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## Conference Paper

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# Deployment of high-speed broadband in rural areas in the EU: Evolution of the investment gap and alternatives to reduce it

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## Abstract

This paper uses an estimation model to calculate the investment gap that needs to be covered to meet the objectives set by the European Commission in the context of the European Gigabit Society (EGS) regarding gigabit networks availability. It analyses the evolution of this gap between mid-2017 and mid-2019 and concludes that it will not be closed in the expected timeframe at the current pace of deployment, especially in rural areas, that are affected by higher costs to deploy. The paper also introduces a high-level assessment of different alternatives that have been proposed to ease the deployment of network and foresees alternative operating models as the most likely option to help reduce the gap in these rural areas.

## 1. Introduction

During the last two years, COVID-19 pandemic has introduced major changes in every sphere of our lives. A new world order, forced by lockdowns and restrictions to mobility, have highlighted the key role of broadband connectivity to support personal communications, to enable remote working and to ensure access to education, among others.

In the current situation, the set of initiatives and proposals that the European Commission made public in September 2016 to promote the availability and take-up of high-speed connectivity among households and the main socio-economic drivers in the European Union, gains special relevance. The strategy on Connectivity for a European Gigabit Society (EGS) established one interim target for 2020, Intermediate 5G connectivity to be available as a fully-fledged commercial service in at least one major city in each EU Member State (Target 1), and three main strategic objectives for the year 2025: (i) All urban areas and all major terrestrial transport paths to enjoy uninterrupted 5G coverage (Target 2); (ii) Gigabit connectivity for all main socio-economic drivers such as transport hubs and main providers of public services as well as digitally intensive enterprises (Target 3); and (iii) all European households, rural or urban, to have access to Internet connectivity offering a downlink of at least 100 Mbps, upgradable to gigabit speed (Target 4).

However, the current status of gigabit broadband networks and the pace at which they are being deployed suggest that these targets will not be achieved on time. The gap is especially relevant in rural areas, where network operators and private capital are more reluctant to deploy broadband infrastructure, due to larger financial requirements and greater uncertainty about returns on the investment. Additionally, current lack of transparency about where coverage gaps exist, both in terms of population and territory, are an obstacle for potential interested parties and public-private initiatives to start.

This paper seeks to illustrate the progress of broadband deployment within the EGS objectives based on the evolution of the remaining investment gap to complete these targets, identifying those areas under special risk (typically rural), and also to explore and propose alternatives that would ease network rollouts in rural areas and then contribute to fill these gaps and get closer to meet coverage EGS objectives there.

Therefore, the paper is structured as follows: Chapter 2 explains the methodology and main hypothesis that support the comparative analysis of progress, the input data and its origin. Chapter 3 includes an explanation of the results, focusing on the investment gaps per target and per country and the evolution from mid-2017 and mid-2019, particularly in rural areas. Chapter 4 introduces a high-level overview on a set of alternatives that may contribute to close the gaps in rural areas. Finally, the article finishes with the authors' main conclusions in Chapter 5.

## 2. Methodology and data

Our methodological approach for the present paper follows the estimation model presented in detail in Ferrandis et al. (2021), which its main stages are reflected in Figure 1.

