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BRIDGING CONNECTIVITY DIVIDES

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BETTER POLICIES FOR BETTER LIVES

Foreword

This report on "Bridging Connectivity Divides" was prepared by the Working Party on Communication Infrastructure and Services Policy (WPCISP). It explores policies and regulations in OECD countries that have proven successful to work towards closing connectivity divides. This report was approved and declassified by the Committee on Digital Economy Policy on 4 December 2020, and was prepared for publication by the OECD Secretariat. The report was drafted by Alexia Gonzalez Fanfalone, Maximilian Reisch, Miki Naito, Jaeho Lee and Verena Weber, all members of the CISP unit within the OECD. It was prepared under the supervision of Verena Weber.

This publication is a contribution to the OECD Going Digital project (Phase II), which aims to provide policymakers with the tools they need to help their economies and societies prosper in an increasingly digital and data-driven world. For more information, visit www.oecd.org/going-digital. #GoingDigital

Note to Delegations:

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Bridging Connectivity Divides

Introduction

How do we achieve an inclusive digital transformation? More specifically, how can policies and regulatory measures help bridge connectivity divides? Reliable and high-quality connectivity is fundamental for the digital transformation as it facilitates interactions between people, organisations and machines. On many dimensions, great progress has been made to increase the number of connected people and start closing divides. However, one of the most challenging questions is how to ensure that everyone benefits from digital transformation and nobody is left behind, regardless of their gender, their income level, or where they live. In short, how to ensure connectivity for all.

To close the connectivity divide, people not only need to have access to broadband services, but they need to be connected *well,* which means access the high-quality communication networks and services at affordable prices. Only then can everyone fully benefit from their use and the digital transformation.

As countries weather the COVID-19 health emergency, connectivity, more than ever, is essential to ensure that economic activities can continue in a remote manner. However, disparities in access to communication services, among and within countries, may accentuate the consequences of the health emergency. Therefore, policies aiming to reduce connectivity divides are of paramount importance as significant challenges remain. First, that of making improved broadband readily accessible in areas with low population densities and for disadvantaged groups, and second, continuing to upgrade these networks so users can take full advantage of the opportunities they offer (OECD, 2018[1]).

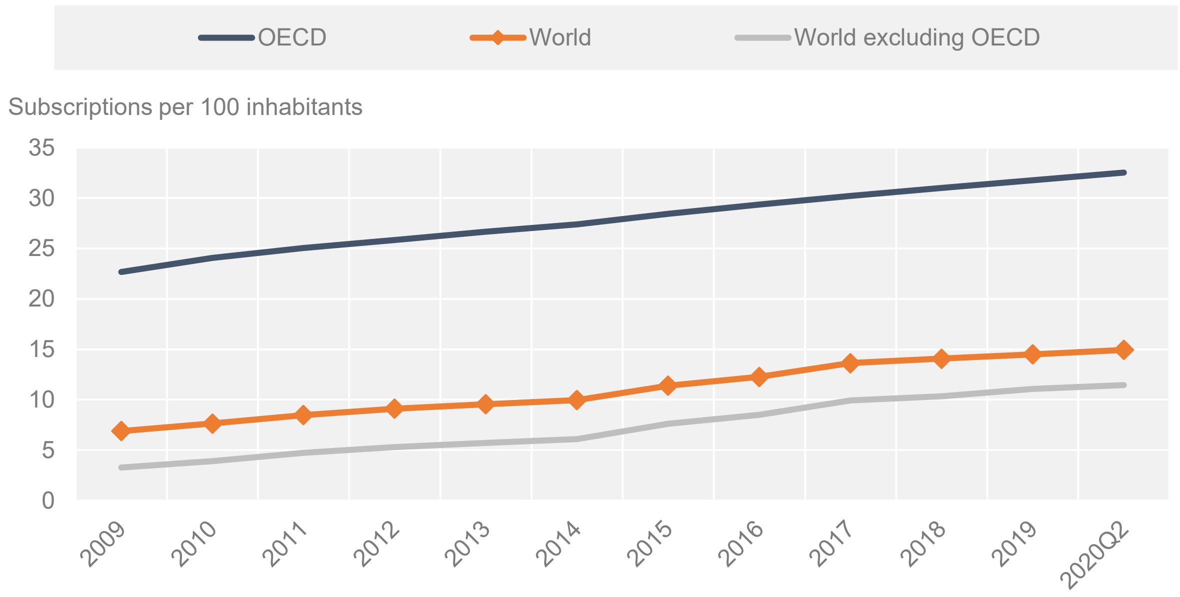
What innovative policies and regulation have proven to work best to ensure connectivity for all? This report identifies key aspects policy makers should consider to address connectivity divides effectively, in particular competition, investment, barriers to infrastructure deployment and a set of policies that are particularly relevant to rural and remote areas.

What is a connectivity divide?

The term “digital divide” is broad concept 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, as a general-purpose technology, provides the physical means for using these services (OECD, 2018[1]).

Digital divides can vary in terms of geography (e.g. as urban and rural areas), by gender, by age, by skill level, by firm size, and in general, by different vulnerable groups in society. Some aspects of digital divides are, of course, common to most geographical areas such as income disparities or lack of skills. Other aspects of the digital divide are accentuated by differences in geography. The definition of “gap” or “divide” inherently means a comparison; therefore, there is an implicit reference group in mind (within or among countries) when assessing them (e.g. rural versus urban areas, small and medium enterprises [SMEs] versus large firms, developed versus emerging economies, etc.). For example, OECD member countries had more than twice a higher level of fixed broadband penetration (32.5 subscribers per 100 inhabitants) than the world's average (14.9 per 100) by June 2020 (Figure 1). However, both groups are following the same growth path.

Figure 1. Fixed broadband evolution, OECD area and world



Note: Data for world average based on ITU data, and for 2020 are estimates.
Source: OECD (2021[2]), *Broadband Portal* (database), www.oecd.org/sti/broadband/oecdbroadbandportal.htm (accessed May 2021) and ITU (2021[3]), *World Telecommunication/ICT Indicators* (database), www.itu.int/pub/D-IND-WTID.OL (accessed May 2021).

Divides can occur on three different layers, all three of which need to be addressed in a co- ordinated way to strive for best results:

- the network or connectivity layer (i.e. access and uptake of communication services)
- the application interfaces and data layer (i.e. applications running on networks; data flows across borders), and
- the end-user layer (i.e. the diffusion of digital technologies and how these are employed taking into account the heterogeneity of firms and individuals).

The focus of this report is the *network layer*. Enhancing connectivity, understood as ubiquitous access to high quality and affordable communication services, is key to achieve an inclusive digital transformation. *Affordability* and *high quality* broadband services usually derive from competition in communication markets and policies that promote investment. In this sense, the term "connectivity divide" is used to refer to gaps in access and uptake of high-quality broadband services in areas with low population densities and for disadvantaged groups.

Box 1. What is a digital divide and a connectivity 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 (OECD, 2018[1]).
- ✓ The term "connectivity divide" is used to refer to gaps in access and uptake of high-quality broadband services at affordable prices in areas with low population densities and for disadvantaged groups compared to the population as a whole.

Being connected *well*

To close the connectivity divide, people not only need to have access to broadband, they need to be connected *well,* which means access the high-quality communication networks and services at affordable prices. Assessing connectivity divides is a pre-requisite to tailor policies and regulatory measures aimed at maximising the benefits of access to and use of broadband services. To do so, it is not only important to measure the availability of broadband through indicators such as coverage, penetration, and uptake by firms and individuals, but also to measure the performance (i.e. quality) of the broadband connection within and across countries. Drawing on both elements of availability and quality will enable setting appropriate broadband objectives and expand access in underserved areas, which is a policy area that ranks high on current policy agendas of OECD member countries. The OECD Broadband Portal provides a range of key parameters related to connectivity, like for example, links to national broadband maps, broadband subscription data by speed tiers, and broadband coverage.

The quality of broadband services

Broadband quality includes several measures such as up- and download speeds, latency, packet loss, resilience, etc. (OECD, 2019[4]). While bandwidth speed is one metric to gauge overall performance, other measures of quality will become increasingly important for operators in the future such as improved network response (i.e. latency) and the need for critical applications to have fewer network errors (i.e. packet loss) (OECD, 2019[4]).

The OECD has laid the foundation for a harmonised measurement approach in 2012 for one dimension of broadband quality: download speeds by tiers (OECD, 2013[5]). Regulators collect information on the advertised download speed of subscriptions, which are compiled to show subscriptions broken down by speed tiers - a view of the "theoretical" speed of subscriptions. While overall broadband speeds have been uniformly increasing in OECD member countries, important disparities still exist between urban and rural areas in terms of the quality of connections. Albeit definitions of what constitutes a rural area vary among OECD countries, there are persistent gaps in the availability of fixed broadband services with a minimum speed of 30 Mbps between urban and rural areas. In 2019, only 59% of rural households in Europe had access to fixed broadband services at 30 Mbps compared to 86% of households in all areas overall. In Canada, 93% of overall households had such availability in 2019, but that share was only 67% in rural areas. At the end of 2018, in the United States,[1] the availability was 77.7% in rural areas, against 94.4% in total. The persistence of rural-urban connectivity divides raises questions about inclusiveness and equal opportunities in the digital age.

There is a potential gap between the speeds advertised to customers and those actually experienced by users. Therefore, measurement of actual or "real" broadband performance is crucial. In this sense, data-driven regulation (i.e. relying on the power of disclosing information to steer communication markets in the right direction), can prove useful to increase broadband in OECD countries. In particular, the transparency generated by data on network quality provides incentives for operators to "self-regulate" and invest in network improvements. Two countries are leading by example in the development of this emerging regulatory tool: France and Korea (Box 2).

Box.2. Improving network quality and coverage through data driven regulation: the examples of France and Korea

France

Arcep, the communication regulator in France, is seeking to provide users with precise and personalised information (Arcep, 2020[6]). This could come from users (crowdsourcing) or be collected by the regulator from operators. Arcep's priority is to make data on coverage and quality of communication networks available to users. In this way, competition extends beyond prices to also include network quality. Since "crowd-sourced" quality measures of broadband depend on the user's connection at home, France moved to use more complex techniques in December 2018. Such techniques, such as Application Programming Interfaces, will be implemented in operators' set-top boxes to measure the quality of networks more accurately (OECD, 2020[7]).

