan for Broadband Convergence Network in Rural Areas (n.a.)
Latvia	Development of Next Generation Electronic Communications Networks in Rural Areas (2013-2020)
Mexico	México Conectado Programme (2015-2019)
Netherlands	Digital Agenda for the Netherlands (2016-2021)
New Zealand	Ultra-Fast Broadband (UFB) programme, the Rural Broadband Initiative (RBI) and the Mobile Black Spot Fund (MBSF)
Norway	Digital Agenda for Norway (2016-2020)
Poland	National Broadband Plan (2014-2020)
Portugal	Agenda Digital Portugal (2015-2020)
Slovakia	Strategic Document for Digital Growth and Next Generation Access Infrastructure (2014-2020)
Slovenia	Development of Next-Generation Broadband Networks (2015-2020)
Spain	Digital Agenda for Spain (2013-2020)
Sweden	A Completely Connected Sweden by 2025 − a Broadband Strategy (2016-2025)
Switzerland	Digital Strategy Switzerland (2016-2020)
United Kingdom	UK Next Generation Network Infrastructure Deployment Plan (2015)
United States	Connecting America: the National Broadband Plan (2010-2020)

Notes: (*) New strategy/plan being prepared, (n.a.) Timeline or online document not available.

The NBP of Austria, updated in 2014, focuses mainly in broadband in rural areas. It calls for the closure of the last "white areas" with broadband infrastructure and in particular the establishment of NGA and backhaul infrastructures to enable the rapid spread of ultra-fast broadband services and promote growth in rural areas. In Ireland, the NBP, which was updated in 2015, calls for a publicly subsidised network to be provided to residential and business users in rural areas, which the government believes would not otherwise receive service at a level sufficient to meet its policy objectives. The network is expected to serve at least 30% of the premises in Ireland who cannot currently get access to sufficient high-speed services (DCCAE, 2016b). That translates into more than 900 000 premises used for residences, businesses or locations such as schools (Kennedy, 2016a). It has been estimated that the network will traverse 100 000 kilometres of road network or 96% of the land area of Ireland.

In Sweden, the aim of the NBP is to connect the entire population in Sweden, regardless of whether in urban or rural areas, with village fibre playing a pivotal role. Fibre networks are being deployed over the whole country, including sparsely populated rural areas where about 15% of the population live. The share of fibre connected households outside urban areas has increased from less than 5% in 2010 to more than 22% in 2016 (PTS, 2017). Continued investments mean that the availability of fibre in rural areas will rise as the share of homes passed was more than 25% by the end of 2016. Moreover, funds in the Swedish Rural Development Programme and the ERDF can be used for expanding broadband access in rural areas. In Finland, in addition to the national connectivity targets, in 2016 a Broadband Implementation Plan was published. This forward-looking plan focuses on creating a favourable ecosystem for digital services and business models, such as IoT applications, and extending high-speed broadband connections across the country, including in sparsely populated areas (LVM, 2016). In Germany, one measure of the Digitale Agenda 2014-2017 was the establishment of a federal programme (*Bundesförderprogramm zum Breitbandausbau*) is in place to finance high-speed broadband networks in underserved areas.

In Estonia, the government launched the EstWin project in 2009 to roll-out high-speed middle-mile networks to sparsely populated areas in Estonia which were unlikely to be covered by market-driven deployment. The aim was to lay over 6 000 km of fibre cables and the construction of network access points with public funding (ERDF) and to stimulate complementary deployments of last-mile connections by commercial operators in order to reach the target of 100% coverage with 30 Mbps and 60% households' penetration with 100 Mbps service by 2020. In Latvia, the implementation of the Development of Next Generation Electronic Communications Networks in Rural Areas, a middle-mile project supported by the ERDF, is progressing on deploying dark fibre and access points up to the centre of municipalities in rural areas not yet serviced ('white' areas).

In Greece, in addition to the NBP, the program Broadband Development in Greek Rural Areas aims to provide broadband infrastructure coverage to a substantial part of the unserved areas of the country as well as reliable and affordable connectivity services. The coverage, in Greece, concerns 5,035 villages with a total population of 525 956 inhabitants. The roll out is in three phases and is expected to be implemented from 2013 to 2030.

In Canada, the main current initiative at the federal level for broadband deployment in rural and remote areas is the Connect to Innovate (CTI) programme, which builds on the success of the Connect Canadians Programme (CCP). Provincial and territorial governments also have periodic broadband programs and the federal government has worked to coordinate and partner on projects. (Box 7).

Box 7. Rural broadband in Canada

On December 15, 2016, the Minister of Innovation, Science and Economic Development launched the USD 376 million Connect to Innovate (CTI) program. CTI is focussed on expanding high-capacity backhaul to underserved rural and remote communities and also connecting anchor institutions such as schools, hospitals, and Indigenous government buildings. More broadly, access to community backhaul will support fixed and mobile services to local homes and businesses at faster speeds. The goal is to provide a transformative level of service to rural and remote communities that can both support current needs and scale for long-term growth.

CTI funding will be provided to support a portion of eligible capital costs to extend or upgrade this network infrastructure via a competitive application process. The ISED website includes a searchable map of underserved areas, geospatial information available for download, an application guide, and an FAQ regarding program criteria. Applications for funding closed on 20th April 2017. CTI builds on the success of the Connecting Canadians program (CCP). CCP provides USD 229 million over five years (2014 - 2019) to extend and enhance broadband networks at a target speed of at least 5 Mbps, with a dedicated northern component to extend and augment capacity in northern communities in Nunavut and the Nunavik region of Quebec.

Funding for rural broadband is also supported by other federal, provincial and territorial initiatives. Indigenous and Northern Affairs Canada and Infrastructure Canada, both federal departments, also administer infrastructure programs that support community broadband development. At the provincial level, some examples of broadband initiatives include the Quebec government's Plan Nord. Plan Nord envisions building an undersea fibre optic network that will connect communities in Nunavik (northern QC) and other select communities of north-eastern Canada to southern Canada. In Ontario, the SouthWestern Integrated Fibre Technology (SWIFT) project, which has received USD 135 million in joint funding from the provincial and federal governments, will bring improved high-speed internet connectivity to over 300 communities in Southwestern Ontario.

Source: https://www.canada.ca/en/innovation-science-economic-development/programs/computer-internet-access/connect-to-innovate.html

In addition to its broader Connecting America efforts (such as supporting price cap areas, small rural carriers and mobile broadband), the United States has many other examples of initiatives to expand rural and remote broadband access. The State of Maine provides one example. In its 2016 Broadband Progress Report, the FCC noted that some 17% of Maine's rural population had no access to "Fixed Advanced Telecommunications Capability" (FCC, 2016). This was the 8th lowest deficit among states with all seven ranking ahead having much lower population densities (five of the eight ahead of Maine were among the 10 states with the highest population densities). This raises the question of why Maine, with a large proportion of their population living in rural areas, appears to have performed very well in providing broadband access (Box 8).

Box 8. Rural broadband program in the State of Maine

Maine has a population density of 15.4 inhabitants per square kilometre ranking it the 36th among states in terms of population density in the United States and with less than half the national average of 34.8. By way of comparison, Maine has a population density similar to Finland (17.9), New Zealand (17) and Norway (16.8). There is one thing that sets Maine a little apart from other States. In 2010, according to the United States Census, Maine is the most rural state in the United States.

At that stage 61.3% of Maine’s population lived in rural areas. The Census Bureau views areas with populations of at least 2 500 as urban and those living outside these areas as being in rural areas. Some counties in Maine have 100% rural populations making it a challenge to deliver infrastructure and services of all types. This does, however, underline why officials in the State are keenly aware of the role broadband can play in areas such as health and education.

Maine has a state-funded programme entitled “ConnectMe” to address rural areas. The two criteria for an application to be eligible are for the area to be unserved or have Internet access service that is less than 1.5 Mbps download speed, and that a completed project provide a symmetrical service of 10 Mbps download and 10 Mbps upload. Each year the ConnectMe Authority hosts “Broadband Day” to highlight service expansion in Maine’s un-served areas, with the event attracting broadband providers and legislators. In January 2017, the completed projects, highlighted at this event, used a range of technologies from fixed wireless to fibre to the home. Beyond state initiatives the United States Federal Government has also played a key role in Maine’s broadband development. For example, the United States National Telecommunications and Information Administration (NTIA) funded this effort through the State Broadband Initiative grant program and awarded an infrastructure grant through the Broadband Technology Opportunities Program (BTOP) to the Maine Fibre Company.