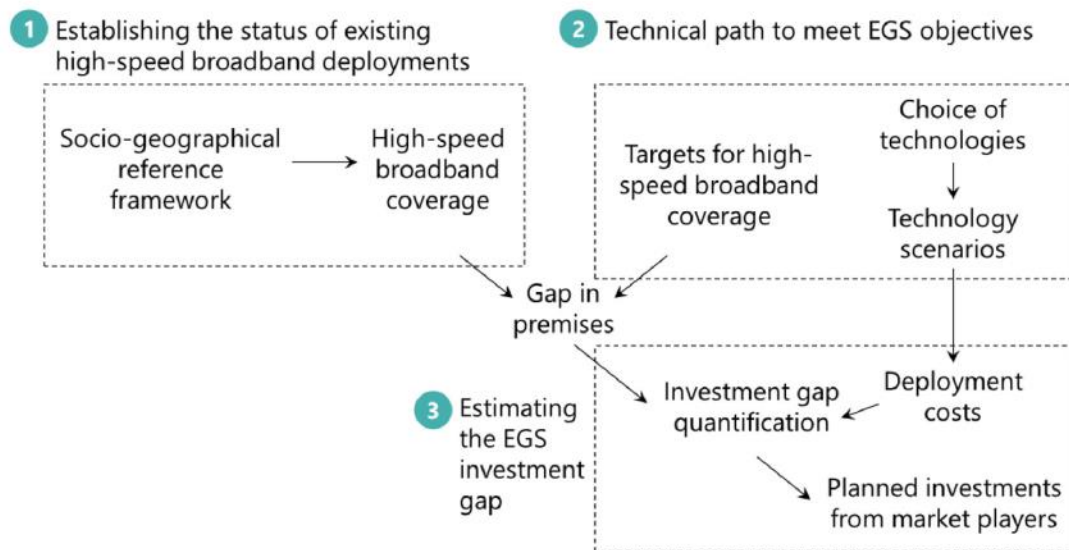


Figure 1. Diagram of the methodology used for the estimation

- (1) The model gets data on population, land area and number of households and enterprises at a NUTS3 level of aggregation from the Eurostat database. A socio-geographical reference framework is then built for every NUTS3 region as an aggregation of five different geotypes (urban, suburban, semi-rural, rural and extremely rural<sup>1</sup>) by using more granular data at a municipal LAU2 or NUTS5 level about area, population and degree of urbanisation (DEGURBA). Data on existing high-speed broadband coverage are obtained from Commission & Directorate-General for Communications Networks (2020). Since they are provided in

<sup>1</sup> Urban: >500 inhabitants/km<sup>2</sup>; suburban: 100-500 inhabitants/km<sup>2</sup>; semi-rural: 50-100 inhabitants/km<sup>2</sup>; rural: 10-50 inhabitants/km<sup>2</sup>; and extremely rural: <10 inhabitants/km<sup>2</sup>.

wide intervals, data are further refined to get a single figure for every NUTS3 region, ensuring consistency with national data available in European Commission (Digital Agenda – Digital Economy and Society Index databases).

- (2) After that, the model follows certain assumptions to select which technologies will be required to meet the different targets for high-speed broadband coverage and then the objectives set by the EGS. Few assumptions are required for objectives 1 and 2, as they already set 5G as the supporting technology. For this study, the baseline scenario is considered, which considers the deployment of a 5G network capable of ensuring “nominal quality” connectivity. However, for objectives 3 and 4, the underlying hypothesis states that all new deployments are based on fibre, following current strategy from operators in each country regarding the technology (FTTH Vs. FTTC/B), while existing fibre and cable infrastructure is reused and updated to support gigabit speeds. There is only one exception for scenario 4, that considers 5G at a nominal quality for deployments in extremely rural areas, as deployment of fibre there is very expensive and does not seem a realistic assumption for 2025.
- (3) Finally, to estimate the cost of deployment, the study combines data from relevant academic literature, studies from institutions and different references in the industry. It also includes a correcting factor that considers how prepared is every country for new broadband deployments according to the geography (how mountainous is the country), sociodemographic factors (dominant type of buildings) and regulation (sharing infrastructure precedents and laws, municipal licences and permissions). The model estimates a specific cost value for each technology and each geotype. After applying these costs to the coverage gap, investment gaps are obtained.

### **3. Main results: Evolution of the investment gap in rural areas**

Considering the general premises of the model that allows the comparison of the progress of the different EGS targets, the starting point of the analysis is the input data from the European Commission & Directorate-General for Communications Networks (2018) and European Commission & Directorate-General for Communications Networks (2020), which include coverages at mid-2017 and mid-2019, respectively. By doing this, we can estimate the investment gaps, for every target and their combination, and evaluate how they have evolved over this two-year period.

As shown in Table 1, total investment gap accounts for 262.5 b€ in mid-2019. Looking at the results by individual target, we can observe that in mid-2019 the most demanding one is Target 4, that requires a total of 140.2 b€ to be fulfilled, negatively affected by a higher number of premises to be covered and higher unitary costs corresponding to fibre deployments to reach premises in rural areas. Target 3 follows, requiring 83.7 b€ for the same reasons. Target 2 is less demanding and requires 52.5 b€, benefitted from the lower cost of deployment for 5G when compared with fibre. Investment needed for Target 1 is the lowest in the ranking, with 12.8 b€, thanks to a lower number of premises that need to be covered, only those in the capital of every country.