Korea

In a similar fashion, the Korean government, through the National Information Society Agency (NIA), monitors the quality of broadband providers through "in the field" measurements, and renders the results publicly available on a yearly basis. The network quality evaluation by the NIA began 1999 with 2G mobile services. According to the NIA, the service quality evaluation has significantly contributed to broadband development, as operators increased network quality after each publication of the results. Furthermore, it has helped increase competition by providing users with objective quality information on communication services. In this way, users can choose providers accordingly (OECD, 2020[7]).

The Korean government has been evaluating and publishing the quality data of communication services in urban and rural areas where it has proven commercially unattractive for operators to invest. Through the assessment, the quality and coverage gap between urban and rural areas in Korea have been narrowing down. The average speed of 4G-LTE in urban areas is faster than rural areas, however, the average speed increase in rural area is higher than the national average (Table 1).

Table 1. Download speed improvement in Korea (nation-wide average, Mbps)

Service	2017	2018	2019	CAGR
4G LTE (national average)	133.4	150.7	158.5	9%
4G LTE (rural area average)	99.6	126.1	128.5	13.6%
Wi-Fi (public spaces)	264.9	305.9	333.5	12.2%
1 Gbps (fixed broadband)	873.8	913.8	951.7	4.4%
100 Mbps (fixed broadband))	99.1	99.4	99.3	0.1%

Source: Communication Service Quality Evaluation Report 2018, and *NIA Quality Evaluation of Telecom Services in Korea and Future Direction*, presented by the NIA at the OECD & BEREC QoS and QoE Webinar, June 2020.

Going forward, in addition to broadband speeds, indicators such as resilience, robustness, latency and reliability will become increasingly important with the next evolution of broadband networks (i.e. 5G and high-capacity fixed networks). One clear trend of 5G is the need to bring cells closer to the user (network densification) to reduce latency and keep up with the pace of data transmission requirements (OECD, 2019[8]). In order to meet increasing customer demands on communication infrastructure, more fibre backhaul will need to be deployed Therefore, measures of the underlying wholesale inputs directly influencing broadband performance, such as backhaul availability, will become increasingly relevant.

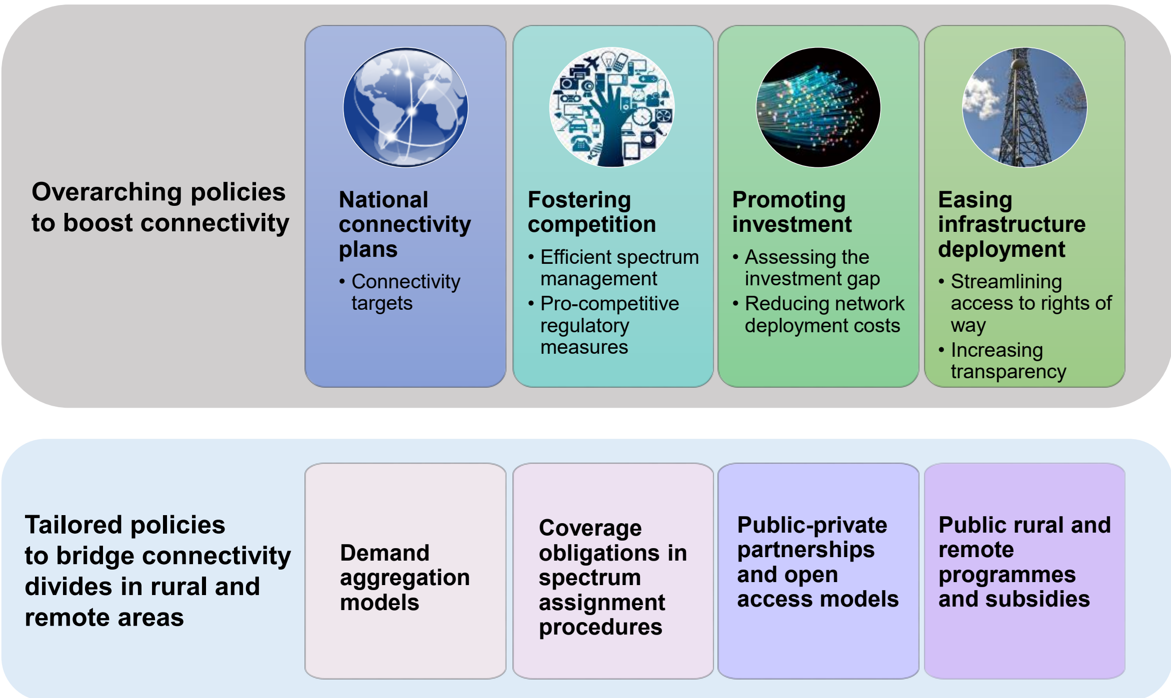
Affordability of communication services

The second relevant parameter to bridge connectivity is affordability, which can represent a major obstacle to broadband uptake. Affordability depends on people's available income as well as the pricing of the communication service. Assessing prices of communication services is thus also key for an inclusive digital transformation. Prices are both a measure of affordability and an important factor in understanding the competitive dynamics of communication markets (see *Competition* section below). While price plans are inherently complex (e.g. as regards bundles, usage patterns, promotional discounts), the OECD has made several advances in this area by providing a pricing methodology that incorporates usage baskets (i.e. low, medium and high usage) to compare prices of communication services across OECD member countries (OECD, 2020[9]; OECD, 2017[10]).

Policy responses and regulatory measures to bridge the connectivity divide

Policies and regulatory measures that improve connectivity and enhance access to communication infrastructures and services are key for an inclusive digital transformation. The section first discusses overarching policies to foster connectivity through key policies. In a second step, the section focuses on policies and regulatory measures that particularly foster broadband development and deployment in rural and remote areas (Figure 2).

Figure 2. *Overview of policies to bridge the connectivity divide and structure of this policy section*



Overarching policies and regulatory measures to expand connectivity

Reliable connectivity is fundamental for the digital transformation facilitating interactions between people, organisations and machines. A growing number of OECD countries consider access to the Internet as a basic right for citizens (e.g. Colombia, Finland, France, Iceland, Ireland, Italy, Mexico, Norway, Poland, Slovenia, Sweden, Turkey and the United Kingdom). In addition, an increasing number of countries in the OECD have changed their legal frameworks to include broadband as part of their universal service framework. In 2008, Switzerland became the first country to include broadband in its universal service framework, followed by Australia, Belgium, Canada, Colombia, Finland, Iceland, Israel, Korea, Poland, Slovenia, Spain, Sweden, Turkey, United Kingdom and the United States.

As such, expanding connectivity to achieve an inclusive society is at the heart of the policy agenda in all OECD member countries. National broadband plans and digital strategies, policies to foster competition, promote investment and ease infrastructure deployment are important tools used by OECD countries to spur the expansion of high-capacity communication networks.

Boosting connectivity through national broadband plans and digital strategies

The vast majority of OECD countries have established connectivity targets through national broadband plans or digital strategies, which set targets for coverage and speeds. Many plans increasingly aim for higher speeds (e.g. “Gigabit” and even 10 Gbps broadband connections). Furthermore, the COVID-19 health emergency has been a “turning point” in the push for ubiquitous connectivity in many countries, with businesses, society and policy makers realising the urgency to act.

Among OECD countries, Korea has the highest broadband target in terms of download speeds, with the aim of covering 50% of urban households (i.e. 85 cities) with connections of 10 Gbps download speed by 2022, as the previous goal of reaching 90% or urban households with 1 Gbps fixed broadband was reached in 2018. When considering both percentage of households, timeframe and speed contemplated, Luxembourg has the highest access target 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 by 2025. Meanwhile, Belgium aims for 50% of its households to have that speed by 2020. Austria is targeting nationwide coverage of 1Gbps broadband connections (i.e. both fixed and mobile) by 2030. Australia, Israel and several European countries have set national goals in the range of 25 Mbps to 50 Mbps, while Chile has a target of 10 Mbps. In December 2016, the Government of Canada released its Connectivity Strategy and set the goal that 90% of Canadians should have access to 50 Mbps download and 10 Mbps upload by 2021, with the remaining 10% to be served in the next ten years (CRTC, 2016[11]). By 2020, the United States aimed to have broadband of 100 Mbps or more for 80% of households, and Norway for 90% of households.

In the European Union, as part of the connectivity goals for a “European Gigabit Society”, the target is to achieve ubiquitous connectivity among all European households (with 100 Mbps connections) by 2025, with schools, universities, research centres, transport hubs, hospitals, public administrations, and enterprises having access to gigabit connectivity (European Commission, 2020[12]). Table A.1 in Annex A shows connectivity targets by OECD country as well as overall progress made with respect to those goals.

The need to foster competition for an inclusive digital transformation

OECD’s research for the past two decades has shown that the liberalisation of the communication sector has brought many benefits in terms of increasing the affordability, availability and quality of communication services. [2] Promoting competition enables users to benefit from greater choice from network service providers and spurs innovation in communication markets. It increases investment, lowers prices and drives up the overall quality and speed of broadband offers, including to underserved populations.

Therefore, policies and regulatory measures that foster competition can be a key driver for bridging the connectivity divide.

The analysis of market structures and their effects on delivering efficient and inclusive communication services has been a key policy and regulatory issue. Prices, for example, depend greatly on the competitive conditions of the market in each country, and in some instances, they also depend on regulation for specific services at a wholesale level. In a sector with high fixed costs and barriers to entry, as is the case for the communication sector, the institutional and regulatory framework weighs heavily on the resulting market structure. As such, it has a direct influence on the affordability of communication services and the discipline applied to prices by competition (OECD, forthcoming[13]).

Increased competition in communication markets not only has rendered these services more affordable, but has also played a significant role in broadband development in OECD countries. The cost structure of communication markets, with high fixed costs, is conducive to barriers to entry in the market; therefore, *ex ante* pro-competitive regulation in wholesale markets is widely used to increase infrastructure and retail based competition. A determining factor that has driven communication prices down in most OECD countries is proper regulation that fosters competition.

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 (OECD, 2018[1]).