In Colombia, several programs in recent years have been implemented to reduce the digital divide and allow access to telecommunications services. Initially, the country sought to provide fixed telephony service in remote areas. Subsequently, as technological advances were made, the priority went from fixed telephony to the Internet (Box 9). In addition to these rural programs, in 2016, Colombia took the decision to use white spaces, in this case in the 470 MHz to 698 MHz frequency band. The Colombian spectrum agency has published new rules for use of TV white spaces in August 2017 (ANE, 2017), within the framework of the free use of spectrum, allowing its use through a mechanism of dynamic access to the spectrum, to promote more efficient use of the resource and increased affordability of access to broadband in rural areas.

Box 9. Policies in Colombia to promote broadband access in rural areas

- Kioskos Vive Digital: There are 6885 Internet community centres for children, youth and adults in rural areas with more than 100 inhabitants, located in the most remote areas of Colombia, where they can connect to the Internet and receive free training in the use and appropriation of ICTs.
- Puntos vive Digital: promotes the use of ICT in municipal head offices and areas of strata 1, 2 and 3, through the provision of community access to functional areas for Internet use, entertainment, training, and the provision of e-gov services. Currently there are 887 in the country.
- High Speed Connectivity for Amazonas, Orinoco and Chocó: the High Speed Connectivity project seeks to connect 28 municipalities and 19 rural zones through the deployment of high-speed, satellite and / or terrestrial networks, benefiting approximately 441 000 people located in the Colombian jungle, and providing connectivity to multiple Kioskos Vive Digital and Puntos Vive Digital located in those regions, as well as to 235 public education institutions and to 11 780 broadband access connections to lower income households.
- "Free Wi-Fi Zones for People", a program that has as goal that by 2018, the country has one thousand free public Wi-Fi zones.
- Broadband connections for lower income households: starting in 2012, a total of 331 118 broadband connections have been subsidized in 734 municipalities so that new customers pay a monthly fee that ranges from USD 3 to USD 6.

In Argentina, since December 2015, the federal government has begun to update their regulatory framework and to implement initiatives that support programmes and projects to bridge the rural digital divide. Through the Connectivity Programme, financed through the USF, the Fibre Optic Network (REFEFO), developed and maintained by the state-owned satellite company, ARSAT, the federal government aims to reach 1 200 localities, deploying more than 200 network nodes, benefitting approximately an additional 20 million inhabitants. REFEFO will provide further wholesale broadband services to local operators and cooperatives, which in turn can supply last mile and retail broadband services to end-users. The cost of the project amounts to around USD 20 million and when concluded 90% of Argentina’s population should be covered. Furthermore, educational institutions are being targeted through the Digital Educational Networks Programme, which aims to provide ICT equipment and connect educational centres with 3 Mbps minimum speed. Within the National Plan for School Connectivity, the aim is to reach 2 000 rural schools through satellite connexions.

In Costa Rica, the federal government has put in place, since October 2016, the “National Telecommunications Development Plan 2015-2021: A Connected Society". The plan contains three action pillars: Digital Inclusion, Electronic and Transparent Government, and Digital Economy. The Digital Inclusion pillar incorporates the Digital Solidarity Agenda and the crdigit@l Strategy. The crdigit@l Strategy, which is partially financed with resources from the USF, FONATEL contains five programs aimed at closing the access, connectivity and digital literacy gap of groups in vulnerable conditions: the Connected Communities, Connected Homes, Equipped Public Centres, Connected Public Spaces and Solidarity Broadband Network.

5.2. Promoting uptake

5.2.1. Affordability

Barriers to broadband uptake in rural and remote areas are many and varied. The main barriers related to broadband adoption include the high cost of serving rural areas. Affordability can, of course, also be a barrier for urban areas though this may not relate to the higher cost of providing service as in rural areas. In Canada, a survey contracted by the CRTC has found that certain low-income households may even sacrifice essential household expenditures such as food, clothing and healthcare in order to continue subscribing to broadband services (EKOS, 2016). This study found, that in order to manage the costs of services, some Canadians are using strategies such as bundling services, subscribing during promotional periods, and using public access sites (e.g. libraries, coffee shops) to access broadband services.

In rural areas, however, if there is available service, commonly, there is limited choice and rural residents typically have access to a lower level of broadband bandwidth than what is available to their urban counterparts. When rural households only have access to lower-speed lower-quality broadband service, they may not be able to use bandwidth intensive Internet applications due to speed limitations, they may experience service interruption due to poor quality of service, or they may simply consume more data than is allowed without overage charges, driving up their expenses. The high costs of deployment in rural areas likely result in some potential customers finding the available services or devices unaffordable or not attractive. Moreover, sector specific taxes are another factor which if reduced could potentially further enable expansion of rural broadband.

To close the affordability of communications gap, some OECD countries have established assistance and subsidised service programmes to low income populations. Canada, for example, in its recent Budget 2017, proposed a new Affordable Access program, which is aimed to assist service providers offer low-cost home Internet packages to interested low-income families. In the United States, the Lifeline programme, proposes to support access to broadband to the most vulnerable populations and low-income consumers. Voucher schemes are also used in some OECD countries to enable access via satellite where no other technological solution is available. In those cases, potential beneficiaries are usually required to sign a declaration attesting to the fact that no alternative means of broadband access is available to them in order to receive a voucher that covers the cost of purchase and installation of a satellite dish and modem, which in Europe amounts to around USD 350 per household. Further to government programs, some ISPs and other organizations have implemented initiatives to provide an affordable Internet service to low-income populations.

In early 2018, the European Union put in motion the WiFi4EU initiative, which plans to use USD 146 million under the Connecting Europe Facility (CEF) through voucher schemes to promote access to internet and local e-services in public places through free Wi-Fi connectivity by 2020. The initiative is designed to facilitate applications for small municipalities with very low administrative capacity and will offer small-value grants to 6 000 to 8 000 municipalities across Europe. Moreover, discussion is taking place regarding the continuation of voucher scheme for other types of technologies, such as for satellite connectivity for individuals or for schools to accelerate connectivity demand in the most underserved areas.

5.2.2. Trust

Adoption is also hindered by other factors beyond affordability. A 2011 survey of more than
15 000 households that had not adopted broadband in the United States found that nearly two-thirds reported that they would not purchase broadband service at any price (Carare, 2015). These households reported non-price barriers to utilization like lack of computer equipment, digital literacy, or fear of Internet crime. Generally, if consumers have concerns about the privacy of their personal information, they will for the most part be restrained from making full use of broadband services, thereby lowering the likelihood of broadband adoption and decreasing consumer demand. Conversely, the protection of customers' personal information may spur consumer demand for those services, in turn driving demand for broadband connections, and consequently encouraging more broadband investment and deployment.

5.2.3. Digital literacy

Digital literacy is the set of knowledge, skills, and behaviours that enable people to understand and use digital systems, tools and applications, and to process digital information. These capabilities and aptitudes link strongly with a population's capacity to be innovative, productive and creative, and to participate in democracy and the digital economy. Given that the Internet is increasingly the platform of choice for providing access to core services, including health care, banking, and government services, digital literacy becomes increasingly important for facilitating meaningful access to these services. Even where broadband Internet services are available, individuals may not be able to use the service to its fullest potential based on their level of digital literacy.

The United States government has identified the "homework gap" issue — the gap between those households with school-age children with home broadband access to complete their school assignments and those low-income households with school-age children without home broadband access. The United States Congress requires the regulator to evaluate the availability of broadband capability of schools and classrooms nationwide. To answer adoption challenges, the National Telecommunications and Information Administration (NTIA) has been designing and implementing programmes, such as the Sustainable Broadband Adoption, to support training activities in rural areas to show the relevance of broadband-based services to rural non-adopters and to encourage people to invest time in digital skills training. In Colombia, government-led initiatives have fostered the training of community champions to promote the locally-based efforts to provide face-to-face assistance to individuals who need help acquiring digital skills.

In Argentina, the Digital Country programme aims to promote connectivity for cooperatives, local SMEs and municipal governments by creating 300 digital inclusion centres for citizens and municipal employees and installing Wi-FI in public parks, schools and public agencies nationwide. Furthermore, the programme aims to also provide technical advice and assistance to local governments in implementing open public data related rules and guidelines.

In Canada, beyond government-led programmes, private initiatives are also seeking to advance digital literacy in remote areas. Pinnguaq, a not for profit technology start-up in Nunavut, is helping remote communities to learn computer and coding skills (Box 10).