	TARGET 1	TARGET 2	TARGET 3	TARGET 4	ALL TARGETS
Mid-2017	12.7	52.3	99.7	173.2	307.6
Mid-2019	12.8	52.5	83.8	140.2	262.5

Table 1. Evolution of the investment gap (in billion euros)

Total gap has reduced from 307.6 b€ in mid-2017 down to 262.5 b€ in mid-2019. The main reason for this 45.1 b€ reduction lays in the increase in the coverage of high-speed broadband networks capable to provide 1 Gbps, that has driven a reduction of 15.9 and 33 b€ on the investment gap for Targets 3 and 4, respectively. However, the gaps for Targets 1 and 2 have slightly increased during the period, negatively affected by a rise in the number of households and in labour costs during the period and the fact that most 5G deployments were still to be implemented and EC does not include data of 5G coverage in its data set.

Aggregating the results for all the NUTS3 regions within each country, we can obtain the gaps on a national basis. As shown in Figure 2, largest gaps in mid-2017 were in France (81.3 b€), Italy (59.0 b€) and Germany (44.7 b€). This three countries account for almost 60% of the total. Lower investment is required to fulfil the EGS objectives in Malta, Cyprus, Luxembourg, Latvia and Estonia.

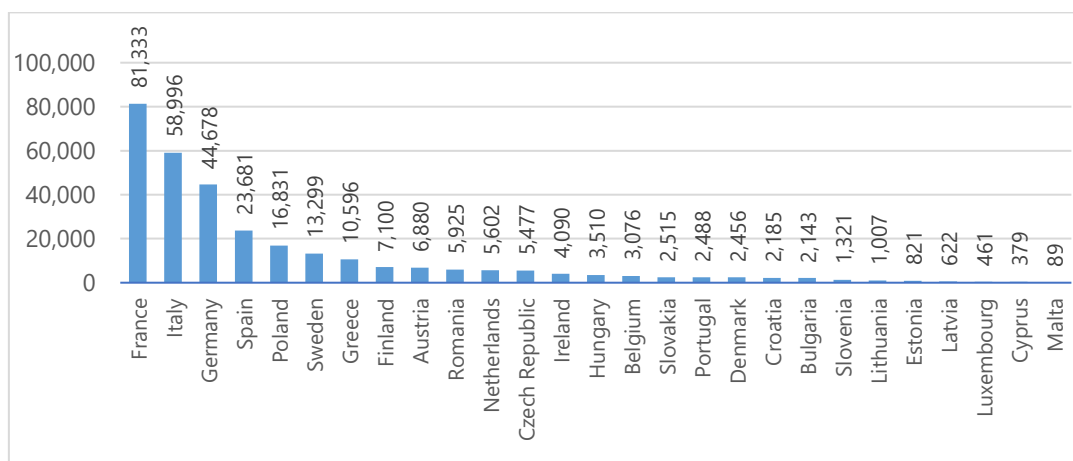


Figure 2. Investment gap to meet EGS targets in mid-2017 (in million euros)

Figure 3 updates this analysis for mid-2019, showing that largest gaps remain in France (75.5 b€), Italy (45.7 b€) and Germany (31.3 b€). This three countries account for almost 60% of the total gap. Lower investment is required to fulfil the EGS objectives in Malta, Luxembourg, Cyprus, Latvia and Estonia. The case of Malta deserves a particular distinction, as it is the only country where Target 3 and Target 4 are already achieved, as 1 Gbps broadband coverage reaches 100%.