A country that provides a clear example of the effects of competition in driving broadband development and fostering uptake of communication services is Mexico. In 2012, Mexico had one of the highest telecommunication prices in the OECD.[3] The results published in the *OECD Telecommunication and Broadcasting Review of Mexico 2017* showed clear evidence that the 2013-telecommunication reform in Mexico was a success, as regulatory reform boosted competition, significantly lowered prices, and increased the quality of communication services (see Annex B for details).

OECD member countries have following diverse approaches to promote broadband development and foster competition. Examples include the promotion of infrastructure competition but also the promotion of common wholesale infrastructures with regulated or non-regulated wholesale access focusing on competition at the retail level (i.e. last mile or access part of the network) (OECD, forthcoming[13]). Insufficient infrastructure competition in some instances may necessitate on-going regulatory intervention or oversight, which explains why integrated incumbents in OECD countries were, and in many cases still are, subject to regulatory measures (OECD, 2019[4]).

The United Kingdom provides an example of service-based competition using the infrastructure of a regulated incumbent. BT’s Openreach offers unbundled access to fibre optic and copper networks at wholesale prices on a “cost plus” basis (European Commission, 2018[14]). End-to-end infrastructure competition, on the other hand, is more evident in mobile markets in OECD countries. However, recent initiatives of shared infrastructure are also emerging in mobile networks (e.g. Mexico and Peru). Such is the case of Mexico, where the government opted for a Private Public Partnership (PPP) national wireless wholesaler network using the 700 MHz band, the “Red Compartida” (OECD, forthcoming[13]). Another example is “Internet para Todos” in Peru that has connected 6 000 localities across Peru with more than 800 base stations with 3G and 4G technologies (Internet para Todos, 2020[15]). MNOs and MVNOs can access these networks under fair, reasonable and objective conditions to provide affordable retail communication services. It is still too soon to determine the success of these policies. However, they do suggest the need for innovative models in infrastructure deployment and the role competition may play.

Recent OECD work found that, while there are many approaches used at the wholesale level of broadband markets with an increasing emergence of wireline- and wireless wholesale-only providers, competition on the access level of the network (i.e. last mile) is still more common for the majority of OECD countries (OECD, 2019[4]).

Efficient spectrum management as a means to foster competition and drive deployment

Spectrum is the primary essential input for wireless communications. Therefore, its timely availability is of critical importance for the next generation of wireless networks (OECD, 2019[8]). Spectrum assignments have been prominent in the OECD since 2016 (e.g. Austria, Canada, Chile, Denmark, Finland, France, Germany, Ireland, Italy, Latvia, Spain, Sweden, Switzerland, the United Kingdom and the United States). Spectrum auctions conducted in OECD member countries follow, in general, the principle of technological neutrality. That said, many recent auctions have intended to encourage 5G deployments.

The use of market-based auction mechanisms for spectrum assignment is a best practice among OECD countries. Furthermore, the use of spectrum caps and coverage obligations in auctions has helped promote competition in OECD communication markets, while expanding network coverage (see more details on coverage obligations in the section below).

Four important elements in spectrum auction design affect the outcome: setting spectrum caps, designing the blocks, coverage obligations and establishing the reserve prices. Spectrum auctions can shape competition dynamics as the design of blocks, together with spectrum caps, can determine how many players will prevail in markets in years to come. Thus, the design of the auctions becomes vital for the sector. When designing spectrum auctions, the different elements of the auction design should embody the objectives of enhancing competition in the market and providing incentives to expand coverage of mobile networks.

Many spectrum assignment procedures in OECD countries in recent years have included means to promote market competition (e.g. giving priority to new entrants, spectrum caps or commitments to host mobile virtual network operators [MVNOs]). For example, in France, Arcep has imposed obligations in spectrum auctions such as hosting MVNOs (i.e. 800 MHz auction) or spectrum caps (i.e. 700 MHz allocation). Spectrum caps are widely used in OECD countries for encouraging entry and addressing dominance. Since 2016, there has been around 35 spectrum auctions conducted in OECD countries, out of which 28 of them included spectrum caps.

There have been spectrum auctions with innovative designs, such as combining ascending and reverse auctions (i.e. incentive auctions), which among other goals, can be used to ensure coverage obligations. The communication regulator of Austria (RTR) used an incentive auction mechanism in the “5G-pioneer spectrum” multi-band auction (i.e. 700 MHz, 1.5 GHz 2.1 GHz bands) that was conducted on September 2020. Successful bidders of the ascending auction had the possibility to earn a price discount on the spectrum fee by accepting coverage obligations. The price discount and level of coverage was determined by a reverse auction (i.e. winning bids would be the lowest cost of deployment and/or highest level of coverage). The auction resulted in 80% of municipalities previously underserved receiving high-quality mobile broadband coverage (RTR, 2020[16]).

Pro-competitive wholesale access regulation seeking to foster connectivity

Regulatory frameworks are increasingly addressing the critical role of access to backhaul connectivity for the competitive dynamics in the market. Such is the case of the European Electronic Communications Code (EECC), which include the possibility to intervene in backhaul markets, if competition problems are identified. The EECC also endorses infrastructure sharing, mainly passive infrastructure but in occasions active, “with a view to ensuring effective and efficient use of radio spectrum or compliance with coverage obligations, in accordance with competition law principles" (European Commission, 2018[17]). It, however, does not specify explicitly provisions related to open access to dark fibre.

Several OECD countries have adopted policies to enhance backhaul and backbone connectivity. For example, the Australian Competition and Consumer Commission (ACCC) has declared certain Domestic Transmission Capacity Service routes (i.e. backbone and backhaul connectivity) as not sufficiently competitive, where providers of these regulated services must offer access to them under specified terms and conditions, including pricing (ACCC, 2019[18]).[4] In the United Kingdom, the government set out measures in the "Future Telecoms Infrastructure Review" (United Kingdom Department for Digital, Culture, Media and Sport, 2018[19]) to boost competition and to drive fibre rollout as the country considers it a priority for 5G. Such measures include allowing "unrestricted access" to Openreach ducts and poles (i.e. the physical infrastructure subsidiary of BT Group) for both residential and business broadband use, including for essential mobile infrastructure.

Sweden, as many other European countries, has a set of next generation access and local loop unbundling regulations for an operator with significant market power (SMP). These SMP measures are based on EU directives and recommendations. Accordingly, Telia has the obligation since 2010 to provide access to the unbundled local loop on copper and wholesale access to fibre. However, the price of fibre access is not determined by the PTS, whereas the price of local loop unbundling (i.e. copper) is set by the regulator. Price regulation on wholesale access to fibre was relaxed for Telia in December 2016. Henceforth, Telia is obliged to provide non-discriminatory wholesale access to local fibre, meeting the requirements of equivalence of inputs (i.e. charging the same price Telia would charge to its retail unit). In this manner, rivals should be able to economically replicate services in the retail market. The latter is examined through an economic replicability test, which is not a full-fledged margin squeeze test, but rather a safeguard that Telia is not abusing its dominant position (OECD, 2018[20]).

The importance of promoting investment

As the demands for reliable and fast connections are expected to continue to increase, policy makers should encourage investment in high-quality and affordable communication infrastructures and services. As more people and things go online, continued investment in communication networks is needed to ensure that connections and transfers of data between connected devices can take place quickly, both in fixed and mobile communication markets.

The use of fibre in fixed networks must be extended to support increases in speed and capacity across all next-generation technologies. In particular, expanding backhaul and backbone connectivity becomes essential. Fixed networks take on the 'heavy lifting' of the increasing demands on wireless networks, especially where radio spectrum is a scarce resource. Therefore, investment in next generation communication networks such as fibre is critical. By bringing fibre physically closer to the end user, whether a business or a residence, Internet speed increases across all technologies, even when the final connections are made using co-axial cable or copper (OECD, 2019[21]).

Core fixed and mobile communication infrastructure are increasingly complementary reflecting two trends. First, network densification inherent to 5G deployments requires installing small cells closer to users to increase network speeds and capacity. These cells require fibre backhaul connectivity. Second, data traffic will continue to grow exponentially driven by a growing use of Internet of Things (IoT) and artificial intelligence (AI) applications. Many OECD member countries have published 5G national strategies with an emphasis on increasing backhaul availability, streamlining rights of way and increasing the spectrum availability in the market (OECD, 2020[7]).

The COVID-19 health emergency has further shown that it will be essential to deploy more fibre deeper into networks and to gradually phase out xDSL technologies to allow for more symmetrical speeds. While transitioning from copper to fibre takes longer-term planning, broadband providers could be encouraged in the medium term to deploy fibre deeper into their networks to gradually phase out xDSL technology and replace it with FTTx technologies. Such investments would add resilience to help combat epidemics like COVID-19 and prepare for a post-crisis environment that is likely to require more connectivity and higher network capacity (OECD, 2020[22])

As of December 2019, on average only 28% of fixed broadband subscriptions in OECD countries were fibre, compared to 34% cable modem subscriptions and 34% DSL subscriptions (OECD, 2021[2]). Where existing copper networks need to be replaced by fibre, the costs for fibre deployment in the last mile are considerable because of the cost of civil works. Deploying fibre in the last mile is an increasing focus by policy makers and communication regulators.

Another concern relates to how to best provide adequate broadband service to areas that are unserved or underserved today. The FCC's National Broadband Plan (FCC, 2010[23]) in the United States, for example, began by identifying households that lacked access to broadband with a minimum of 4 Mbps downstream and 1 Mbps upstream. These tended to be in remote rural areas. The FCC calculated the investment gap (in terms of *net present value* [NPV], distinguishing between capital expenditure [CAPEX] and operating expenditure [OPEX]), required to supply all inhabitants with basic broadband with at least 4 Mbps downstream and 1 Mbps upstream. They found that about half of that investment gap was tied to just 0.2% of households (FCC, 2010[23]). In a similar manner, the European Investment Bank (EIB) has estimated the magnitude of the funding gap necessary to meet Europe's Digital Agenda and Gigabit Strategy objectives (see Annex C for a detailed description).

