NERA
ECONOMIC CONSULTING

# Telecommunications Infrastructure International Comparison

## A Report for the Department for Digital, Culture, Media and Sports

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## EXECUTIVE SUMMARY

The Department for Digital, Culture, Media and Sports (DCMS) has asked NERA Economic Consulting (NERA) to conduct an international comparison how the deployment of ultrafast telecommunications infrastructure has worked in six countries: Australia, France, Germany, New Zealand, Spain and Sweden. DCMS instructed NERA to focus on the deployment of fibre-to-the-premises (FTTP) networks; fibre backhaul for mobile networks; and how those countries were preparing for the deployment of fifth-generation (5G) mobile networks and services. DCMS also asked NERA to identify which of those experiences could be relevant inputs to policy making in the United Kingdom.

We have identified those countries to follow five different policy models to foster FTTP deployment:

(1) **Unregulated infrastructure competition between private operators**. No asymmetric ex ante regulation is imposed on fibre connections. This is the case in urban areas in Spain and France.

(2) **Regulated infrastructure competition between private operators**. The incumbent operator's fibre services are subject to asymmetric ex ante regulation. This is the case in Germany.

(3) **Nominated regional networks with public funding**. This is the case in urban areas in New Zealand, where the government tendered public subsidies to private operators who committed to deploy wholesale-only FTTP networks in an area on a non-exclusive basis.

(4) **State-owned regional networks that compete with other networks**. This is the case in Sweden, where municipalities deployed wholesale-only networks to compete with incumbent telecommunications and cable operators.

(5) **State-owned monopoly national network**. This is the case in Australia, where the government set up a national network operator who acquired all other networks to build a monopoly.

Because of the different economics and market dynamics of different customer segments and different geographies, we have organised our analysis in four sections: urban FTTP development; rural ultrafast broadband deployment; corporate and mobile backhaul services; and 5G readiness.

This division is consistent with the fact that most countries have applied different policies in different geographic areas (Figure 1).

**Figure 1**
**Policy models applied to urban and rural areas**

| Policy | | Urban | Rural |
|---|---|---|---|
| Market-driven infrastructure competition | ① Unregulated Fibre |  | |
| | ② Regulated Fibre |  | |
| Public-Private Partnership | ③ Open to infrastructure competition |  |  |
| | Franchise Monopoly | - | - |
| Government led | ④ Infrastructure Competition |  |  |
| | ⑤ Infrastructure Monopoly |  |  |

**Urban FTTP development**

All countries in the sample have extensive next-generation access (NGA) deployments. The three countries with the most extensive FTTP deployments are New Zealand, Spain and Sweden. In contrast with them, some of the others have relied on VDSL or cable instead of FTTP for all or part of their territory (Germany and partially Australia).

Best practices have followed different policy approaches:

- Spain implemented **unregulated infrastructure competition between private operators**, using regulated access to the incumbent's ducts. This model has also been successfully implement in very dense areas in France, and in countries outside our sample such as Portugal, the US, Brazil and Chile.
- Sweden implemented **state-owned regional networks that compete with other networks** (municipal networks and an incumbent telecommunications operator partially owned by the central government).
- New Zealand implemented **competition for the market** through **tenders that granted public funding to nominated wholesale-only regional networks with public partnership,** in exchange for their commitment to deploy an FTTP network in specific geographic areas. Services are delivered at negotiated prices and operators are not granted exclusivity in their areas.

We have identified some factors that are present in most or all of best practices, and less frequently or never in countries with lower FTTP development.

- Deregulation or flexible regulation of fibre services;
- Access to passive infrastructure;
- Active measures to decrease the cost and time required to deploy fibre cables in the final drop of the local loop (from the street cabinet to customer premises);

- Infrastructure competition is fostered, or at least permitted;
- Administrative processes are lean.

We have also identified other common trends:

- Large FTTP deployments have resulted in increased infrastructure competition;
- Countries with vertically integrated and wholesale-only operators have similar outcomes;
- In countries with vertically integrated operators, consolidation and fixed-mobile convergence at the retail level are associated with larger FTTP deployments;
- Wholesale-only networks require public funding in all cases in the sample, because they have been unable to make a profit that covers private investors' cost of capital.

**Rural ultrafast broadband**

Rural ultrafast broadband policies in all of the analysed countries have relied on public support and the partial use of wireless technologies.

Public subsidies are usually offered to **nominated operators to deploy regional networks** in tenders that foster competition for the market in a given geographic area.

- The franchise model (legal exclusivity in a given area) is untested in the countries that we analysed.
- State-owned operators are not deploying FTTP in rural areas, except municipal networks in some parts of France and a few places in Germany.
- In addition to financial support, operators sometimes receive other help that contributes to lower their costs, such as privileged access to existing passive infrastructure or streamlined permits.

Wireless networks play an important role in rural NGA deployment.

- Rural coverage obligations were attached to 4G spectrum licences and are likely to be attached to 5G licences.
- Satellite and fixed wireless access solutions have been included in some rural broadband plans.
- Technologically neutral tenders have sometimes resulted in wireless solutions being chosen.