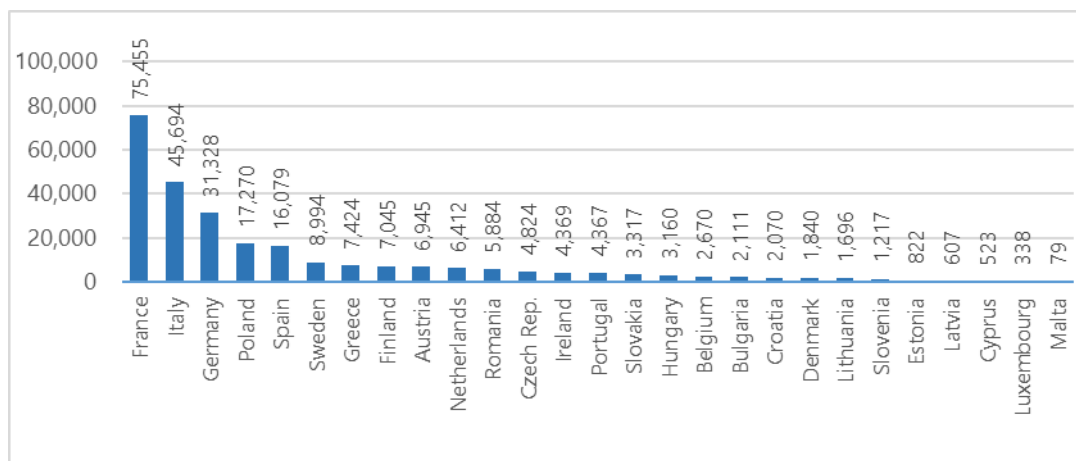


Figure 3. Investment gap to meet EGS targets in mid-2019 (in million euros)

It is worth noting that, when analysing the results for every country individually, some inconsistencies can be found. In some cases, for instance, the investment gap has increased significantly, mostly due to significant changes in the input data. This is the case of Lithuania, where the gap grows by a 70%. New data set allows a more accurate allocation of premises across geotypes, that result in a higher proportion of them in rural areas, where costs to deploy are higher. It is also the case of Portugal, where the gap grows by a 75%, given the EC data for mid-2019 considered a value for 100 Mbps coverage that is lower than the one reported in mid-2017, and so leads to greater gap in premises that requires a larger investment to be covered.

The evolution of the total investment gap during the two years from mid-2017 to mid-2019 suggests that it is not closing fast enough to presume that EGS objectives for 2025 might be achieved. Considering that the pace of reduction keeps constant at a 22.5 b€ yearly reduction, we can estimate a gap of approximately 125 b€ pending to be closed by the year 2025.

Table 2 and Table 3 include the detail of the investment gap per country and per target. When aggregating the four different scenarios to estimate the total amount of investment required, it must be taken into account that there exist some overlaps among them. In particular, Target 1 already includes Target 2 for those urban geotypes within the capital city of each country. Additionally, part of Target 3 is already covered by Target 4.

	COUNTRY	TARGET 1	TARGET 2	TARGET 3	TARGET 4	ALL TARGETS
AT	Austria	486.5	1187.5	2230.5	3933.9	6879.9
BE	Belgium	287.8	1118.7	735.2	1359.6	3076.1
BG	Bulgaria	126.8	493.0	722.3	1069.7	2143.3
CY	Cyprus	151.4	82.8	100.1	146.3	378.6
CZ	Czech Rep.	175.7	762.9	2352.3	2916.4	5476.6
DE	Germany	764.3	8807.1	10733.9	26483.7	44678.2
DK	Denmark	203.2	937.0	546.7	1120.7	2455.7
EE	Estonia	84.6	163.4	407.7	264.5	821.3
EL	Greece	666.3	1012.0	4466.0	5613.9	10596.1
ES	Spain	1267.0	6542.7	7820.5	9986.2	23680.7
FI	Finland	522.9	1401.6	2993.8	2851.7	7100.2

	COUNTRY	TARGET 1	TARGET 2	TARGET 3	TARGET 4	ALL TARGETS
FR	France	3575.6	10907.4	25837.7	50262.9	81333.3
HR	Croatia	80.1	327.7	634.6	1374.3	2185.0
HU	Hungary	200.0	635.7	1102.8	2037.6	3510.0
IE	Ireland	270.6	602.0	1422.6	2393.3	4090.4
IT	Italy	1161.0	6410.2	20257.2	36029.7	58996.2
LT	Lithuania	190.1	366.1	268.6	431.6	1006.9
LU	Luxembourg	178.2	52.3	107.1	160.6	460.6
LV	Latvia	70.3	128.7	298.3	225.1	622.3
MT	Malta	53.5	31.3	14.1	16.3	89.0
NL	Netherlands	392.2	3153.1	1136.0	1654.9	5601.5
PL	Poland	184.6	2057.2	6192.0	10164.0	16830.6
PT	Portugal	408.8	902.8	956.7	1017.7	2488.5
RO	Romania	166.2	1075.9	1664.8	3569.1	5924.8
SE	Sweden	816.1	2661.0	4991.6	5932.3	13299.0
SI	Slovenia	117.6	168.7	477.6	723.1	1320.5
SK	Slovakia	87.4	287.5	1229.8	1424.5	2514.8
EU-27		12688.5	52276.0	99700.4	173163.6	307560.0