The Swedish Post and Telecom Authority (PTS) used a sophisticated cost model to estimate the investment needed to fulfil Sweden's National Broadband Plan "A Completely Connected Sweden by 2025 − a Broadband Strategy", which aims to achieve "access to high-speed broadband in all of Sweden" by 2025 (Government Offices of Sweden, 2016[24]).[5] PTS estimated the feasibility of this goal and found that, under the assumption that the private sector would invest USD 2.43 billion (SEK 23 billion) during 2020- 25 (including SEK 7 billion in 2020),[6] and with substantial additional public investments amounting to USD 68.7 million (SEK 650 million), the following coverage would actually be attained:

- 86-87 % of Swedish households will have access to at least 100 Mbps by 2020
- 97.9-98.9% of households will have access to 100 Mbps by 2025, and
- 97.5-98.5% of all households will have access to or in the form of homes passed of 1 Gbps by 2025.

While most of the investment in broadband deployment usually comes from market participants, including private as well as publicly owned networks (e.g. municipal networks or national wholesale networks), investment in the communication sector has been complemented by public funding in many OECD countries in the form of state aid. While authorities in OECD countries need to be cautious of the possibility of state aid hindering incentives by the private sector to deploy networks, Sweden has implemented some tools to ensure this is the case (OECD, 2018[20]). These tools include prior market analysis to identify the areas that are not commercially attractive, and once the areas are detected, public consultations of the planned financed expansions are held where private operators can identify if these plans clash with a planned commercial development (Government Offices of Sweden, 2017[25]).

The challenges relevant to mobile networks are somewhat different. Achieving last mile connectivity with mobile networks tends to be less problematic, since civil works (e.g. digging trenches) are not required for each individual house or each individual user. Mobile coverage is for this reason much more extensive than fixed worldwide. For mobile, the economic challenges often relate instead to ensuring sufficiently capable backhaul capabilities to the mobile cell sites. The migration to 5G mobile services is expected to compound this problem. 5G will achieve higher capacity than 4G by using a much larger number of cells, typically operating at higher frequencies, in areas where high capacity is needed. For dense metropolitan areas, this is likely to require new backhaul facilities to be deployed, in most cases by running fibre to the base station.

Co-investment to spur infrastructure deployment

An increasing number of OECD countries have adopted policies to reduce the costs of broadband deployment through measures of co-investment, or joint-deployment of broadband networks. While there is still limited research on the effects of co-investment on competition in communication markets, co-investments can have pro-competitive and anti-competitive effects. When deciding about whether to allow and provide incentives for co-investment, the particular case at hand needs to be carefully analysed. Important factors to look at are, for example, the kind of operators that want to co-invest (e.g. incumbent vs. challenger, large vs. small firm), the geographical location of co-investment (e.g. rural vs. urban areas) and the competitive situation in the market.

For example, within the European Union (EU) zone, the EECC envisages creating incentives to co- investment as it provides for regulatory relief to operators entering in such agreements. Namely, the EECC establishes that an operator with Significant Market Power (SMP) will be able to propose commitments on offers for co-investment in new networks that consist of optical fibre elements up to the end-user premises or base station.[7] If these commitments fulfil certain criteria on access for co-investors and third parties, and are made binding by the national regulatory authority, the operator with SMP would be exempted from *ex-ante* regulation.[8] The co-investment offer has to be open to any willing co-investor while granting access to the network also to non-co-investment parties, under certain conditions. EU Member States, as for the rest of the EECC, had a deadline to transpose these elements of the EECC into national law by the end of 2020.[9] Furthermore, BEREC published in December 2020 guidelines to foster the consistent application of the criteria for assessing co-investments in very high capacity network elements (BEREC, 2020[26]).

In Italy, a measure towards co-investment is the SMP regulation (decision n.623/15/CONS) that obliges the fixed incumbent, TIM, to publish an early announcement about future fibre access deployments so that other operators may have the possibility to share the cost of deployment with TIM. In Portugal, for example, the communication regulator, ANACOM, supports co-investment agreements if the conditions do not harm competition. However, no specific policy or study on benefits/drawbacks has been performed by ANACOM so far. There have been co-investment agreements in the past in Portugal (e.g. between the mobile operators NOS, Optimus and Vodafone, and between MEO and Vodafone). From the first quarter of 2018, the Portuguese operators NOS and Vodafone have also initiated a co-investment agreement, which includes sharing existing infrastructure and commitments on both parts for building new shared infrastructure.

Promoting infrastructure sharing while safeguarding competition

Passive, as well as active infrastructure sharing may also be a way to speed-up broadband deployment and increase the access to it. In all cases of infrastructure sharing, it is important to keep the public policy goal of fostering competition in markets in mind. Typically, passive infrastructure sharing raises less concerns than active infrastructure sharing. However, especially in rural and remote areas, active infrastructure sharing can also be viable way to not only ensure that mobile coverage is extended, but also that different operators can compete with their offers in those areas. In France, for example, infrastructure sharing in rural areas is very common and has successfully extended broadband coverage.

Passive infrastructure sharing is common in OECD countries (e.g. Australia, France, Korea, and Switzerland). In Australia, the ACCC developed the Facilities Access Code, which states that the access to certain facilities owned by telecommunication carriers, including mobile towers and underground ducts, must be provided to other carriers seeking to install their equipment in those facilities. In France, symmetric regulation on fibre imposes that the firm exploiting a fibre cable must provide reasonable open access to other firms on a non-discriminatory basis. For mobile networks, the four French operators are obliged since 2018 to consult other operators before deploying towers and to share passive infrastructure in white areas. In Korea, passive fixed and mobile infrastructure sharing is an increasingly common practice, especially with the emergence of 5G networks. All three major operators need to consult with each other over potential joint installations when deploying telecommunication equipment and facilities.

There is also an increasing number of examples for active infrastructure sharing in OECD countries, such as radio access network (RAN) sharing agreements (e.g. in the Czech Republic, France, Sweden and Switzerland) and national roaming agreements (e.g. in Colombia and France). RAN sharing, which includes antenna, mast and backhaul equipment may help reduce deployment costs. However, some challenges faced by operators in implementing these types of agreements are the inherent differences in network architecture, equipment purchased from different vendors and differences in network management procedures. In France, for example, there is an obligation for RAN agreements and spectrum sharing in rural “white areas”, i.e. areas with limited mobile coverage (BEREC, 2019[27]). In Switzerland, a RAN sharing agreement exists between Sunrise and Salt to increase coverage and/or capacity in certain areas. In Europe, Article 47 of the EECC mentions that regulators may provide for the following possibilities attached to spectrum licences to promote the efficient use of spectrum and compliance of coverage obligations: (a) to share passive or active infrastructure which relies on spectrum, (b) to enter into commercial roaming access agreements and (c) to jointly deploy networks that make use of spectrum. Sharing agreements remain subject to competition law (BEREC, 2019[27]; European Commission, 2018[17]). Several regulators in Europe through BEREC’s Common Position on Mobile Infrastructure Sharing have highlighted positive aspects of passive and active infrastructure sharing, such as cost-saving, extending coverage in areas of high-cost deployment (often rural areas), efficient use of spectrum, and public interest. Some potential challenges noted include a decrease of investment incentives and diminished infrastructure-based competition. In the case of active sharing, it may foster collusion due to information sharing (BEREC, 2019[27]).

Implementing “dig-once” policies

A number of OECD countries have focused on “dig-once” policies to leverage non-broadband infrastructure projects (e.g. highway/ road construction, railways, utilities, and street light providers) to reduce the costs of broadband network deployment. For example, many European Union member states have transposed the European Union Broadband Cost Reduction Directive (2014/61/EU) into national law (e.g. Italy with Law 33/2016 and Greece with Law 4463/2017). The directive includes provisions that allow communication network operators to access other utility infrastructure. In Switzerland, through commercial agreements in the past decade, Swisscom has signed several contracts of cooperation with municipal utilities to deploy the FTTH network in communal territories.

Easing infrastructure deployment

Streamlining access to rights of way

One key objective among OECD countries consists in removing barriers to infrastructure deployment and getting the regulatory measures “right”. This becomes even more crucial with the next generation of both fixed and broadband networks as the deployment of next generation networks entail significant costs for operators and as wireless and fixed broadband networks become more complementary.

One effective way to ease infrastructure deployment and increase the speed of deployment is through establishing simplified permit granting procedures and reducing approval and construction times. Therefore, many OECD countries are aiming to streamline rights of way. The granting of public rights of way usually requires the active participation of public authorities, often at different levels of government in managing or authorising the civil works needed in constructing ducts or other infrastructure required for networks. A public right of way permit is usually an agreement between the government and an applicant (OECD, 2008[28]).

Streamlining "rights of way" for telecommunication operators becomes increasingly important to deploy massive numbers of small cells for 5G and fibre backhaul to connect the cells (OECD, 2019[8]). Rights of way are also crucial when it comes to the deployment of communication networks in the last mile. The main cost component is civil work which involve costs associated with opening (and closing) trenches and laying ducts. This cost depends on the size of the city and population density. Streamlining access to rights of way can reduce the costs of civil works and therefore provide an important impetus to stimulating the roll-out of next generation networks and, in particular, fibre. Three examples of reducing the costs of access to rights of way are the United States, the United Kingdom and the European Union (Box 3).

Box 3. Country examples of reducing the costs of rights of way: United States and the European Union

The United States

Several OECD countries have been making efforts in streamlining rights of way to facilitate network densification. In the United States, an example of regulatory action to streamline rights of way is the FCC Order, "*Accelerating Wireless and Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment,*" adopted on September 2018 (FCC, 2018[29]). The decision clarifies the FCC's views regarding the amount that municipalities may reasonably charge for small cell deployment given the practicalities of 5G deployment and the importance of 5G to the United States. In offering guidelines for determining this value, the FCC cited the rules of twenty states that limit upfront pole fees to USD 500 for use of an existing pole, USD 1 000 for installation of a new pole, and recurring fees of USD 270 (OECD, 2019[8]).

The United Kingdom

The United Kingdom reformed its Electronic Communications Code (ECC) in 2017 as part of the Digital Economy Act 2017. These reforms, which came into force in December 2017, were intended to reduce the cost and make it easier for operators to deploy communication infrastructure.