**Corporate and mobile backhaul fibre services**

Business customers and mobile operators demand different services to residential customers. Corporate networks often require fibre links. Mobile backhaul is more reliant on fibre with each generation (quite reliant for 4G and critically reliant for 5G).

Larger business customers generally have few problems with access services. They lease competitive services in many areas with network competition and regulated leased lines or active broadband services in less competitive zones. Fibre connections are usually available on-demand even in areas where there is no FTTP deployment, usually at a higher price than in metropolitan areas.

Mobile operators that do not own a fixed network have to build their own fibre links or rely on fibre backhaul supplied by third parties. Some countries have implemented policies to ease mobile operators' access to fibre backhaul.

- Wholesale-only network operators sell fibre for backhaul as one of their services.
- Mobile operators have the right to lease ducts to deploy mobile backhaul in Spain and France. In Spain, they have the right to lease dark fibre when there is no free space in ducts.

**5G readiness**

The analysed countries are launching 5G national plans to make their digital sector ready for 5G. All 5G plans analysed take a comprehensive perspective. That is, they look at spectrum planning and at other issues beyond radio expected to be critical to 5G deployment:

- Timely allocation and release of spectrum in 5G bands;
- Test beds of 5G equipment and services; and R&D in applications and equipment related to high priority use cases; and
- Removal of barriers to 5G deployment: streamlining building permit processes, reviewing competitive conditions to relax competition law barriers to active network sharing, etc.

In Sweden, there is not a separate 5G plan. All types of ultrafast technologies are considered together in the Completely Connected Sweden plan.

# 1. INTRODUCTION

Broadband communications networks are key to social and economic development in the 21st century. The most developed countries in the world are implementing policies to ensure that they have best-in-class connectivity for business and residential subscribers so they remain competitive in a global world.

The Department for Digital, Culture, Media and Sports ('DCMS') has asked NERA to look at international policies meant to foster the deployment of Gigabit Next Generation Access Networks ('NGANs'), specifically Fibre to the Premise ('FTTP') and Fifth Generation ('5G') networks. This report covers the experiences of six countries with profiles in many aspects similar to the UK: France, Germany, Spain, Sweden, Australia, and New Zealand. In addition to our own research, we have relied on the answers received to a questionnaire we sent to authorities, operators, academics and trade associations from those countries.

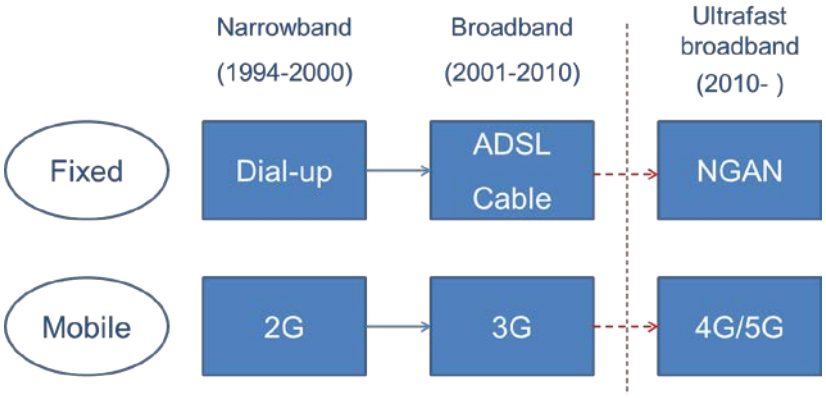
We examine policies and outcomes associated with different geographies (urban versus rural) and customer segments (residential, business, backhaul), and present findings regarding the types of policies that have proven most effective in these six countries. Specifically, the first three sections examine FTTP developments for residential urban broadband services (section 2), rural broadband services (section 3), and business services, including backhaul (section 4). Section 5 reviews these countries' 5G strategies and plans. Section 6 presents our conclusions.

First, however, the remainder of this introduction presents a brief history of the development of broadband technologies and networks (Section 1.1.) and explains why the deployment of FTTP and 5G technologies presents unique challenges compared with prior technological transitions (Section 1.2).

## 1.1. Development of Ultrafast Broadband Networks

Broadband development has occurred in three consecutive waves of network technology and investment. Mass data communications were introduced in the mid-1990s with the opening of the Internet and the introduction of narrowband fixed and mobile data services over the existing voice networks at speeds below 100 kbps. Broadband services followed in the late 1990s using packet switching network technologies specifically devoted to data communications. These technologies were asymmetric digital subscriber line ('ADSL'), cable modems, fibre optics, 3G mobile, Wi-Fi, and digital satellite – services with speeds in the range of 200 kbps to 25 Mbps. As user requirements for speed grew, superfast and ultrafast technologies were devised to deliver connectivity at speeds faster than 30 Mbps; technologies called NGANs.