Table 2. Detail of the investment gap in mid-2017 (in million euros)

	COUNTRY	TARGET 1	TARGET 2	TARGET 3	TARGET 4	ALL TARGETS
AT	Austria	481.6	1176.5	2167.3	3990.9	6945.1
BE	Belgium	282.8	1193.1	567.5	1041.0	2669.6
BG	Bulgaria	122.7	533.2	641.0	1064.2	2110.6
CY	Cyprus	161.8	88.0	149.6	223.4	523.4
CZ	Czech Rep.	193.1	828.4	2007.8	2443.2	4823.5
DE	Germany	780.6	8796.5	6499.9	17127.7	31327.8
DK	Denmark	206.6	720.3	373.5	814.9	1839.8
EE	Estonia	93.5	174.6	371.8	277.5	822.4
EL	Greece	642.8	1223.7	2795.2	3890.5	7424.2
ES	Spain	1297.5	6492.3	4851.8	5203.9	16078.8
FI	Finland	538.2	1410.7	2954.9	2751.7	7044.5
FR	France	3588.6	10837.4	24380.5	44726.6	75455.1
HR	Croatia	80.4	326.0	613.3	1255.1	2070.0
HU	Hungary	205.5	679.2	1004.3	1702.2	3160.0
IE	Ireland	303.0	617.4	1460.0	2521.4	4368.5
IT	Italy	1137.2	6616.0	16144.8	25944.7	45693.9
LT	Lithuania	125.7	265.1	617.1	884.0	1695.7
LU	Luxembourg	190.8	56.2	50.1	78.3	337.8
LV	Latvia	74.7	143.1	264.8	226.4	607.1
MT	Malta	72.3	40.3	0.0	0.0	78.9
NL	Netherlands	402.2	3066.3	1399.0	2203.3	6412.1
PL	Poland	195.9	2140.0	5849.8	10582.1	17269.9
PT	Portugal	412.1	902.1	1790.8	1980.6	4366.6
RO	Romania	177.9	1146.9	1677.9	3375.6	5883.5
SE	Sweden	828.7	2513.5	3127.6	3498.3	8994.3
SI	Slovenia	127.3	180.0	408.9	651.5	1217.3

	COUNTRY	TARGET 1	TARGET 2	TARGET 3	TARGET 4	ALL TARGETS
<b>SK</b>	<b>Slovakia</b>	94.5	304.6	1593.2	1760.8	<b>3316.9</b>
<b>EU-27</b>		<b>12817.8</b>	<b>52471.3</b>	<b>83762.6</b>	<b>140219.8</b>	<b>262537.4</b>

Table 3. Detail of the investment gap in mid-2019 (in million euros)

Table 4 includes a deeper analysis of the investment gap in accordance with the different geotypes, showing that 63% of the total gap corresponds to rural areas, that requires 165.4 b€ in comparison to the 97.2 b€ needed to cover urban areas. In the case of Target 1 (5G connectivity to be available as a fully-fledged commercial service in at least one major city in each EU Member State), urban areas account for 93% of the gap. This result is biased by the assumption followed in the model making a major city equivalent to the capital of every country, where most people live in high-density areas. For the Target 2 (all urban areas and all major terrestrial transport paths to enjoy uninterrupted 5G coverage), urban geotypes account for 78% of the gap, as it could be derived by the own definition of the target. In the case of Target 3 (Gigabit connectivity for all main socio-economic drivers such as transport hubs, and main providers of public services as well as digitally intensive enterprises) and Target 4 (all European households, rural or urban, to have access to Internet connectivity offering a downlink of at least 100 Mbps, upgradable to gigabit speed), the result is the opposite, with rural areas accounting for 74% of the total required investment, as the lower number of premises in these areas is more than offset by larger gaps to cover and higher unitary cost of fibre deployments. The only exception comes from extremely rural regions, where the model considers that 5G, and not fibre, is the technology chosen for deployments.