European Union

Another example for facilitating network deployment can be found in the EECC. Article 57 of the EECC aims to minimise authorisation requirements and costs of the deployment of small cells. According to this EECC provision, competent authorities shall not subject the deployment of small-area wireless access points, i.e. small cells, which comply with certain characteristics laid down in a future implementing act, to any individual town planning permit, to other individual prior permits, or to any fees or charges going beyond the demonstrated administrative charges (European Commission, 2018[17]). In 2019 and 2020, the European Commission held two public consultations on a "light deployment regime" for small cells to facilitate their rollout, as these will be needed for the densification of existing networks. On June 2020, the European Commission adopted the regulation specifying the physical and technical characteristics of small cells for 5G networks within the European Union (European Commission, 2020[30]).

Source: FCC (2018[29]), "FCC Facilitates Wireless Infrastructure Deployment for 5G | Federal Communications Commission", https://www.fcc.gov/document/fcc-facilitates-wireless-infrastructure-deployment-5g; OECD (2019[8])," The road to 5G networks: Experience to date and future developments", https://dx.doi.org/10.1787/2f880843-en; and European Commission (2018[17]). *Directive (EU) 2018/1972 establishing the European Electronic Communications Code,* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.321.01.0036.01.ENG.

Making information available for operators and increasing the deployment efficiency

Increased access to information and public assets also plays a crucial role for broadband deployment. For example, a lot of the time in the deployment process in mobile infrastructure may be spent on the determination and acquisition of locations to build towers. To ease this process, countries can increase the transparency of and access to information about public assets.

For example, they could consider establishing a one-stop online portal that geo-references publicly owned buildings available for lease as the one that was build up for Mexico. In Mexico, the National Telecommunication Infrastructure Information system (Sistema Nacional de Información de Infraestructura, SNII), approved and issued by board of the Mexican communication regulator (IFT), includes useful information pertaining to rights of way geared at allowing concessionaires to deploy communication infrastructure on public assets, such as buildings.[10] This inventory aims at revealing the availability and status of this infrastructure to increase efficiency in deploying communication networks lower the costs for infrastructure deployment, and increase coverage across the country.

In the aim to reduce deployment costs, Belgium created a central electronic counter in each region for applying for licences to roll out infrastructure and for granting licenses swiftly, promoting access to existing infrastructure. In addition, the country published guidelines and issued a “fibre ready” label for citizens that plan to build or renovate their residences. Based on the European Union Directive, it also seeks to optimise the co-ordination of roadworks and the distribution of costs among network operators (telecommunication companies, cable companies, power grid operators, water companies, transport, etc.) participating in the joint roadworks (OECD, 2018[1]). In addition, Belgium encourages mobile site sharing (Act of 13 June 2005 on electronic communications). The implementation of site sharing is followed up by the non-profit making association Radio Infrastructure Site Sharing (RISS) (BIPT, 2021[31]).

Tailored policies and regulation to close connectivity divides in rural and remote areas

Policies to promote competition and private investment, as well as independent and evidence-based regulation, have been tremendously effective in extending broadband coverage in OECD member countries. 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 (OECD, 2018[1]).

Bridging the connectivity divide is by no means an issue related solely to rural and remote areas. However, these areas generally have a unique set of issues associated with their distance to core network facilities (OECD, 2018[1]). Assisting rural and remote communities to bridge broadband access and uptake gaps is critical to strengthening their overall economic development and, in general, to harness an inclusive society.

Some initiatives to bridge connectivity divides in rural and remote areas, in addition to promoting market forces and reducing deployment costs, include demand aggregation models, using coverage obligations in spectrum auctions, subsidising, national and rural broadband networks, as well as specific funds or carrying out competitive tenders to foster deployment in rural areas. Regarding public funds, as state aid may hinder network deployment incentives by the private sector (i.e. “crowding out”), the correct identification of which sparsely populated areas require subsidies is crucial.

Demand aggregation (identification) models

Especially in areas where it is economically difficult to roll out broadband networks, the model of demand aggregation can be used to increase certainty for investors and operators. Demand aggregation coordinates and bundles consumer demand to increase the profitability of the network roll-out, increase certainty, and, depending on the area to cover achieve economies of scale. Community networks can also be an effective mechanism for demand aggregation because of their intimate knowledge of local conditions.

Some OECD countries have used demand aggregation tools to foster broadband roll-out. In Germany, for example, demand aggregation is used to extend connectivity in particular in rural and remote areas. Before deploying fibre-to-the-home (FTTH) networks, firms aggregate demand and require that a certain percentage of households commits to use their broadband services for a certain period of time. They typically ask for a commitment of 30 to 40% of households before deploying networks. One of the most prominent companies in Germany using this model is *Deutsche Glasfaser*. The company reports that so far it has installed over 500 000 FTTH connections using this model (Deutsche Glasfaser, 2020[32]).

Local cooperatives in the Netherlands have also registered and aggregated user demand from households, and then contracted a private company to build and operate a next-generation broadband network. Lijbrandt Telekom and OnsNet, for example, have applied this model to identify areas for private-sector investment in next-generation broadband networks. The demand registration schemes have all involved consumers making a contractual commitment for a service several months in advance of that service becoming available. This contrasts with most of the schemes in first-generation broadband deployment, which were more an ‘expression of interest’ with no firm commitment (Analysis Mason, 2008[33]). Case studies on demand aggregation in Analysis Mason (2008[33]) suggest that interventions involving demand aggregation tend to break-even relatively quickly.

In Sweden, demand aggregation forms part of some municipality fibre networks that have been fully or partially facilitated, built, operated or financed by local governments, in particular the ones taking a *village fibre* approach (OECD, 2015[34]). The “village fibre” approach is based on the premise of community involvement to plan, build and operate local fibre networks in co-operation with municipalities and commercial operators (OECD, 2018[20]). The deployment of fibre networks in these villages is sometimes 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. Given that village networks are deployed in areas where no commercial operators are deploying fibre networks, they meet the key criteria for state aid. Compared to commercial broadband projects, village fibre projects can achieve cost savings of some 50% using an innovative handling of permissions as well as excavation and voluntary work (OECD, 2018[20]).

In Australia, the National Broadband Network (NBN) was designed to allow aggregation at 121 Points of Interconnect (POIs) across Australia where the networks of retail service providers connect to the NBN network, which in turn connects to the end user. A number of communication operators also offer demand aggregation for smaller operators, particularly to provide cost effective access to the POIs. The NBN rollout is nearly complete (99%) providing wholesale broadband to premises in all areas of Australia.

Demand aggregation models seem to further have an impact on stimulating broadband adoption. In an empirical analysis on the one-year adoption changes of broadband in a sample of European countries, all surveyed forms of demand stimulation had statistically significant positive effects once deployment was sufficiently advanced. However, no other demand side policy had as strong an effect as demand aggregation (Parcu, 2011[35]).

Coverage obligations in spectrum assignment procedures

When designing spectrum assignment procedures in OECD countries, policy makers take into account policy objectives such as increasing coverage of communication networks and enhancing competition in mobile markets. Coverage obligations in auctions have proven an effective tool used in OECD countries to extend mobile broadband coverage in rural and remote areas. However, the extent of coverage obligations should not impede certain actors from bidding in the auction (OECD, 2019[36]).

In some cases, countries have included obligations to provide connectivity to specific premises, such as schools or highways, 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 (OECD, 2018[1]).

Spectrum assignment procedures (i.e. auctions or comparative selection processes) in OECD countries from 2016-2019 have frequently included coverage obligations. For example, in the June 2019 auction for spectrum licences of the 2.1 GHz and 3.6 GHz bands, Germany included coverage obligations of 98% of all households per federal state with 100 Mbps per antenna sector by the end of 2022. It also included coverage obligations of all transport ways (motorways, main roads, waterways, railways) by the end of 2022 or 2024. The assignment holders may use their entire spectrum holdings to meet the coverage obligation and are not restricted to use only the frequency blocks acquired in this auction (BNetza, 2018[37]). In 2011, during the 800 MHz auction, Spain imposed commitments on operators to jointly cover 90% of the villages with fewer than 5 000 inhabitants at 30 Mbps (Government of Spain, 2018[38]).

During the 2016-19 period, out of the approximately 35 spectrum auctions conducted in OECD countries, 16 included coverage obligations when considering all frequency bands (i.e. high [>6 GHz], mid-bands [1GHz<Band<6 GHz], and low [<1 GHz]). Ten of these auctions pertained to low frequency spectrum (i.e. lower than 1 GHz), which is a spectrum band that is particularly suitable for extending coverage in rural areas. Seven out of these ten procedures included coverage obligations.

Public-private partnerships and open access models

For many years, OECD countries followed the path of continued liberalisation of the communication sector with a focus on investments by the private sector and competition among private companies. More recently, some countries have started to provide public funding with a focus on remote and rural areas, and some even deploy national broadband networks once they determined that there is insufficient competition in certain areas. Public funding reaches from grants for public-private partnerships (PPPs), to funding entire national broadband networks. Not all funding and deployment cases have been successful.

Some of the PPP initiatives have been designed as open access networks, providing wholesale access capacity on fair and reasonable terms with a certain degree of transparency and non-discrimination. If elaborated well, this model enables more competition and innovation at the retail level, for example, by local or community networks, among others. If public funding is awarded to these networks (e.g. through preferential loans, subsidies), typically certain open access conditions can be imposed and companies need to comply with these conditions in exchange for public funds. This model has been used to expand connectivity to rural and remote areas such as in New Zealand and is intended to ensure that public funding promotes competition in these regions. Singapore represents an example of a nationally-catalysed PPP initiative to create an open access network that is structurally separated and has generated positive results in the market (see Annex D for details) (OECD, 2019[4]).

Municipal networks

Municipal networks which are 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 (OECD, 2015[34]), are used in several OECD countries to promote fibre deployment in cities, smaller towns and surrounding regions. Implementing bottom-up models to finance and deploy high-speed networks has been an approach for assisting rural and remote areas to cope with continuously growing demand for higher broadband capacity. Municipal networks can extend the connectivity in regions where deployment by national communication companies is lacking or deemed unprofitable. In areas in which coverage is provided by national players, municipal networks are likely to spur competition.

For example, a decisive factor in Sweden's high fibre take-up is that municipal networks have been widely deployed in the country since the liberalisation of the communication market (OECD, 2015[34]). Most Swedish municipal networks provide retail "operator" neutral network infrastructure based on fibre to the building or fibre to the home (FTTB/FTTH). That is, their business model relies on open networks where they act as physical infrastructure providers offering wholesale access to retailers on a non-discriminatory basis (OECD, 2018[20]). This has led to a notion of "open" municipal networks, which contrasts with other business models for backbone and backhaul provision of fibre that rely on completely vertically integrated telecommunication operators present both in wholesale and retail markets (OECD, 2015[34]).