Box 10. Teaching coding for Canada's most isolate communities

Founded in 2012, the technology start-up Pinnguaq was created to create games based on Inuit mythology, apps that teach traditional languages and songs and a syllabics translator for Google Chrome. The start-up created a not-for-profit association branch to teach computer and coding skills to communities in Nunavat, a Canadian territory with a population density of 2.7 persons/km^2 (a land mass equivalent to Western Europe with a population of 36 000). The Pinnguaq major challenge was developing a digital literacy and coding training where broadband connectivity was unreliable and where devices were scarce. To cope with the connectivity challenges, Pinnguaq developed offline open-source training programmes that are stored in USB sticks and provided for evert participant of the trainings, which culminate with participants designing a game together where they can incorporate elements of their Inuit culture

Source : Pinnguaq (2017), https://pinnguaq.com/; Laidlaw (2017), “This startup is teaching coding to Canada's most isolated kids”,http://www.wired.co.uk/article/pinnguaq-nunavut-computer-science-education-canada

6. Emerging technologies to fill gaps in broadband service

New technological developments will likely influence the provision of services in underserved areas, including with fibre optics, coaxial cable, copper, fixed and mobile wireless, satellites and hybrid approaches. There is potential for innovation and new approaches using such technologies in the "middle mile" and "last mile" connections providing broadband services. This is one reason for policy makers to prefer technological neutrality in setting objectives.

6.1. Technological trends

In the OECD area, networks that once provided standalone telecommunication or cable television services provide most fixed broadband connections. Over time, these networks have been upgraded and in some cases extended to provide broadband coverage in rural and remote areas. At the outset of the broadband era, countries with wide coverage of cable television networks in rural areas could often reach more people than those with only telecommunication networks, even after both were upgraded to provide broadband. This was because the various varieties of digital subscriber line (xDSL) technologies had a more limited range from telecommunication exchanges than did services over the hybrid fibre-coaxial (HFB) cable networks used for television. Put another way, the further a customer was from a telecommunication exchange the lower speed they could expect to a point where an operator could not offer service via xDSL.

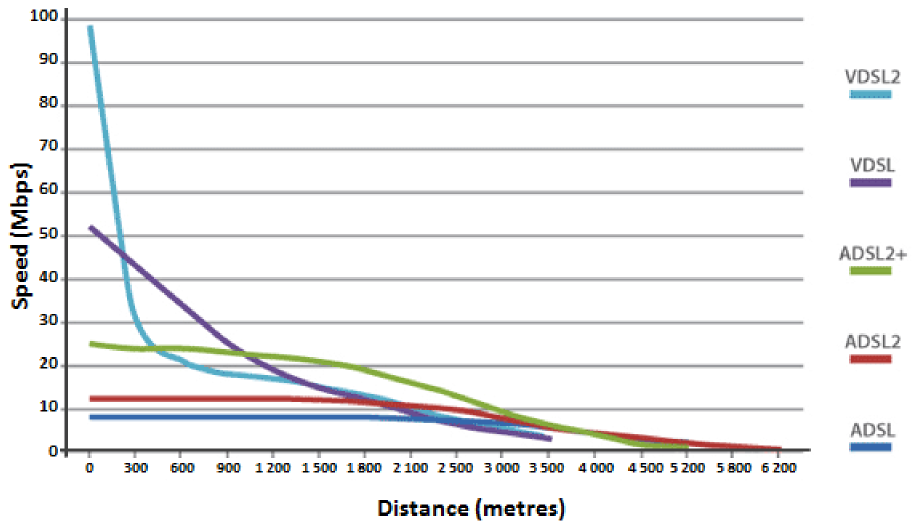
People with a traditional telephone service but outside the coverage of upgraded telecommunication or cable networks continued to use narrow band service for Internet access (i.e. dial-up), until they could access an alternative path, such as mobile, fixed wireless or satellite broadband services. For example, the onset of 3G mobile networks enabled some operators to provide a fixed wireless service in rural areas in some countries, with users mounting an external antenna on their rooftops and tariffs differentiated from mobile services. Meanwhile, some users replaced dial-up service with other types of fixed wireless or satellite broadband. While they represented an increase in service performance in rural areas, some divides increased because of the pace of developments in urban areas.

6.1.1. Fixed broadband provision

For their part, operators have deployed fibre optics deeper into their networks to support the evolving "last mile" technologies that are designed to make copper, wireless and coaxial cable able to deliver higher speeds or, in the case of some operators, taken fibre all the way to the premises of their customers. Where this has occurred in association with expanded service in rural and remote areas it has bridged service divides. On the other hand, some last mile telecommunication technologies can only guarantee faster speeds over an ever-shorter distance from an exchange or network point (i.e. nodes/cabinets or distribution points/mini-nodes) between an exchange and a customer. They rely on fibre being available to that point in a network and this may not be economically attractive or the cost may be prohibitive in some rural and remote areas.

By deploying deeper fibre and other upgrades into their networks, cable operators increase the performance of their coaxial cable last mile connections and this has benefited people in rural areas with such a connection. HFC networks can typically provider service up to 40km.[7] Telecommunication networks have also extended fibre but each recent generation of xDSL needs fibre to reach further to a customer if they aim to match the performance of cable. Indeed, each of the variations of xDSL is surpassed by a preceding one at a certain distance from a network point such as an exchange or cabinet (Figure 5).

Figure 5. xDSL Speeds and Distance



Source: Ofcom

In the case of copper, operators have used a range of xDSL technologies to improve the performance of copper use in their networks but these are most applicable for urban or closely settled rural areas. The five to six kilometre ranges, for the first xDSL services, roughly mirrored the distance used for "plain old telephony", local loops in those areas. In rural areas, however, local loops offering telephony service were generally much longer with equipment in an exchange or cabinet extending service up to 15 kilometres.

At present the highest speeds achieved over copper have been with G.fast by adding spectrum to copper lines up to 300 to 400 metres from a fibre connected node. Beyond that distance, manufacturers such as Nokia say VDSL2 will offer better performance from a fibre-connected node. The bit rate trade-offs between different copper based technologies and distance then decline the further a potential user is from an exchange or node. This means that for rural or remote locations to benefit fibre needs to be taken closer to them though, as noted, this may not always be economically feasible. In the future, one way this may be addressed for some locations may be the use of so called "skinny fibre", as is starting to be used in Australia.

While fixed network operators have different timelines and strategies for taking fibre to the premises, node or a distribution point, all are deploying fibre closer to their customers. The further fibre is deployed in the so called "middle mile", which provides backhaul, the more options are opened up for either fixed technologies (fibre and copper) or wireless technologies to address the "last mile". At present fixed operators are for the most part using fibre to the premises (FTTP) or to some point in a network such as a cabinet (FTTC) or Node (FTTN) from which copper is used for the final connection (e.g. final 300 metres). Finally, there is also an approach known as fibre to a distribution point (FTTdp). FTTdp is similar to Fibre to the Node but delivers fibre to a "distribution point unit" nearer to a customer's premises than a node or cabinet before connecting via the copper network (iiNET, 2016). In the future, fixed wireless may also become an option for that final connection.

6.1.2. Wireless broadband provision

There are two main configurations for using wireless technologies to provide terrestrial broadband access. One is a fixed wireless broadband approach and the other a mobile service. Before considering wireless capabilities both are reliant on the backhaul capacity available to them (i.e. the middle mile connections to towers from a carrier's main network). Elevated facilities (e.g. towers, masts) for fixed wireless or mobile wireless are today predominantly connected by fixed line or to a less extent via microwave connections. In the United States, for example, AT&T connects individual cell sites to its main network with high-speed fibre cables (Ethernet backhaul), and says that within its 22-state wireline footprint more than 99% of their mobile data traffic moves between cell towers at high speeds over backhaul across their wireline network (Weissberger, 2016). In other areas, however, AT&T as a mobile provider needs to rely on local incumbents or other network providers.

Provisioning mobile and fixed wireless technologies for broadband often have different underlying economics and pricing such that they have tended to not be substitutes. Mobile and fixed wireless have also typically used different spectrum frequencies (e.g. paired vs. unpaired) and technologies. However, these lines are blurring. For example, there may be an increasing deployment via unpaired spectrum used for fixed access to homes in rural areas and greater capacity for mobile services in urban areas where there is a higher density of mobile users and most fixed access is via wireline technologies. There may be synergies in these cases. At the same time, there is potential for deployments with combined licenced/unlicenced spectrum.