	TARGET 1	TARGET 2	TARGET 3	TARGET 4	ALL TARGETS
Urban	9.8	37.5	2.7	5.4	45.0
Suburban	2.2	3.4	19.0	31.4	52.1
Semi-rural	0.5	3.5	29.4	56.5	83.2
Rural	0.3	5.0	24.1	44.4	68.2
Extremely rural	0.0	3.2	8.5	2.5	13.9
<i>Total urban</i>	<i>12.0</i>	<i>40.9</i>	<i>21.8</i>	<i>36.8</i>	<i>97.2</i>
<i>Total rural</i>	<i>0.8</i>	<i>11.6</i>	<i>62.0</i>	<i>103.4</i>	<i>165.4</i>
<b>TOTAL</b>	<b>12.8</b>	<b>52.5</b>	<b>83.8</b>	<b>140.2</b>	<b>262.5</b>

Table 4. Split of investment gap in mid-2019 among geotypes (in billion euros)

As mentioned before, the gap does not seem to be closing fast enough. In addition to this, and as 5G deployments gain in importance, as it is happening for the last years, it seems reasonable to think that new investments could help reduce gaps for Target 1 and Target 2, but at the expense of Target 3 and Target 4, which will probably prevail as the most significant ones (even more if we consider that further deployments in rural areas will be less attractive for current stakeholders due to the higher costs and the worse business cases).



Furthermore, European Commission (2022) recognizes that the probability to meet the EGS objectives is low in most of the countries, especially for the objective of ensuring access to download speeds of 100 Mbps upgradable to 1 Gbps for all (Target 4). For this target, this probability is qualified as low for eighteen countries, as medium-low for another one, as medium for other six and it is only high for two, Denmark and Latvia. This report also recognizes that the main challenge lays on the deployment of gigabit networks in remote and rural areas.

#### 4. Alternatives to reduce the gap

According to the results presented before and given the need to progress on the EGS Targets completion, the present section introduces a high-level overview of different options that have been identified from a preliminary desk research as potential alternatives for operators to ease the deployment of broadband networks in rural areas. Considering the leading role of operators to impulse network deployment, the aim of this analysis is to provide a first assessment of which alternatives might contribute positively and constitute a real option to achieve the objectives set for the European Gigabit Society, given the current market conditions and expectations.

As a first attempt to structure the analysis of the different options, we propose a framework comprising three different categories, according to its nature or the stakeholders involved: (i) alternative technologies, (ii) alternative operating models, and (iii) public policy and regulation. Table 5 includes a summary of the main pros and cons of the different alternatives, that are further discussed in the next paragraphs.

		<b>Pros</b>	<b>Cons</b>
<b>Alternative technologies</b>	Satellite	Great coverage, leveraging a global footprint	Poor performance Expensive customer equipment
	Satellite + wireless	Lower cost to deploy and cheaper customer equipment	High operational costs
<b>Alternative operating models</b>	Local communities / public private partnerships	Evidence of some contribution to reduce the digital divide	Uncertain scalability and long-term sustainability
	Partnerships between operators and other players	Lower financial risk	Probably not willing to cover extremely remote areas
<b>Public policy and regulation</b>	Public funds / Direct aids	Selective focus to cover less attractive rural areas	Risk of disincentivising private investment and/or distorting competition

Geographic regulation segmentation	Larger areas with higher facility-based competition	Risk of derive investment towards competitive unregulated areas at the expense of regulated ones
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Table 5. Assessment of alternatives to deploy networks in rural areas (own elaboration based on existing literature and market intelligence reports)

### Alternative technologies

Evolution of technology has traditionally been a key lever to increase performance of broadband networks and to reduce the cost of deployments. However, along this evolution, fixed technologies have always been ahead in terms of performance, outpacing wireless technologies. Now, there exists the consensus in the industry that fibre is the only technology able to provide gigabit connectivity to households and enterprises at a great scale. That is, indeed, the hypothesis in the estimation model used in this paper, which only considers 5G to cover extremely rural areas due to the high cost of deploying fibre in this geotype.

This high cost erases any incentive that private companies might have to cover these areas and increases the amount of budget that public bodies need to dedicate to extend gigabit connectivity there. That is the reason why other technologies are constantly monitored to have an updated assessment on the possibility that, under some circumstances, they could constitute an alternative to fibre. Satellite connectivity is one example.