Municipal networks can be a very good means to provide rural areas with Gigabit networks. Experience shows that networks which focus on the provision of dark fibre and relying on full open access models are particularly successful. These typically trigger innovation and competition at the retail level, in both the fixed and the mobile communication market. In Sweden, for example, in 2017 there were 156 municipal fibre networks present in 200 of the 290 Swedish municipalities, where most of them provided wholesale products such as "dark fibre" and Ethernet capacity (OECD, 2018[20]).[11] The latter means that the passive network is separated from active network provisioning and services, which proponents say reduces the risk for conflict of interest, and promotes a competitive service and retail market (OECD, 2015[34]). Municipal wholesale networks, together with a new entrant in the fibre market (i.e. IP Only), have triggered higher investments in high-capacity fixed networks in Sweden. Although Telia still accounted for 50% of investment in fixed infrastructure for the past ten years, since 2006, investment by other players (e.g. IP Only and municipal fibre networks), together with state aid, have taken a more prominent role (OECD, 2018[20]). In the mobile market, one operator reported that in the city of Stockholm it would be impossible to compete with the incumbent without the possibility to lease fibre backhaul from Stokab.

Looking ahead, municipal fibre networks might ease the deployment of 5G in cities disposing of such a network. An important prerequisite for 5G is the deployment of fibre deeper into mobile backhaul networks and the connection of mobile cells with fibre. The existence of a fibre network in a municipality eases the connection of smaller antennas to fibre and reduces deployment costs. A further advantage is that the coordination between the municipal network and the municipal facilities (e.g. with respect to lampposts, bus stations etc.) might be facilitated in case there is a common owner and a joint public interest.

Overall, municipal networks provide an effective means to extend high-quality connectivity. While their total number is growing, an important aspect to consider is to ensure frictionless coordination between the different municipal networks. Other challenging aspects to consider are labour shortages due to migration or an aging population, which may occur in certain rural areas in OECD countries (e.g. Japan). In addition, given inherent difficulties in terms of business cases for market actors to provide broadband in rural and remote areas, the co-ordination among diverse stakeholders becomes even more critical. The Swedish Broadband forum is a good example of how to ensure this coordination exists, and it has contributed positively to fibre expansion in Sweden (OECD, 2018[20]). The main functions of the forum include: i) promoting the collaboration between public and private players regarding mobile and fixed broadband expansion, ii) providing guidance about robust fibre networks to municipalities, iii) identifying relevant barriers for infrastructure deployment, iv) establishing measures to support broadband deployment in rural areas, and vi) acting as a Secretariat for regional broadband coordinators (The Swedish Broadband Forum, 2021[39]). Another factor to consider is monitoring the effect of the wholesale network on competition and ensuring that it does not reduce the number of players in the market nor dictate the choices for retail operators. Finally, it is important that wholesale networks dispose of enough financial resources, long-term investment horizons and adequate free cash flows. In this regard, it seems that there is a growing appetite by the financial market, including private equity and pension funds to invest in such wholesale projects, also in rural and remote areas, as these are expected to generate stable financial returns over the years.

Public rural and remote programmes and subsidies

In the majority of OECD countries, private investment is the largest source of investment in communication infrastructures. However, in some instances, governments may be better placed to take a longer-term and broader view of returns, and may choose to invest alongside private actors through public-private partnerships to share the risks associated with the creation, development and operation of an infrastructure asset, especially in areas where positive business cases are hard to achieve.

Often, such investment takes place through national broadband plans. The majority of OECD countries have included specific components in their plans related to the expansion of broadband in rural and remote areas (OECD, 2018[1]). Such national broadband strategies should address all of the key barriers to the expansion of high-speed networks. In addition to national broadband plans, the vast majority of OECD member countries have specific programmes for expanding broadband access in rural and remote areas. For example, New Zealand has established the Rural Broadband Initiative and the Mobile Black Spot Fund that are delivering improved broadband and mobile services to inhabitants in rural and remote areas. Over USD 296 million (NZD 430 million)[12] in grant funding from the Telecommunications Development Levy has been allocated for the Rural Broadband Initiative in New Zealand to provide improved broadband to target around 10 000 rural households and businesses. The aim is to connect 99.8% of the population of New Zealand to broadband (Government of New Zealand, 2020[40]). In Korea, the 2010-2017 rural connectivity project called “Broadband Convergence Network” (Rural BcN) connected 13 473 remote rural villages (i.e. of less than 50 households) to 100 Mbps broadband access (Box 4).

Box 4. Investing in rural area connectivity and its economic effects in Korea

While Korea achieved fibre-based fast and reliable broadband networks covering large parts of the country, private sector investment often lagged in rural and remote areas, mostly due to issues around the economic feasibility of broadband deployment. To tackle this problem, the Korean National Information Society Agency (NIA) joined efforts with local governments and the network operator KT to build broadband networks in small rural communities (i.e. villages with less than 50 households) to enable access to the 100 Mbps or higher speed Internet to residents in those communities. The eight year rural connectivity project “Broadband Convergence Network” (Rural BcN), which was finalised in 2017, managed to bridge the connectivity divide in 13 473 rural villages, including 360 villages part of islands.

The results of a recent survey show that the total economic benefits of the Rural BcN Project amount to around KRW 160.45 billion (USD 138 million), comprised by estimated annual average cost-savings of KRW 28 billion (USD 24 million) and by an estimated effect derived by the increase of household income of KRW 132.45 billion (USD 114 million).[1] The total amount of budget invested into the project was approximately KRW 142 billion (USD 121.8 million) over a period of eight years, where the private operator KT funded half of the project, 25% of the budget was provided by the national government; and another 25% by each local government.

Note: 1. Using exchange rate of 1165.499 KRW/USD from OECD (2020[41]).
Source: MSIT and NIA (2017) “Broadband convergence Network, 8 Years of Rural Broadband convergence Network Project in Korea,” Ministry of Science and ICT in Korea (MSIT) and the National Information Agency (NIA), Seoul, November 2017

Public-private partnerships can also help bridge the connectivity divide. They could also diminish reliance on public resources derived from taxation or universal service funds. As such, policy makers and regulators have increasingly used market mechanisms, such as using competitive tenders and reverse auctions, 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. Colombia, Estonia, Greece, Hungary, Italy, Korea, Slovenia, the United Kingdom and the United States have used reverse auctions to this effect. A recent example of the use of reverse auctions is the Rural Digital Opportunity Fund (RDOF) in the United States (Box 5).

Box 5. The RDOF fund in the United States: a reverse auction mechanism

The Rural Digital Opportunity Fund (RDOF) aims at bridging the connectivity divide in rural and remote areas in the United States. Through a two-phase reverse auction mechanism, the FCC will fund up to USD 20.4 billion over ten years to finance up high-speed broadband networks ("up to Gigabit speeds") in rural and remote areas (FCC, 2020[42]). The Phase I auction, which began on 29 October 2020, and ended on 25 November 2020, awarded up to USD 16 billion support to bring broadband to over five million homes and businesses in census blocks that were entirely unserved by voice and broadband with download speeds of at least 25 Mbps. The funds were awarded by reverse auction in a process favouring faster download speeds, but also those willing to take the lowest amount of grant per customer (FCC, 2020[43]).

Source: FCC (2020[42]), *Implementing the Rural Digital Opportunity Fund (RDOF) Auction*, https://www.fcc.gov/implementing-rural-digital-opportunity-fund-rdof-auction

Tailored policies by usage groups: the case of SMEs

Ensuring that digital divides are bridged requires that policy makers consider evolving demands for broadband services that exist in different groups of the economy and society. Policy makers around the OECD are seeking ways to ensure that all businesses, regardless of their size, can benefit from the digital transformation. In particular, some OECD countries have tailored policies to specific usage groups considered to be lagging behind, such as small and medium enterprises (SMEs).

In France, since 2016, connecting SMEs with fibre networks has been a priority for the regulator Arcep. In order to promote competition and innovation on the provision of broadband services, the French regulator has opted to experiment, by putting in place a "regulatory sandbox", in practice a limited regulatory waiver of up to two years, for start-ups wishing to test new technologies or offer an innovative service. In the United Kingdom, Ofcom carried out quantitative and qualitative research to understand the experiences and attitudes of the market for communication services for SMEs (Ofcom, 2018[44]). The research found that SMEs often have Internet services that are not optimal for their business, in particular with reference to bandwidth, affordability, upload speeds or use in peak times.

Can emerging technologies help bridge connectivity divides?

New technological developments will likely influence the provision of services in underserved areas. These technological developments include the usage of 5G technology for fixed wireless access (FWA), but also creative solutions around satellites and other emerging technologies.

Fixed wireless access (FWA) broadband

While the vast majority of OECD countries currently conceive mobile and fixed communication services as complementary rather than substitutes, some potential advantages of 5G over 4G have led a number of industry experts to believe that 5G fixed wireless access (FWA) networks could be able to compete with wireline broadband services in the future (OECD, 2019[8]), and in some circumstances, help bridge connectivity gaps in rural areas. By the end of 2019, Ericsson estimated 51 million FWA connections, expected to triple by 2025 (Ericsson, 2020[45]). However, some remain sceptical of the short-term potential of 5G to compete with fixed broadband services (OECD, 2019[8]). One report undertaken for the United States NTCA, a trade association of rural broadband providers, argues that fixed and mobile technologies are still essential complements rather than substitutes (Thompson and Vandestadt, 2017[46]). The main reason presented is their finding that performance is still significantly hampered by interference issues inherent to millimetre wave spectrum. Another consideration could be the degree of congestion in mobile networks.

Satellite broadband

Satellite broadband from geostationary (“GEO”) satellites may in some cases be used to provide direct to the home or community aggregator backhaul for residential broadband users living in rural and remote areas. However, geostationary satellite technologies usually have higher latency, less bandwidth and are more expensive than fibre optics, hence, these technologies should only be considered in cases where other solutions are not available. While the affordability and therefore the widespread viability of the emerging low and medium earth orbit (“LEO” and “MEO”) satellite systems will depend on the customer uptake, their improvements in performance over their legacy GEO counterparts may allow them to compete with terrestrial options. However, this has not been shown yet to be the case (OECD, 2017[47]).