In France, as in other countries, mobile operators have been replacing copper line connections to mobile cellular towers with fibre optic ones and leveraging their fixed network infrastructure to the greatest extent possible to provide backhaul (ARCEP, 2015). As ARCEP, the regulator in France, has noted:

> *"Technological developments over the past ten years have resulted in fixed and mobile networks becoming less and less specialised, which has enabled their convergence. This process initially only concerned core networks. It is now progressively extending to backhaul and local loop links. Convergent operators consequently seek to exploit, when supplying mobile services, the most part of their fixed infrastructure, in particular backbone networks, as well as backhaul networks." (Weissberger, 2016).*

In the future, wireless technologies may also develop in ways that provide more options for backhaul (e.g. mesh wireless networks, point to point microwave). For 4G deployment in some rural towns in the United Kingdom, mesh networks have been trialed. They mesh wirelessly together before also connecting wirelessly back to a normal macro base station some 6km away and, according to EE, a MNO in that country, could work over distances up to 12-15km (Meyer, 2014). On the other hand, most projections for 5G, whether for fixed wireless or mobile use, involve a relatively limited distance between a user and a fixed line backhaul point of connection. In the United Kingdom, for example, Arqiva a mobile telecommunication and broadcasting tower provider, has announced London trials of 5G fixed wireless in partnership with Samsung to take place in 2017 (Arqiva, 2017). Arqiva provides backhaul not only from towers but also street furniture, such as lamp posts, or on the sides of buildings in urban areas. The 5G trials will operate in the 28GHz band, for which Arqiva has a national license in the United Kingdom and "small cell" locations to provide high speed fixed wireless over short distances. Samsung says their initial tests, of the wireless range, have reach 500 metres in ideal conditions.

In the case of Verizon's 5G fixed wireless trials in the United States the distance between fibre and a customer's premise is up to 300 metres (Engebretson, 2016). For mobile coverage, 5G is also expected to have smaller cells and that these will be mostly connected to fibre backhaul. Under certain conditions microwave may also be used to connect small cells but this will likely be to a macro tower connected to fibre (Engebretson, 2016).

To service more customers at higher speeds mobile networks are making their cells denser, a process expected to continue with 5G. In addition the frequencies used for 5G are expected to be higher making it harder to send them over longer distances. As a rule, higher frequencies "…allow for faster transmission in built up areas, while lower frequencies offer additional coverage distance, but more limited bandwidth." (Team AA, 2016)

This may magnify the traditional challenges operators have always had in securing rights of way or permission to install towers or masts (Lawson, 2016). In 2016, Verizon said it took an average of 24 months to get a location for a small cell up and running because every single one of their small cells has fibre backhaul to a macro cell, requiring them to secure rights of way and permission to undertake installation (DeGrasse, 2016). In April 2017, the FCC initiated a rulemaking that seeks to streamline deployment rules for mobile broadband providers and reduce regulatory barriers to deployment.

6.1.3. Implications for rural and remote areas

In rural and remote areas, in the future, carriers that have fixed infrastructure in place may well provide fixed 5G service using their existing backhaul and cellular towers. As with the trend in xDSL, however, the higher performance may only be over shorter distances than earlier generations. The 5G wireless ranges from existing rural towers, as noted, will likely be less than fixed wireless using 3G or LTE (4G). Some fixed wireless providers such as Rise Broadband in the United States say that this is why LTE (4G) will provide superior coverage in rural areas than 5G simply because more towers or small antennas or repeaters would be needed and this may not be economic (Engebretson, 2017).

Relatively new or developing terrestrial wireless technologies are likely to play an important role in meeting more advanced universal fixed broadband targets (25 – 100 Mbps+, with adequate usage allowances) over the next five to 10 years. This may involve variants of 4G/4.5G (TDD-LTE in particular) and beyond. They may encompass a mix of macro or smaller cells, perhaps approaching line-of-sight communications depending on population density.

One report undertaken for the United States NTCA, a trade association of rural wireline broadband providers, says that fixed and wireless technologies are still essentially complementary rather than substitutes. According to the report:

> *"All broadband providers today – wired and wireless alike – realize that the way to increase broadband capability is to increase the amount of fibre in their network. Landline providers are replacing their copper cable with fibre, cable operators are replacing their coax cable with fibre, and even wireless providers are actually replacing their wireless networks with fibre by placing their towers (or small cells) closer to the customer. …. wireless networks rely heavily on the wireline network, and this reliance will only increase with 5G since only a small portion of the last-mile customer connection (i.e., the "local loop") will use wireless technologies. 5G networks are predominantly wireline deep fibre networks, with only a very small portion of their network using a wireless technology. This small wireless portion of the network determines the ultimate broadband capacity of the network, since it is the network bottleneck." (Vantage Point, 2017)*

That being said, operators use microwave to provide backhaul in some locations and this may well continue to have a role with 5G. The projected characteristics of 5G mean that there either needs to be more towers than previous generations of wireless technologies (3G and 4G), with the additional backhaul this requires, or an alternative approach. Thus, policy frameworks that promote the expansion of telecommunication and cable networks to the maximum extent possible are desirable -- not least because they reduce the area that needs to be addressed by other means but also because they are likely to be a key ingredient in providing those alternatives. At the same time, technologies being introduced such as LTE-M or on the horizon such as Facebooks trials with massive MIMO, while not offering the same capacity as expected with small cell 5G deployments, could expand rural coverage from existing wireless towers.

Authorities considering spectrum available for 5G have to weigh up many factors and future areas of use, including in rural areas. In France, for example, ARCEP conducted a public consultation during the first quarter of 2017. The regulator also released a report to share its understanding of the issues and challenges at hand (ARCEP, 2017b). Some key findings were that some 5G towers would need to be larger to cope with the use of MIMO and, in urban areas, would need to use infrastructures such as bus shelters, lamp posts, public buildings and billboards. At the same time, ARCEP highlighted the likely substantial investment of connecting 5G cells with fibre insofar as it will probably be necessary in the majority of cases to ensure expectations in quality of service. The industry will, ARCEP said, have to develop innovative technological approaches that will minimize the costs of deploying 5G in rural areas.

In the short run

One hybrid approach to addressing the shorter range of advancing xDSL is to combine the technology with LTE networks. So called carrier aggregation is an approach enabling operators, with multiple networks, to pair the services available at a customer's premise. For example, if a rural residence is within 500 metres of a network point enabling VDSL2 the service can be paired with an LTE network. It combines a "DSL modem with a LTE UE modem at the user side along with integration in the core network to allow supplementing the service of one technology where the other falls short. It reduces bottlenecks in performance so for example when xDSL service slows to a crawl it taps the capacity of LTE." (Rayal, 2015)

In countries with relatively high population densities, such as Germany, the latter with 99.8 inhabitants per square kilometre in rural areas, carrier aggregation is a relatively new approach to improving broadband services. In Germany, Deutsche Telekom has been offering a wireline (xDSL) and LTE service since announcing a hybrid router in early 2015 (The Online Reporter, 2015). It is important to note, however, that this technology has the same challenge in terms of distance given it is limited to the range of an xDSL coverage area. In other words it is a technology aimed at improving service for people in xDSL coverage areas but unable to take advantage of the capabilities of technologies, such as VDSL2 because of their distance from a network point. By way of contrast, today's LTE networks can be upgraded to support some types of services over much longer distances than they are used for mobile service though aimed at machine-to-machine (M2M) communication.

LTE-M is one of a number of low power, wide area technologies aimed at providing connectivity to M2M or Internet of Things (IoT) devices. It has the capability to offer lower powered consumption with extended battery life and, importantly for rural areas extend the range of existing LTE mobile networks. As the technology is essentially a software update it allows mobile operators to rapidly roll out coverage. In Korea, for example, SK Telecom upgraded all its towers in three months while AT&T plans to enable all its towers across Mexico and the United States over a 12-month period (AT&T, 2017a). Other carriers deploying LTE-M include, KDDI, KPN, NTT DOCOMO, Orange, Telefonica, Telstra, Telus and Verizon (Telegeography, 2017a).

While the LTE-M technology is not aimed at broadband access, in the traditional way an ISP offers services, it will enable mobile networks to provide M2M or IoT services to businesses and consumers in a wider coverage area and use existing towers and backhaul. While LTE-M coverage, as always with wireless technologies, depends on a variety of factors, some put a top speed at 1 Mbps for downstream and upstream connectivity with a theoretical range up to 100 km in ideal conditions, including better penetration through walls (Lawson, 2017). In short this is not a substitute to what might be expected from a regular fixed or wireless broadband service but opens up tremendous new capabilities for the use of M2M or IoT services in rural and remote areas.

A further promising technology to expand rural broadband coverage is the use of so called Massive MIMO on existing LTE wireless networks. The technology is already incorporated into wireless standards, such as LTE and Wi-Fi.[8] The approach relies on adding more antennas for transmitting and receiving wireless signals increasing performance and reliability. It has several other advantages including not relying on a line of sight as do some fixed wireless technologies and being able to be deployed to fit "…into the profile of an existing passive antenna to make sure carriers aren't inhibited in deployment by power companies, zoning, or other regulations" (Govaerts, 2017). While Massive MIMO will be used in urban and rural areas, the advantage in the latter is being able to target beams over longer distances. For smaller rural towns, the use of the technology can provide higher performance up to 4 kilometres, while Facebook is trialing much longer ranges with targeted beams.[9] Meanwhile, companies such as Blu Wireless and Nokia are making products available using WiGig, which uses the 60GHz band rather than the 2.4 or 5Ghz bands and has higher speeds than 5GHz WiFi, to offer fixed wireless connectivity up to 300 metres from backhaul networks (fibre, wireless satellite). This technology can be used to create a mesh network for small communities if backhaul technologies are available to that location[10].