For the last twenty years, satellites have been considered as an option to offer communications services and Internet access in those areas where no other technology reaches. The main reason for that is their global coverage. Once put into orbit, satellites illuminate a large area of land, that can comprise several countries, so that they can offer connectivity to any premise inside this footprint, independently of its location. However, limitations in terms of performance and costs prevent pure satellite networks, where satellites establish direct communication with end users, from being an option for every person in the world. It would require, for example, customer equipment that can reach a price of 800 dollars.

As an alternative, some combinations of satellite with other technologies have been explored. Chiha et al. (2020) analyses the techno-economic viability of hybrid solutions, with satellite supporting the backhaul network and wireless 4G used for the access network that connects to the end user. This solution would allow a reduction in the investment required to provide connectivity and alleviate the cost for the end customers, as 4G devices can be used to access to the network. However, it presents a significant drawback in the shape of high operational costs, that would increase the total cost of ownership and reduce the appeal from a financial perspective.

Currently, and from a technological point of view, it is difficult to envisage an alternative to fibre that could meet the ambitious targets set by EGS in terms of performance and speed. Most of the hopes seems to be placed on the own evolution of fibre technologies or in new ways of deploying fibre networks that could bring a reallocation of incentives among all the stakeholders.

## Alternative operating models

During the last two decades, several proposals have appeared that rely on local communities and public private partnerships (PPP) for the rollout of broadband networks. Gerli & Whalley (2021) analyses the impact that PPPs and local communities have had on the digital divide by addressing market failures. It concludes that these projects can be successful and then contribute to the reduction of the digital divide, although scalability and long-term sustainability remain unclear, and they have failed to ensure a wide coverage of superfast broadband. Uncertainty about scalability and sustainability lead us to think that any positive effect on the reduction of the coverage gap will be limited.

In this context, several operators are looking for new ways to fund the deployment of fibre networks, leveraging partnerships with new players in the market that bear a significant part of the investment. Telefonica, for example, in 2020 created a joint venture in Germany with insurance company Allianz, under the name Unsere Grüne Glasfaser, to deploy fibre to pass two million homes in underserved rural and semi-rural areas, aiming to invest five billion euros during six years<sup>2</sup>. Additionally, they are currently looking for a partner to create a new company in Spain that will own a part of current fibre network, comprising 2.5 million homes in rural areas, and that will deploy new fibre to reach another 2.5 million<sup>3</sup>.

Another leading European operator, Orange, sold 50% of its fully controlled company Orange Concessions to La Banque des Territoires (Caisse des Dépôts), CNP Assurances and EDF Invest in 2021. Orange Concessions operates 23 networks, on behalf of local public authorities, that are open to all operators and represent 4.5 million existing and planned connections<sup>4</sup>. The transaction will help Orange to reach its ambitions while sharing required investment. Also in 2021, Orange Polska announced an agreement with APG, a society that manages pension funds in The Netherlands, to create of a joint venture to support the rollout of fibre for 1.7 million houses in areas of Poland where high-speed broadband networks are limited or inexistent<sup>5</sup>.

These are only a few examples among several initiatives of this type that are taking place across European markets. In most cases, these new companies aim at deploying networks in rural areas. The infrastructure is then rented, following a wholesale business model, to any telecom operators that sells connectivity services to the end users on top of it.

With this strategy, operators aim to alleviate the capital requirements and reduce the financial risk linked to network deployments. This would make them more willing to cover less densely populated areas that, otherwise, would have remained unattended. This might have a positive effect on the proliferation of gigabit connectivity and reduction of the gap in rural areas, but this effect has not been quantified yet.

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<sup>2</sup> <https://www.telefonica.com/en/communication-room/telefonica-and-allianz-create-a-partnership-to-deploy-fibre-in-germany-through-an-open-wholesale-company/>

<sup>3</sup> <https://www.bolsamania.com/noticias/empresas/telefonica-espera-obtener-500-millones-45-fibra-rural-espana--9896685.html>

<sup>4</sup> <https://newsroom.orange.com/to-support-its-fibre-development-in-rural-areas-and-underline-the-value-of-its-infrastructure-orange-creates-orange-concessions-through-a-partnership-with-long-term-investors/?lang=en>

<sup>5</sup> <https://newsroom.orange.com/orange-partners-with-apg-for-the-deployment-of-an-additional-1-7m-ftth-plugs-in-poland-through-a-50-50-joint-venture-valued-at-605-million-euros/?lang=en>

## Public policy and regulation

Even in the case that previous trends have a positive effect and contribute to reduce the investment gap in rural areas, certain regions will never be commercially viable and remain unattended. In these areas, selective public intervention will be required to achieve the objectives of universal gigabit coverage.