There has been recent developments in low earth orbit (LEO) satellites with the aim of providing high-speed broadband in rural and remote areas. One example is Starlink by SpaceX, a LEO satellite constellation. SpaceX is preparing to launch services in rural and remote areas of northern United States and Canada during 2020-21, and then expand global coverage. As of August 2020, Starlink had launched 600 satellites and was building a system of ground stations as well as terminal equipment (The Verge, 2020[48]). Results from Ookla’s speed test in August revealed that download speeds of the constellation were about 35-60 Mbps (Inverse, 2020[49]), lower than what SpaceX originally claimed for the constellation (i.e. 1 Gbps). The company aims to launch 12 000 LEO satellites.

Other emerging technologies

There has also been a number of initiatives from the private sector that aim at offering alternative solutions to extend connectivity. Recent developments in high-altitude platform station (HAPS) systems show promise that these have the potential bridge connectivity divides in rural and remote areas. HAPS stations operate in the earth’s stratosphere (layer of the atmosphere starting at 20 km), and can provide broad coverage at a lower latency than satellite systems. They have existed since the late 90s, but have recently become more viable due to technological advances in energy efficiency, among other factors. However, the economic viability of this technology also depends on spectrum availability and other existent underlying infrastructure (ITU, 2020[50]). As such, HAPS systems face challenges to become a commercially viable option for broadband delivery in several countries. To accelerate the development and adoption of HAPS technology, the HAPS alliance was formed by a number of companies, including HAPSMobile (SoftBank Corp), Loon (Alphabet), AeroVironment, Airbus, Bharti Airtel, China Telecom, Deutsche Telekom, and Telefonaktiebolaget (Ericsson) (HAPS, 2020[51]).

Concluding remarks

Reliable connectivity is fundamental for the digital transformation facilitating interactions between people, organisations and machines. The COVID-19 health emergency has further accentuated the awareness of how availability, resilience and capability of broadband networks are becoming even more critical to ensure an inclusive society as more and more activities are conducted in a remote manner. In a sense, it has been a "turning point" in the push for connectivity in many countries, with businesses, society and policy makers realising that this is now urgent to act.

To close the connectivity divide, people not only need to have access to broadband, they need to be connected *well,* which means access the *high-quality* communication networks and services at competitive prices. Policies and regulations that foster competition, promote investment in fixed and mobile networks, and reduce barriers to infrastructure deployment have been extremely effective in boosting connectivity in OECD member countries.

Some initiatives to bridge connectivity divides in rural and remote areas, in addition to promoting market forces and reducing deployment costs, include demand aggregation models, building on local knowledge and initiatives through municipality or community networks, using coverage obligations in spectrum auctions as well as subsidising national and rural broadband networks, using general revenues, specific funds or carrying out competitive tenders to foster deployment in rural areas.

Annex A. Connectivity targets by OECD country

Table A.1. National Broadband Plans and targets in OECD countries and progress made on connectivity goals

Country	Year	Coverage	Progress made *vis-à-vis*- the target
Australia	2020	90% of fixed line households and businesses with 50 Mbps/10 Mbps (download/upload)	90% of fixed-line NBN premises with 50Mbps or higher (as of 2020)
Austria	2020	99% of households with 100 Mbps (both fixed and mobile coverage)	68% of households with fixed connections of 100 Mbps (2020), with 77% of households will have 100 Mbps fixed network coverage in the coming years
Belgium	2020	100% of households with 30 Mbps	98.8% of households with 30 Mbps (2018)
Canada[1]	2021	90% of households and businesses with 50 Mbps/10 Mbps and latest mobile technology available to all households, businesses and major roads.	85.7% of households with 50 Mbps/10 Mbps (2018)
Chile	2022	90% of households with 10 Mbps	
Colombia	2022	70% of households connected to the Internet, and 32 million subscriptions with speeds higher than 10 Mbps	60.9% of households connected to the Internet (2018)
Czech Republic	2020	100% of population with 30 Mbps population and a coverage of at least 100 Mbps for 50% of households by 2020	89.8% of households with 30 Mbps (2018)
Denmark	2020	100% of households and businesses with 100 Mbps/30 Mbps	87.9% of households with 30 Mbps (2018)
Estonia	2020	100% of households with 30 Mbps and 60% with 100 Mbps or faster	82.8% of households with 30 Mbps and 68.5% household penetration with 100 Mbps (2018)
Finland[2]	2015	99% of households, businesses and public offices with 100 Mbps	51.8% of households with 100 Mbps (2018)
France	2022	100% of households, businesses and public offices with 30 Mbps	58.5% of households with 30 Mbps (2018)
Germany	2025	Full gigabit coverage of all households and businesses	
Greece	2020	100% of households with 30 Mbps	
Hungary	2018/2020	100% of households with 30 Mbps (2018), and 50% household penetration with 100 Mbps (2020)	85.5% of household with 30 Mbps, 78% household penetration with 100 Mbps (2018)
Iceland	2020	99.9% of households and businesses with 100 Mbps9	97.5% of households with 30 Mbps (2018)
Ireland	2020	100% of households with 30 Mbps	88.5% of households with 30 Mbps (2018)
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	90.8% of household with 30 Mbps, 23.9% with 100 Mbps (2018)
Japan	2022	Reduce the number of households not covered by FTTH to 180 000.	98.8% of households have been covered with FTTH (2019)
Korea	2022	Fixed internet with maximum 10Gbps download speeds will be disseminated to 50% of urban households (85 cities) by 2022.	
Latvia	2020	100% of population with 30 Mbps mobile broadband and 100% of rural areas with optical backhaul	91.5% of households with 30 Mbps (2018)
Lithuania	2020	100% of populations with 30 Mbps; 50% of populations with 100 Mbps	62.7% of households with 30 Mbps, 60.6 household penetration with 100 Mbps (2018)
Luxembourg	2020	100% of households, businesses and public offices with 1 Gbps/500 Mbps	94% of households with 100 Mbps (2018)
Mexico	2024	92.2% of the population with 4 Mbps downlink per 1 Mbps during the network peak hour	Progress in the deployment of the "Red Compartida" as of June 2020 was 54.8% of

			the territory, where 48.5% of the population lives
Netherlands	2020	100% of households with 30 Mbps	99.8% of households with 100 Mbps (2018)
New Zealand	2025	99% of households with 50 Mbps and the remaining 1% with 10 Mbps	
Norway	2020	90% of households with 100 Mbps	82% of households with 100 Mbps (2018)
Poland	2020	100% of households and businesses with 30 Mbps and 50% of households with at least 100 Mbps by 2020	53% of households with 30 Mbps (2018)
Portugal	2020	100% of population with 30 Mbps population and a coverage of at least 100 Mbps for 50% of households by 2020	75.6% of households with 30 Mbps (2018)
Slovak Republic	2020	100% of households with 30 Mbps	85.7% of households with 30 Mbps (2018)
Slovenia	2020	96% of households with 100 Mbps and the remaining 4% with 30 Mbps	79.4% of households with 100 Mbps
Spain	2020	100% of population with 30 Mbps population and a coverage of at least 100 Mbps for 50% of households by 2020	88.2% of households with 30 Mbps (2018)
Sweden	2025	98% of households and businesses with 1 Gbps	78% of households with 100 Mbps (2018)
Switzerland	2020	100% of municipalities with 30 Mbps	99.8% of households with 30 Mbps (2019)
Turkey	2020/2023	50% of households with 100 Mbps by 2020, 100% of them with 100 Mbps by 2023	
United Kingdom	2020	95% of households and businesses with 25 Mbps	93% of households with 30 Mbps (2018)
United States	2020	80% of households with 100 Mbps/50 Mbps	90.5% of population with 100/10 Mbps (2018)

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
Sources: OECD (2018[1]), "Bridging the Digital Rural Divide" and DEO 2020 Regulatory questionnaire for the connectivity targets. Country specific sources to assess the advances with respect to the targets. For Canada: CRTC (2019[52]), *Communications Monitoring Report 2019*, https://crtc.gc.ca/eng/publications/reports/policymonitoring/2019/cmr9.htm#a3; Colombia: MinTIC (2018[53]), *Boletín trimestral del sector TIC - Cifras segundo trimestre de 2018*, https://colombiatic.mintic.gov.co/679/w3-article-80413.html; EU: European Commission (2018[54]), *Study on Broadband Coverage in Europe 2018*, https://ec.europa.eu/digital-single-market/en/news/study-broadband-coverage-europe-2018; Japan: MIC (2019[55]), *Data of Broadband Deployment in Japan*, https://www.soumu.go.jp/main_content/000371278.pdf; Poland: European Commission (2020[56]), *Country information – Poland*, https://ec.europa.eu/digital-single-market/en/country-information-poland; Portugal: European Commission (2020[57]), *Country information – Portugal*, https://ec.europa.eu/digital-single-market/en/country-information-portugal; Spain: European Commission (2020[58]), *Country information – Spain*, https://ec.europa.eu/digital-single-market/en/country-information-spain; and the United States: FCC (2020[59]), *2020 Broadband Deployment Report*, https://docs.fcc.gov/public/attachments/FCC-20-50A1.pdf.