Satellites are a key technology for providing rural and remote broadband access. Today, satellites provide service to more than 2.3 million subscriptions or about 0.6% of all broadband subscriptions in the OECD area. While small in overall terms they make up a much larger proportion of subscriptions for people living in rural and remote areas. These satellite broadband connections enable critical applications such as eHealth or eLearning in these areas as well as in providing critical services in periods of disruption to terrestrial services across all geographical locations.

A 2017 OECD report on broadband via satellite examines the evolving role of satellite in delivering broadband to rural and remote areas in light of recent innovations in the industry (OECD, 2017c). These include the emergence of new constellations in low-earth orbit (LEO) and medium- earth orbit (MEO), the development of new launch technologies, and the innovation of high-throughput satellites (HTS) and their use of spot beams for more efficient reuse of frequency. In recent years, numerous stakeholders, including governments, have launched High Throughput Satellites (HTS), using multiple spot beams to cover the service area rather than a small number of wide beams. HTS allow higher power transmission that is more efficient and that permits a higher rate of data transfer over a large surface area. These innovations lead to a discussion of the viability of satellite to meet the unmet demands of rural connectivity due to the improvements in performance over previous satellite constellations and the potential reductions in costs to the consumer.

The report also examines the cost of obtaining broadband via satellite in the market across OECD and partner countries, and finds marked differences between regions in terms of affordability of market offers. Finally, the report concludes by examining governments' approach to satellite policy. A number of countries have acknowledged the role that satellites could play to connect rural and remote areas and many have incorporated subsidies for satellite service in their national broadband plans. Many have taken strides to reduce the regulatory burden on satellite broadband providers and to adopt a technology-neutral approach to policy (Box 11).

Box 11. The evolving role of satellite networks in rural and remote broadband access

Usage-based pricing over limited capacity reduces consumers' use of streaming video applications, while latency may limit the use of highly interactive real-time applications, as compared to terrestrial broadband networks. Innovations designed to address these limitations of network capacity and network latency are being incorporated into new satellite systems and are described in the report. First, because the height of orbit for the satellite above the Earth's surface has a significant impact on system cost and types of services delivered a number of new Low-Earth Orbit (LEO) and Medium-Earth Orbit (MEO) systems have been proposed or deployed to provide satellite broadband services. The resulting power savings and latency reductions can significantly reduce satellite equipment costs on the user's premises, and allow for a much higher quality of experience associated with real-time services such as multi-player gaming services, Voice over Internet Protocol (VoIP) calls and video chat. Second, while LEO and MEO systems require more satellites to cover a large area given their lower altitude, new technologies such as reusable launch vehicles and electric propulsion systems are leading to lower cost satellite launch systems. Third, geostationary (GEO) high-throughput satellite (HTS) systems are being launched regularly which use multiple spot beams to significantly increase the throughput of the satellite system. The 2017 OECD report describes several new HTS systems that have been recently deployed with substantial capacity to deliver broadband services.

Source: OCDE (2017c), "The evolving role of satellite networks in rural and remote broadband access", *OECD Digital Economy Papers*, No. 264, Broadband Satellite Access", http://dx.doi.org/10.1787/7610090d-en.

6.2. Technologies on the horizon

While the main trends in fixed and wireless telecommunication networks, serving the majority of populations in OECD countries in urban and more closely settled rural areas, is to provide higher capacity services over shorter distances, there are technologies on the horizon that promise to address the challenges of distance. These include, among others, AT&T's Project AirGig, Google's Project Loon and those grouped under Facebook's Telecom Infra Project. There follows a brief description of each of these technologies, though being experimental in nature it is not possible to provide information on costs or quality. Moreover, commercial incentives for any deployment at scale need to be borne in mind.

6.2.1. AT&T's Project AirGig

After the turn of the century, a number of energy utilities trialed Internet over power lines. For a number of reasons, the technology was never commercialized with any scale and to the extent these players remained in the communication market they generally ran Fibre cables in parallel to their power lines. In 2016, however, AT&T announced its laboratories had developed a technological approach that could enable wireless signals to be guided over energy utility infrastructure without the need to lay Fibre in parallel to that infrastructure or to use the powerlines to transmit signals.

AT&T's *Project AirGig* is developing a multiple ways to send a modulated radio signal around or near medium-voltage power lines. AT&T says there is no direct electrical connection to the power line required with a potential for multi-gigabit speeds. Instead, low-cost plastic antennas and devices are located along the power line to regenerate millimetre wave (mmWave) signals (AT&T, 2016). This capability can be used for 4G LTE and 5G multi-gigabit mobile and fixed deployments.

In terms of rural and even for some remote locations, the potential of such a technology is to utilise the infrastructure already in place. For example, energy or telecommunication providers could use existing poles instead of having to bury new cables or build new towers reducing deployment costs. In January 2017, AT&T said the first two trials with utility companies would commence in the second half of that year (AT&T, 2017b).

6.2.2. Google Project Loon

Project Loon proposes a network of balloons traveling in the stratosphere, designed to extend Internet connectivity to people in rural and remote areas. Trials have been undertaken in countries such as New Zealand, Indonesia, Peru and Sri Lanka. More recently, Project Loon has partnered with AT&T to restore mobile service to rural parts of Puerto Rico whose infrastructure was destroyed by hurricane Maria (Lee, 2017). Originally, the Google researchers thought there would have to be a series of many balloons floating over vast distances to provide coverage. More recently they have developed artificial intelligence to predict currents in such a way that a balloon can be kept over a countries airspace for longer periods (Metz, 2016). The balloons use LTE technology with the aim of providing service to both fixed locations and to extend the mobile coverage of cellular networks. There have been, however, challenges in some countries related to the availability of spectrum such as in Sri Lanka[11] or opposition from incumbent players such as in Indonesia[12].

6.2.3. Facebook Telecom Infra Project

Facebook's Connectivity Lab is exploring the use of different access technologies and network architectures – such as unmanned aerial systems, satellites, lasers and terrestrial wireless systems – with the aim of extending broadband access to rural and remote areas. The company's *Telecom Infra Project* aims to "open source" new approaches to building and deploying telecommunication network infrastructure. Two of several projects are aimed at providing Internet access in rural and remote areas. Perhaps the most high profile initiative is Aquila, which uses solar-powered drones flying for long periods at high altitude (Turner, 2017). Meanwhile, the fixed wireless project named ARIES incorporates multiple antennas into a large mounted array to beam connectivity over longer distances than current mobile networks.

ARIES, or Antenna Radio Integration for Efficiency in Spectrum, focuses on covering rural areas (Lardinois, 2016). It advances the use of 4G networks with multiple input, multiple output (MIMO) —using multiple transmitters and receivers to transmit more data (i.e. Massive MIMO). By 2016, the trial platform used 96 antennas supplying up to 24 streams simultaneously with 10x spectral and energy efficiency gains over traditional 4G systems (Choubey and Yazdan, 2016). The aim is to use existing wireless towers but extend their range in rural areas. Facebook says, "…providing backhaul to rural environments can be prohibitively expensive, but the hope with systems such as these is that costly rural infrastructure can be avoided while still providing high-speed connectivity" (Choubey and Yazdan, 2016).

6.2.4. Microsoft's Rural Airband Initiative

Microsoft has been experimenting with TV White Spaces since 2009 and has implemented pilot projects in countries such as Colombia, Namibia, the Philippines, Tanzania, the United Kingdom and the United States.[13] In the United States, the FCC adopted rules enabling the use of TV white spaces in 2010, but it has taken time to develop the hardware and software technology to make it a practical business model. In 2017, Microsoft announced a plan to invest their resources and stimulate further private sector investment in combination with efficient public-sector support. They say they will invest in broadband connectivity, digital skills training in the newly connected communities and stimulate investment by others through technology licensing.

6.3. Technologies bridging connectivity gaps in OECD countries

OECD countries have a range of population densities from those with the fewest inhabitants per square kilometre, such as Australia and Canada, to those with more closely settled rural areas such as Denmark and Ireland. Accordingly, different technologies are used to fill connectivity gaps in underserved areas. The technologies being used include everything from fibre to the premises and fibre to the node as well as fixed and mobile wireless and satellite services. They include private operators, public private partnerships, municipal networks and commercial trials of new approaches, such as using Television White Spaces. Moreover some government initiatives are aimed at improving "middle mile" capabilities (i.e. regional backbone networks) to encourage private investment in local access networks (i.e. backhaul and last mile connections via fixed or wireless solutions), while others also offer financial support for the last mile such as in Sweden. There follows here some examples for the use of different technologies in selected OECD countries.