In this sense, the European Commission and the EU Member States have been very active in the last twenty years in dedicating public funds to the deployment of broadband infrastructure. Bourreau et al. (2020) reviews all the initiatives during the period 2003-2018 and concludes that in 95% of the cases the focus has been focused on the supply side, with a particular aim of extending broadband coverage, as 86% of the initiatives applied to white areas, those where there exists no provider of connectivity. In the first years, public funds were linked to “Basic Broadband”, but “Fast Broadband” and “Ultrafast Broadband” have gained relevance at the end of the period.

Financial instruments committed by the European Union for the next years can represent a good opportunity for funding the deployment of broadband infrastructure. According to European Commission (2022), 2021-2027 Multiannual Financial Framework, with a budget of 1.21 trillion euros, and the temporary instrument of Next Generation EU, with additional 807 billion, open new opportunities, as some of these funds aim to “ensure comprehensive 5G and fibre coverage”, “large-scale deployment of 5G corridors and smart traffic management systems along transport pathways”, “enable universal and affordable access to gigabit connectivity in all urban and rural areas”, “investments in very high-capacity broadband infrastructure”, with especial focus on white areas.

The introduction of this type of aids requires special care and a close monitoring of the market, as they may negatively affect willingness to invest by existing players and could also alter competition. In the literature we can find evidence of both positive and negative effects on these variables, so no clear conclusion about this can be extracted.

Public bodies can also have an influence on the proliferation of gigabit networks through regulation. European Commission (2021) argues that, in addition to state aid and financial instruments, regulation is one of the favourable conditions for the rollout of high-speed broadband networks in the EU. Infrastructure based competition, for example, has been a key driver for deployments. It can be encouraged through different measures, as asymmetric and symmetric access regulation (to civil works, ducts), local and virtual unbundling, etc.

Frias & Martínez (2019) analyses the effect of the regulation in Spain and identifies the key role that “an investment-friendly regulatory framework, which did not mandate access to the optical loops” has played for the deployment of fibre networks in this country. This paper includes the concept of geographic segmentation, that was introduced in Spain by the regulation approved in 2016, and obliged operators to offer virtual unbundled local access (VULA) over their infrastructure in non-competitive areas. This obligation didn’t affect to networks deployed in the 66 municipalities that were tagged as competitive areas, where only access to ducts and vertical drops needed to be ensured. The study concludes that “a hypothetical VULA for fibre networks following a market analysis in 2013 would have led to a larger proportion of households being left out of the coverage of any NGA infrastructure” while “the areas benefiting from full NGA facility-based competition would have also been larger, as the investments would have been primarily received on competitive unregulated

areas". In this particular case, regulatory measures do not seem to contribute to extend coverage of high-speed broadband networks.

## 5. Conclusions

This paper uses an estimation model to quantify the investment required for the rollout of high-speed broadband networks to meet the four objectives set in the Strategy on Connectivity for a European Gigabit Society for the year 2025. It also analyses the evolution of this investment gap between mid-2017 and mid-2019 and concludes that it is not likely to be closed at the current pace of deployment. The focus of the analysis is set on rural areas, where gaps will probably remain, as operators find lower incentives due to higher costs to deploy.

Finally, the paper introduces a high-level assessment of different alternatives that have been proposed to ease the deployment of network in these areas and that might contribute to close the gap. It concludes that, although it is difficult to envisage a technology that could replace fibre, alternative operating models might help operators share the investment and the risk in less attractive rural areas and then have a positive effect on reducing the gap. Other measures linked to public policies and regulation might also contribute positively, although they may distort competition or potentially disincentivize investment by operators.

Further research is required to have full picture and a deeper understanding of all potential alternatives. Future work might also be oriented to include some of these alternatives in the estimation model and quantify its effect on the investment gap.

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