Annex B. Expanding connectivity through a telecommunication reform that boosts competition

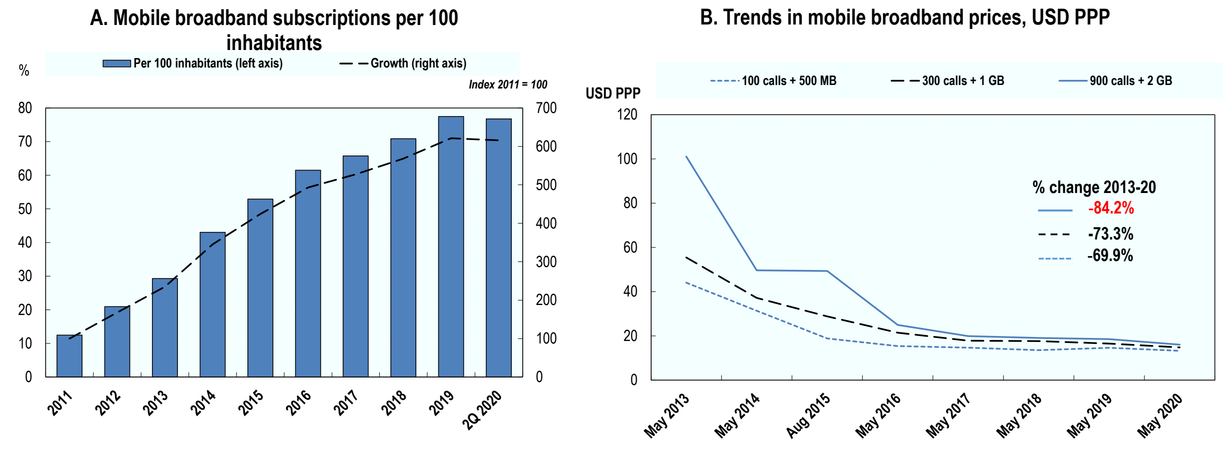
The case of the 2013 reform in Mexico and its effects on subscriptions and prices

The OECD Review of Telecommunication Policy and Regulation in Mexico (OECD, 2012[60]), released in 2012, provided recommendations for regulatory and policy reform. Since then, the Mexican telecommunication sector has experienced substantial progress. These changes stem from a reform in 2013, which closely reflected the 2012 OECD recommendations, and that led to a change in the Constitution and the development of a new telecommunication law.

The OECD Telecommunication and Broadcasting Review of Mexico 2017 assessed subsequent market developments and evaluated the implementation of the 2012 OECD recommendations (OECD, 2017[61]). It recorded the remarkable progress made in implementing policy and regulatory changes (i.e. Mexico had implemented 28 out of 31 recommendations set out in 2012). The reform created a strong, independent, and converged regulator for telecommunication and broadcasting, the IFT with the necessary tools to foster competition in a sector that was marked by very high levels of concentration for more than twenty years. Another milestone was eliminating restrictions on foreign direct investment in all telecommunication and satellite communication services, which allowed new entrants to join these markets (e.g. AT&T), boosting competition and encouraging increased availability of advanced technologies and acquisition of specialised knowledge in these markets.

The reform increased connectivity, and by doing so, it improved the lives of many Mexican citizens and “brought online” new groups of the population that were previously underserved and did not have the means to connect. Tangible benefits include the increase of over 72 million additional mobile broadband subscriptions from 2012 to 2020, which is the equivalent to slightly more than the combined population of Colombia and Chile. This allowed many people - especially from low-income households – to connect to the Internet for the first time (Figure A.B.1, side A). In addition, competition in the sector led to a sharp decline in mobile broadband prices, e.g. from around 70% to 84% for different OECD communication baskets over the 2013-20 period (Figure A.B.1, side B). Overall benefits include the elimination of national long distance calls, higher quality of communication services, and increased investment levels.

Figure B.1. Trends in mobile broadband subscriptions per 100 inhabitants (2011-20) and prices in Mexico (2013-20)



Source: OECD Broadband Portal https://www.oecd.org/sti/broadband/broadband-statistics/

Annex C. Assessing the combined fixed and mobile funding gap in the European Union

The European Investment Bank (EIB) has estimated the magnitude of the funding gap to achieve the European Union's fixed and mobile broadband objectives, as expressed in the Digital Agenda for Europe (DAE) together with the European Gigabit Strategy (EGS). The DAE requires full coverage of the European Union with basic broadband (already achieved), and seeks to further ensure that "by 2020: i) everyone in the European Union has access to much higher internet speeds of above 30 Mbps and, ii) 50% or more of households in the European Union subscribe to internet connections above 100 Mbps" (European Commission, 2010[62]).

The EGS goes much further, establishing strategic objectives by 2020 of (i) achieving availability of 5G connectivity as a fully-fledged commercial service in at least one major city in each Member State; and by 2025 of achieving (ii) "Gigabit connectivity for all main socio-economic drivers such as schools, transport hubs and main providers of public services as well as digitally intensive enterprises;" (iii) uninterrupted 5G coverage for all urban areas and all major terrestrial transport paths; and (iv) providing access to Internet connectivity offering a downlink of at least 100 Mbps, upgradable to Gigabit speed, to all households in the European Union, rural or urban (European Commission, 2010[62]).

The European Investment Bank (EIB) found that a total investment of USD 453 billion (EUR 384 billion) would be required by 2025 under the most likely assumptions. Of this, USD 149 billion (EUR 126), that is 33%, would be required to complete achievement of the 2010 DAE; USD 77 billion (EUR 65 billion), that is 17%, would be needed to meet the 5G connectivity goals; USD 111 billion (EUR 94 billion), that is 24%, would be required for rural connectivity, and USD 116 billion (EUR 98 billion), that is 26%, would be required for gigabit connectivity to companies and institutions ("socio-economic drivers").[13]

Under more ambitious goals and assumptions, the total investment to 2025 would be USD 505 billion (EUR 428 billion) instead of the USD 453 billion (EUR 384 billion) associated with the most likely scenario. Conversely, under more modest goals and assumptions, with greater reliance on wireless for rural coverage and a much smaller number of companies and institutions to be provided with Gigabit connectivity, the total investment to 2025 would amount to USD 227 billion (EUR 192 billion), or roughly half of the cost of the most likely scenario.[14]

The EIB further estimated that USD 153 billion (EUR 130 billion, that is 33% of that funding, could be expected to come from private investments, and that the remaining USD 300 billion (EUR 254 billion) represented an investment gap that would somehow have to be addressed by some combination of public policy interventions

Annex D. Example of a wholesale-only passive infrastructure operator

The case of Singapore

In 2007, the Singapore government announced plans for a national broadband network to enhance the competitiveness of the country's economy. Through a Request for a Proposal (RFP) process, the rollout of the new fibre network commenced in 2009 through the creation of OpenNet as the Network Company (NetCo). Singtel, the incumbent telecommunication carrier, was a part owner (OECD, 2019[4]). For its part, Singtel committed to transfer infrastructure to OpenNet. At the time, its chief executive officer stated that "[…] *passive network assets like ducts and manholes will no longer be a telco's competitive advantage as every service provider has equal access to the infrastructure*" (Chin, 2017[63]).

In 2011, Singtel established NetLink Trust (managed by its Trustee-Manager, CityNet) to hold the passive non-fibre infrastructure assets used to support OpenNet's deployment of the national fibre network. In August 2013, OpenNet, CityNet, NetLink Trust and Singtel submitted a consolidated application where CityNet would acquire 100% of the issued and paid-up capital in OpenNet. The application received conditional approval in November 2013. The network connects all residential homes and non-residential premises in Singapore. The wholesale-only operator provides dark fibre services to Operating Companies (OpCo) who in turn provide bandwidth services to retail service providers. These retail service providers provide retail broadband services to residential and business end-users. NetLink Trust was floated on the Singapore stock exchange in 2017 and the regulator had required Singtel to divest its majority stake in NetLink Trust (OECD, 2019[4]).

Singapore was one of the first countries to offer 10 Gbps connection to end-consumers and has now more broadband subscriptions than households. The wholesale access model allows retailers to provide any layer of service above the wholesale dark fibre layer and has allowed for significant innovation in the market by retailers that assessed demands in a way that might not have been obvious for the wholesale company. For example, MyRepublic offers a dual fibre subscription which includes two 1 Gbps lines for a household. Another offer consists in a fibre line with a mesh Wi-Fi system for a 4500 square meter Wi-Fi coverage and home automation connections (MyRepublic, 2020[64]).

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End notes

[1] For the United States, the speed threshold is 25 Mbps, and has uses percentage of population coverage rather than percentage of households covered.

[2] The OECD has two decades of experience conducting reviews of telecommunication policy and regulation that provide an overview of the challenges and achievements in a country's telecommunication sector, and putting forward recommendations. The OECD has undertaken 22 country reviews of telecommunication policy and regulation since 1999.

[3] In 2012, Mexico had one of the highest telecommunication prices in the OECD, both when measured at purchasing power parity or in United States dollar.

[4] The ACCC has the ability to declare access to these services under Part XIC of the Competition and Consumer Act 2011.

[5] The Swedish Broadband Strategy included the three following milestones. First, to achieve 95% of connected households and businesses by 2020 with broadband of at least 100 Mbps. Second, by 2023, all of Sweden should have access to reliable high-quality mobile services; and third, by 2025, 98% of the population should have access to 1 Gbps broadband in their residences and work places, the remaining 1.9% with 100 Mbps, and 0.01% with 30 Mbps (Government Offices of Sweden, 2016[24]).

[6] Using exchange rate of 9.456 SEK/USD for the year 2019 from OECD (2020[41]).

[7] Under the EECC, not all "Very High Capacity Networks" (VHCNs) are eligible for co-investments. To be eligible, they must consist of fibre up to the end-user premises or to the base station.

[8] In the context of the EECC, examples of co-investment include co-ownership, long-term risk sharing through co-financing, or purchase agreements "giving rise to specific rights of a structural character".

[9] EU Member States can only include these elements from end 2020, and before that date, only to the extent that they do not contravene the current framework.

[10] The National Telecommunication Infrastructure Information system (Sistema Nacional de Información de Infraestructura, SNII) was created by the approval of IFT's board of the "Guidelines for the delivery, registration and consultation of information to build the National Infrastructure Information System". These guidelines aimed at creating the conditions that would allow identifying the location of the infrastructure used for the provision of telecommunication and broadcasting services to promote their deployment under competitive conditions. See https://www.dof.gob.mx/nota_detalle.php?codigo=5576710&fecha=28/10/2019

[11] The predominant business model for municipal networks is one of open networks where they are physical infrastructure providers (PIP). These networks own and maintain the passive infrastructure and offer wholesale access on a non-discriminatory basis to Network Providers (NP). The NPs operate, and typically own, the active equipment and this role can be performed by incumbent operators, new independent operators and specialised broadband companies. The NPs subsequently provide capacity to ISPs (OECD, 2015[34]).

[12] Using exchange rate of 1.453358 NZD/USD for the year 2019 from OECD (2020[41]).

[13] Using the exchange Rate for 2018 of 0.847 EUR/USD from OECD (2020[41]).

[14] Idem.