6.3.1. Australia

Australia has the lowest population density in the OECD area at 3.1 inhabitants per square kilometres compared to Iceland 3.3 and Canada 3.6. In 2013, in predominantly urban areas, Australia's population was 297 inhabitants per square kilometres compared to nine in intermediate areas and 0.6 in rural areas. This compares to 347.4, 18.8 and 1.1 for Canada in the same year.

The Australian National Broadband Network (NBN) strategy is to use the most appropriate technology for each particular location but, in broad terms, this involves providing fixed line access to around 92% of Australian homes and business, fixed wireless to 5% and 3% via satellite. Elements of the NBN have been considered in previous OECD documents, including the use of satellites to reach those areas not able to be cost effectively covered by fixed and fixed wireless facilities (OECD, 2017c). The NBN satellites provide the last 3% of Australian premises with services to ensure universal coverage to meet the policy objective of 100% coverage. This is being achieved through a 'multi-technology mix' approach to build the wholesale-only network in the most cost effective way using the technology best matched to each area of Australia.

In Australia, all premises will have access to wholesale download data rates of at least 25 MBps, with at least 50 Mbps to 90% of fixed line premises through the NBN. Wholesale plans are available over the fixed network at up to 100 Mbps, with wholesale plans on the fixed wireless network at up to 50 Mbps and up to 25 Mbps over the satellite network. Upgrade paths are being developed for each network. Unlimited retail data offers or higher data caps are also available over fixed networks at lower prices compared to fixed wireless. In turn, some fixed wireless retail offers also have unlimited data offers or higher caps than satellite offers and NBN has announced plans to offer 100 Mbps service over fixed wireless. In recent trials, NBN fixed wireless reached 1Gbps, a theoretical maximum for the network, which involved installing extra radio equipment at a nearby tower relying on fibre backhaul. NBN has also tested 10Gbps for fixed networks. There are more than 100 retail service providers offering fixed network and fixed wireless services over the NBN network, with around ten retailers offering satellite services.

NBN was originally planned to offer fibre-to-the-premises (FTTP) to meet its original target for 93% of the population. This was subsequently changed in 2014 to use a mix of different technologies – the “multi-technology mix” – for the final connections. While fibre continues to be deployed deeper into Australian networks and FTTP is still employed, how close fibre is taken to a customer's premises depends on the characteristics of that location. For many places, the current choice is fibre-to-the-node (FTTN). In this case, fibre replaces copper from a traditional telephone exchange to existing nodes and power is installed in that node (Simpson, 2016). The final connection, said for NBN to be a maximum of 400 metres in practice (and 384 residences), is provided by the existing copper connections, most of which were originally installed for telephony.

The decision to adopt a multi-technology model for the deployment of the NBN network is aimed at enabling a more rapid roll out of services as well as meeting existing objectives to provide connections (i.e. minimum speeds) in a cost effective way. One challenge arising from this approach was the length of some suburban streets relative to the existing node locations, given Australian cities are typified by standalone residences. This has led NBN to consider the use of a technology, dubbed skinny fibre, to deploy fibre closer to the premises. This type of network configuration has been called fibre to the distribution point (FTTdp) or fibre to the curb (FTTC) and its sits between FTTN and FTTP. As one commentator noted:

> *“Fibre to the distribution point brings the fibre almost to users' doorsteps, with the distribution point in the name referring to the individual junction box in the telecommunications pit in the street outside each property. With fibre running to within metres of the property, and therefore metres of the first connection point within a premises, FTTdp brings fibre much closer than FTTN, and almost as close as FTTP. This means near-gigabit network speeds can be achieved over the very short run of copper between premises and pit, and an upgrade to full fibre to the premises is easily possible in the future.” (Simpson, 2016)*

Skinny fibre has a number of potential advantages for network deployment and expanding broadband access. As indicated by its name the fibre cable is narrower than the fibre used to connect nodes to exchanges and can potentially therefore be deployed at a more economical cost than its counterpart (e.g. being pulled through existing ducts used for copper lines). While it may not have the capacity of a larger cable it would represent greater performance than copper and, importantly, allow higher speed service at longer distances from a node. NBN conducted trials of skinny fibre in 2016 and has said it will use the technology in new housing estates from 2017, as well as for some locations where it assesses FTTdp to be a better option than FTTN (Crozier, 2016).

The Australian fixed wireless market is also undergoing changes that have implications for the boundaries between technology connection categories in rural and remote areas. For smaller towns and the rural areas around them, NBN uses LTE (4G) as a fixed wireless service (NBN, 2015). It uses this cellular technology to transmit signals to and from a small antenna on the outside of a premise, which is pointed directly towards the NBN tower. NBN notes that fixed wireless, unlike a mobile service where speeds can be affected by the number of users moving into and out of an area, offers a more steady service. A line of site connection can be up to 14 kilometres. To provide this service NBN holds 2.3GHz and 3.4GHz spectrum rights in regional areas.

The use of fixed wireless technologies by other providers is also active in Australia. Just as FTTH startups have emerged to offer 1 Gbps in some urban areas, they say fills a gap in NBN retailers’ current offers, a number of ISPs use unlicensed spectrum to offer services to areas not yet covered by NBN's fixed or fixed wireless technologies in rural areas. ISPs such as Red WiFi or Wi-Sky place their transmitters on existing elevated facilities such as wheat silos or water tanks, which exist in many rural Australian towns or around farms.[14] From this vantage point they can offer services up to a 30 kilometre radius with line of site and the ability to add coverage with further towers. Such ISPs typically ask a local community to sign up 50 potential subscribers in advance and can offer service to up to 1 000 subscribers in the same geographical area.

The advertised prices are typically more expensive than NBN's fixed wireless and with lower speeds (i.e. 5 Mbps to 25 Mbps) but at lower prices than for NBN's satellite services as well as larger data caps or unlimited offers. The upload speeds are also higher than satellites with some offers being symmetrical. Beyond existing towers and topography enabling line of site the main challenges to such fixed wireless providers are securing backhaul, including at competitively based prices, and the ongoing use of spectrum. Wi-Sky puts the cost of a point of presence to connect to fibre backhaul at between USD 23 000 to USD 38 000 (Hunt, 2016). The other concern such ISPs have raised is whether the spectrum they use will continue to be available to them (Vujkovic, 2017). On the other hand, at least one MNO in Australia (Vodafone) has offered to make a commercial arrangement with such ISPs to share its towers and spectrum, sometimes underutilized in these locations, to improve services in rural areas and as a commercial opportunity (Baker, 2017). For its part, Vodafone has also begun to use NBN's towers to expand its mobile LTE (4G) service in rural areas where it does not have its own facilities (Bendel, 2017). In February 2017, it launched service by co-locating its equipment on an NBN tower and using NBN's fibre backhaul to deliver traffic to their point of presence. By offering tower co-location and backhaul NBN has opened the opportunity for MNOs to expand coverage as well as other providers to offer Wi-Fi or small cell services.

6.3.2. Canada

Like Australia, Canada has among the lowest population densities in the OECD area and many of the same challenges for extending broadband access in rural and remote areas. One advantage Canada had over Australia, at the onset of the broadband era, was very widespread cable television networks. By upgrading these networks Canadian broadband coverage had a longer reach than that country's traditional telecommunication networks or in those countries like Australia without cable coverage in rural areas.

In June 2016, cable broadband networks still represent a larger share of total connections in Canada than for all other fixed broadband technologies (xDSL, FTTH, Fixed Wireless, Satellite and other) technologies. This is something that Canada has in common with three other countries (Belgium, Chile, and United States). In terms of cable connections per 100 inhabitants, Canada leads at 19.2 followed closely by Belgium and the United States both with 19.1. Like Canada both Belgium and the United States had very high cable television network coverage at the outset of the broadband era including in some rural areas. Overall the reach of these cable networks allowed these countries to be among the early leaders in terms of broadband penetration, though for Canada and the United States the lower population densities made it more challenging to roll out competitive choice, especially beyond the distance of telecommunication networks. That is why today a country like Belgium, with universal coverage of fixed telecommunication and cable networks little uses fixed wireless, while Canada is one of the larger user of fixed wireless broadband connections in the OECD area.

6.3.3. Denmark

Denmark has a population density of 131 inhabitants per square kilometre and, among the highest in the OECD area, some 76 inhabitants per square kilometre in rural areas. The country also has among the highest fixed broadband penetration in the OECD area second only to Switzerland. At the same time, some parts of the country have recorded among the highest download and upload speeds in the OECD for consumer services and these are not in the most populated locations.

In 2016, according to "Speedtest.net" the top 10% of download results in the Danish town of Frederikssund (population 15 865 in 2015) reached 880.66 Mbps (Speedtest, 2016). This was recorded by Hiper, an ISP offering standalone Internet access, offering services over fibre (1Gbps symmetrical for USD 43 per month), cable (100 Mbps / 25 Mbps at USD 28 per month) and copper (10 Mbps to 100 Mbps at USD 28 per month).[15]

Hiper's standalone Internet access service, the company says, is aimed at younger Danes that do not wish to take bundles and prefer to use "over-the-top" services (Tees, 2015). One of its rivals, Gigabit, offers a 5 Gbps symmetrical service for USD 71 per month, aimed at IT specialists, gamers and traders as well as similar offers to Hiper.[16]

As start-up ISPs, having launched in 2013 (Gigabit) and 2015 (Hiper), the companies are among several that use the underlying networks of TDC, the incumbent telecommunication and cable company to offer services. The gigabit services are available where TDC offers fibre, including the network it purchased from DONG, an energy company in North Zealand, a region in Denmark. Other large infrastructure networks, which provide wholesale services to ISPs, include Stofa, the second largest cable network and Waoo, the brand used for joint marketing by several energy companies.

The mix of infrastructure competition and regulated access has led to an extremely competitive market in Denmark. At the gigabit end of the market, companies such as gigabit use TDC's "raw fibre" and Gigabit the company provides the active equipment at both ends. This is opposed to using wholesale products defined by TDC and priced in a different manner up to 100 Mbps. At a time when many offers in Denmark were pitched at xDSL speeds (e.g. from 10 Mbps in 2013), even when over FTTH, Gigabit decided to launch services at 100 Mbps and then 1 Gbps. As the company said:

> *"It was said that there was no demand for fast speeds. A competitor marketed for example a 500 Mbps fibre but had few customers. It was just that it cost USD 143 per month! We want the price to be set so that people can afford to buy the products. Our first offer of 1 000 Mbps was in line with what others offered for 50 Mbps and our 100 Mbps was cheaper than 10 Mbps in others. Suddenly there was demand and now we see that others are scrambling to roll out higher speeds." (Gigabit, 2015)*

That being said, companies such as Gigabit or Hiper also use TDCs wholesale products over cable and copper where the company does not provide fibre. They advertise the maximum speed of 100 Mbps in these cases but point out it depends on the distance from the user to the cabinet in the case of xDSL.

For its part, TDC had passed 67% of the Danish population with fixed line broadband services capable of offering 100Mbps, with plans to reach 70% by 2018 (Moulding, 2017). Even though it was Denmark's incumbent telecommunication operator, the company expanded into cable television in the mid-1990s. The initial intent was to offer pay-TV and it meant that TDC was one of a few companies in OECD countries that had coaxial cable for television and traditional telecommunication lines using copper running in to the same premises. In addition, acquisitions mean the company has FTTH in some areas as well as covering 99.5% of Denmark’s population with its mobile LTE network. Today, this makes the companies choices for servicing its customers with different technologies in different geographical regions a notable case.

Faced with competition by ISPs offering 1 Gbps services, TDC has launched cable broadband services with advertised speeds of 1 Gbps and says the technology can be upgraded to provide 10 Gbps in the near future (Burkitt-Gray, 2016; Telegeography, 2017b). The technology used is DOCSIS 3.1, with TDC planning to upgrade the 1.4 million households passed by its cable network in Denmark. In areas not passed by cable, such as in some rural areas, TDC plans to continue to use VDSL2 but not G.fast (Burkitt-Gray, 2016; Nokia, 2016). This is due to the greater distance a customer can be served with VDSL2 (500 metres) than G.fast (300 metres). In addition, the company plans to use “four carrier aggregation” across its networks to improve rural coverage. Finally, an interesting aspect of TDC’s approach is that for the managed services provided by the manufacturers it uses, such as Huawei, its contracts specify that performance measures are from an end-user perspective and not in the network (Burkitt-Gray, 2016). While such an approach is not specific to rural areas it may assist operators assessing broadband performance in these areas to a greater extent than in the past.

6.3.4. Ireland

Ireland has a population density of 67.3 inhabitants per square kilometre and some 49.9 per square kilometre in rural areas. Much of the population lives in urban areas with those places having a very high population density (1 387 per square kilometre in predominantly urban areas) and the Greater Dublin Area accounts for 39% of the country’s population. That being said, the ratio between the national average and rural average is one of the closest in the OECD area.

As the country did not have widespread cable television coverage, at the outset of the broadband era, the traditional telecommunication network was the mainstay for expanding high-speed access in rural areas. Today, Eir (Eircom) as the incumbent telecommunication provider has the largest share of the broadband market. It has, however, been joined by a number of infrastructure based competitors, in the most closely settled areas, such as Virgin Media, a cable broadband company; Vodafone a fixed and mobile network provider that has partnered with ESB (a large energy provider and broadband network owner) to form Siro (a joint venture to roll out fibre); Magnet, a cable broadband company; Smart Telecom, a fibre network; and Enet, predominantly a backbone open wholesale network. In addition, Imagine is Ireland’s largest fixed wireless provider offering services in many rural areas.

In 2016, three bidders were shortlisted for Ireland’s national broadband project – Eir, Enet and Siro – with contracts to be awarded in 2017. As in other countries the boundaries of areas that need subsidies or can be delivered by the market, as well as the choice of technologies to meet objectives, are all issues at the forefront of discussion in Ireland. The winning contractor, or contractors, will have to be able to deliver a guaranteed minimum of 30 Mbps download speeds and 6 Mbps upload speeds. They will also need to use a technology viewed as being future proof and offer wholesale access to existing players in areas covered by subsidies for this development. While the government has not specified the technology to be used, policy makers regularly mention FTTP networks and the three shortlisted bidders are all building fibre networks in rural centres or locations. If this technology is chosen by the successful bidders this would make one of the largest FTTP networks to service rural areas in the OECD area.

The three potential bidders are already in somewhat of a race to roll out fibre networks. Near the close of 2016, Siro reported it had passed 36 500 premises and Eir a similar amount (Kennedy, 2016b). Siro said at that date it was passing 10 000 premises per month with an aim of reaching 200 000 in total by the close of 2017 (Kennedy, 2016b). Eir plans to connect 322 000 homes and businesses, mostly in rural areas, to FTTP by the same date. Some critics have said that the FTTP roll out by Eir is undermining the NBP because it is increasing the costs for competitors bidding for contracts, something Eir denies (O'Dwyer, 2017). The claim is that Eir is installing services in the lowest cost rural areas and leaving the higher cost areas to competitors.

Meanwhile, criticisms have also been made by Imagine, one of the parties eliminated from the final list of qualified operators to tender for the NBP (Burke-Kennedy, 2017). Imagine supplies fixed wireless to rural areas in Ireland and says its network added coverage for over 500 000 premises in the second half of 2016. In early 2017, it had 50 live sites and had about 11 500 customers, with approximately 2,500 joining each month (O'Dwyer, 2017). Imagine aims to grow this to 400 sites and 160 000 customers within three years. The fixed wireless LTE network offers 20 GB per day to its customers for a monthly price of USD 64 advertising speeds up to 70 Mbps (Ofcom, 2016b).[17] The number of customers are limited to 400 per each phase with a range of up to 13 kilometres (Galway Advertiser, 2016).

6.3.5. United Kingdom

In 2014, the United Kingdom had a population density of 266.2 inhabitants per square kilometre and a rural population density of 21.9. Since the launch of the BDUK competitive tender process, several start-up companies have started providing broadband connectivity in rural areas in the United Kingdom. A further advantage to that programme is that it enabled different companies to innovate and try new approaches to rolling out infrastructure. By way of example, in 2016 Gigaclear was trialing 5 Gbps FTTP services and working in partnership with Affinity Water, the largest water-only supplier in the United Kingdom, to pilot the use of the utility company's out of use pipes in a rural area. The project aims to establish the overall feasibility of the concept and its scalability, as well as testing the technical aspects of how to install the fibre cables through the pipes (Gigaclear, 2016).

A further example of trialing new technologies to deliver connectivity solutions is the use of "White Spaces", the gaps in radio spectrum that exist between digital terrestrial television channels. In 2013, Ofcom took the decision to proceed in making white spaces available to the unused parts of the radio spectrum in the 470 to 790 MHz frequency band and implemented a license exemption in 2016 using dynamic spectrum access databases to identify unutilized spectrum at particular geographic locations (Ofcom, 2013). Currently, four database operators are qualified to provide such services in the United Kingdom, from which white space devices may obtain operational parametres (Ofcom, 2016c). One of the authorised database operators is Nominet, better known for administering the United Kingdom's country code domain name (.uk). Together with its partners, Nominet is undertaking a trial on the Isle of Arran (Box 12).

The Scottish Island has around 4 600 inhabitants spread over 432 square kilometres. Some areas are covered by BT's network but some parts of the island have few inhabitants. To provide services in these areas, the trial established an ISP called Arran Broadband. By June 2016, Arran Broadband connected 25 remote premises with wireless broadband. The advertised offers are USD 31 for 25 Mbps (2 Mbps upstream) and USD 43 for 35 Mbps (3

Mbps upstream). [18] There is a connection fee of USD 250, which the government funds under the "Better Broadband voucher" scheme for qualified recipients. Scotland has a goal of reaching 95% of its population with speeds of 30 Mbps or above by the end of 2017 and 100% by 2021 (Davidson, 2017).

Box 12. Nominet experience with Television While Spaces

One of the main advantages of using TVWS technology to deliver an Internet signal is the ability to cover a large area without line of sight connections, but these signals are also better at penetrating obstacles than 5GHz microwaves and more resilient in poor weather conditions, hence why it is so effective somewhere remote like Arran, an island that has its fair share of inclement weather. Arran Broadband, using TVWS technology, offers a usable range of 25km, or 4km at rooftop height.

Wider deployment potential: the identified benefits position the use of TVWS to deliver connections as a potential solution to the connectivity issues of any remote communities across the United Kingdom, especially those where challenging topography and isolation dissuade more traditional broadband providers. When all other means of enabling Internet are impossible or inaccessible, TVWS can enable connectivity.

Nominet says TVWS's technology relative affordability also makes it a good option for developing countries, where many people do not have access to the Internet but would greatly benefit professionally and personally from being online. For example, Nominet are working with Microsoft to use TVWS in Africa to help enable connectivity as part of their Affordable Access initiative.TVWS technology also dynamically identifies and utilises spectrum that is standing vacant, providing a potential solution to the challenges of increased demand, for services such as the Internet of Things (IoT), on a finite resource.

Nominet sees the main barriers standing in the way of wider deployment of TVWS as being backhaul locations, a government permitting dynamic TVWS access and any restrictions from a country's government on the power level of the TVWS transmitter on a base station. This technology also relies on the availability of devices and access to a registered database for identifying available spectrum.

Source : Paula Feery, Nominet, contributed this box for this document.

6.3.6. United States

In the State of Maine, the wide availability of backhaul provided by the dark-fibre Maine Fibre Company (MFC), introduced earlier in this document, has encouraged commercial providers to include underserved areas in their plans, using different types of technology. One example is RedZone, a fixed wireless network, which aims to cover 90% of the population of Maine including some of the more remote areas of the State (MFC, 2016). The company reports their wireless network has been tested to maximum speeds of 450 Mbps, operating within a frequency range of 5.1 – 5.8 GHz. The approach uses a proprietary method for aggregating licensed 4G LTE spectrum and unlicensed 5.8 GHz spectrum on a single tower, with the aim of improving broadband speeds and performance.

The company uses FCC licensed 2.5 GHz (Educational Broadband Service) and unlicensed 5 GHz spectrum bands, under an agreement with the University of Maine to access its spectrum and expand fixed wireless Internet service statewide. RedZone says they have achieved throughput of 450 Mbps with the service. They are marketing the service as providing up to 50 Mbps down and 10 Mbps up for USD 79 per month, with 100 Mbps available at some locations at USD 99 per month. The fixed 4G LTE service is offered at speeds from 10 Mbps to 20 Mbps starting from USD 39 per month. All plans have no data cap, no contract and no obligation to take additional services such as cable television.

Since June of 2015, Redzone Wireless has expanded its fixed wireless broadband network to over 60 Maine communities, covering 225 000 Maine households and more than 40 000 businesses across the state. The company believes that makes it the largest multi-spectrum fixed wireless deployment of its kind in the United States (Redzone, 2017). Using fixed wireless and having backhaul readily available has enable rapid service roll out with the initial stage covering 25% of the population of Maine in 2015. By early 2017, some 50 000 households were supported by the faster services available using licensed and unlicensed spectrum. Challenges have included the fact that Maine's dense evergreens and rocky mountainous terrain create adverse conditions for the deployment of the wireless infrastructure best placed to service areas with low population densities. Telrad, the company providing the equipment to RedZone, notes that rural areas with dense foliage and hilly terrain can heavily attenuate wireless signals (Erann, 2016). To address this factor they use several advanced techniques, such as 4x4 radio with advanced MIMO (multiple-input and multiple-output).

7. Conclusion

Access to broadband services in rural and remote areas is essential for individuals and communities to take advantage of the benefits of the digital economy. While there are many elements that create "digital divides" this report has mainly concentrated on addressing the fundamental challenges created by distance from core networks. Tremendous progress has been made to improve broadband services in recent decades, including in areas with some of the lowest population densities in the OECD area, but by its nature the level of broadband service necessary to participate in the digital economy continues to evolve apace.

All OECD governments have initiatives to address the challenge of providing improved access to broadband services in rural and remote areas and, therefore, to foster the opportunities it creates for economic and social development. Nonetheless, the available evidence indicates that, despite advances in recent years, gaps between urban and rural areas remain considerable. For the most part, despite developments in technology, increasing demand and a range of other factors, the chief obstacle to providing service often remains one of higher cost in some geographical areas compared to others.

There are, of course, other related challenges especially for policy makers as they seek to address digital divides. These include ensuring the availability of relevant information to advise on the best approaches and technological options, particularly where public funding is provided or decisions need to be taken over scarce resources such as spectrum allocation, as well as co-ordination between different parts of government. Accordingly, in addition to discussing existing and emerging technologies for closing geographical digital divides, this report highlights a set of good practices based on OECD countries' experiences to promote the deployment of broadband infrastructure in rural and remote areas. Progress in this respect can bring about stronger and more inclusive growth from the digital revolution irrespective of geographical location. As such it should be considered a crucial component in building a coherent and comprehensive policy approach for going digital.

Notes

1. For more information about the Mapping of Broadband Services in Europe project see: https://www.broadbandmapping.eu/.

2. For the coverage of broadband service in OECD countries mapped by access technologies and speed tier see: www.oecd.org/internet/broadband/oecdbroadbandportal.htm#map.

3. The interactive platform "Mapping Broadband Health in America" developed by the Federal Communications Commission can be accessed here: www.fcc.gov/health/maps

4. For more information about the Maine Fibre Company's operations see: www.mainefibreco.com

5. For more details about the Broadband for Rural North (B4RN) see: https://b4rn.org.uk

6. Further information about Reggefibre in the Netherlands can be found at: https://www.eindelijkglasvezel.nl/corporate/?sc_lang=en&preflang=en

7. The most common system used by cable TV companies to offer Internet access is called DOCSIS (Data Over Cable Service Interface Specification) with versions from 1.0 to 3.1 Full Duplex (Torres, 2013).

8. For more information about Massive (Very Large) MIMO Systems see: https://massivemimo.eu

9. See for example solution offered by Mimosa Networks to delivers 5G fixed wireless to rural, suburban and urban areas: http://mimosa.co/news/126/78/Mimosa-Networks-Delivers-5G-Fixed-Wireless-Solution-to-Displace-Fibre-to-the-Home.html and http://ap.help.mimosa.co/srs-tuning-agc.

10. More details about the technological solutions by Nokia and Bluwireless can be found at: www.nokia.com/en_int/news/releases/2017/10/16/nokia-demonstrates-first-pon-solution-with-integrated-wireless-drop-alternative and www.bluwirelesstechnology.com.

11. For further details on the spectrum challenges in Indonesia see: www.en.netralnews.com/news/business/read/908/telkom.ready.to.face.google.balloons.in.indonesia.

12. For further details on challenges faced by Google Loon's project in Sri Lanka see: www.economynext.com/Google_may_abandon_Sri_Lanka_balloon_trials_over_legal_hitch-3-7353.html.

13. More information about Microsoft's initiatives on rural broadband can be found at: https://blogs.microsoft.com/on-the-issues/2017/07/10/rural-broadband-strategy-connecting-rural-america-new-opportunities

14. See Red WiFi's and Wi-Sky's websites for more information on their networks and services: www.redwifi.com.au and www.wi-sky.com.au.

15. The prices indicated are those as offered by Hiper on 14 March 2017. For more information see: www.hiper.dk

[16] The prices indicated are those as offered by Gigabit on 14 March 2017. For more information see: https://gigabit.dk.

[17] For more information on Imagine Broadband services in Ireland see: www.imagine.ie/broadband/

[18] For more information about Arran Broadband see: www.arranbroadband.co.uk

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