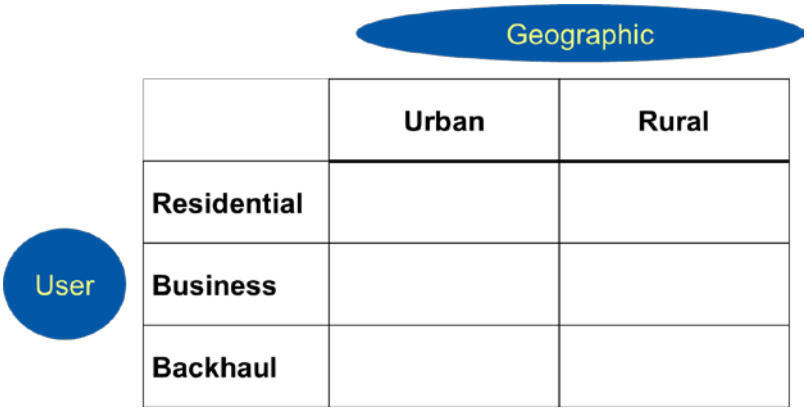
**Figure 2. Evolution of Broadband Networks**




NGAN technologies include FTTP, cable modems using DOCSIS 3.0 and 3.1 standards, very-high-bit-rate digital subscriber line ('VDSL') in wired networks, and WiMAX, 4G, and 5G in wireless networks. Of them, FTTP, cable modems, and 5G have the potential to deliver services at gigabit speeds. VDSL modems using G-Fast technology are also expected to deliver speeds close to 1 Gbps in the right environment.[1]

Different customer segments and diverse geographic settings require unique solutions. Because of differences in demand, service offerings often are different for individual consumers as opposed to businesses (especially large corporates) as are the supporting networks for telecommunications operators (especially mobile backhaul). In addition, because of strong differences in network economics, solutions in rural areas tend to be different from in urban ones. Therefore, we separately consider each of those settings.

**Figure 3. Clusters for Ultrafast Broadband Solutions**




## 1.2. Policy models

The countries in our sample follow different policies to foster FTTP deployment. We have summarized them in the following five policy models:

[1] The International Telecommunications Union (ITU) reports that recent trials of G.Fast have delivered speeds faster than 1 Gbit/s at distances between 35-70 meters using good quality cabling and vectoring. It quotes Nokia stating that G.Fast would "eventually support 2Gbit/s or more at 100 meters." ITU News, 'New G.fast trials bring new deployment scenarios of the ITU technology', March 27, 2017, http://news.itu.int/615-2/

(1) **Unregulated[2] infrastructure competition between private operators**. This is the case of urban areas in Spain and France, where no asymmetric ex ante regulation was imposed.

(2) **Regulated infrastructure competition between private operators**. This is the case of Germany, where the incumbent operator's fibre services are subject to ex ante regulation.

(3) **Nominated regional networks with public funding**. This is the case of urban areas in New Zealand, where the government tendered public subsidies to private operators who committed to deploy wholesale-only FTTP networks in an area on a non-exclusive basis.

(4) **State-owned regional networks that compete with other networks**. This is the case of Sweden, where municipalities deployed wholesale-only networks to compete with incumbent telecommunications and cable operators.

(5) **State-owned monopoly national network**. This is the case of Australia, where the government set up a national network operator who acquired all other networks to build a monopoly.

Because of the different economics and competitive dynamics in urban and rural areas, most countries have applied different policies in different geographic settings (Figure 4).

**Figure 4**
**Policy models applied to urban and rural areas**

| Policy | | Urban | Rural |
|---|---|---|---|
| Market-driven infrastructure competition | ① Unregulated Fibre |  | |
| | ② Regulated Fibre |  | |
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| | Franchise Monopoly | - | - |
| Government led | ④ Infrastructure Competition |  |  |
| | ⑤ Infrastructure Monopoly |  |  |

The number of case studies available for each model is small. Because of this, we cannot perform a statistical analysis linking policy model and performance. To overcome this limitation, we perform a more granular analysis by reviewing the influence on performance of specific drivers.

[2] We use the term "unregulated" in this report to describe operators that had no asymmetric obligations imposed on their wholesale fibre services, nor were they forced to functional or structural separation of network and retail activities. They are usually subject to other regulatory obligations, including asymmetric, such as duct and pole access.

## 1.3. The Challenge of FTTP and 5G Deployment

Deployment of some ultrafast broadband networks technologies occurred mainly through incremental investment in existing networks. For example, broadband cable networks only require the replacement of electronic equipment and some densification of cabinets to upgrade to DOCSIS 3.0. VDSL requires the deployment of active equipment and fibre links to existing street cabinets but reuses the final (and more expensive) drop of the copper local loop. 4G mobile can reuse the base station grid of existing 2G and 3G networks at similar frequency bands; it requires backhaul at higher speeds than 2G and 3G, but there is fibre available in most places and microwave radio links can sustain the backhaul speeds needed.

However, FTTP and 5G architectures require a full upgrade of the network. FTTP fibres have to be deployed all the way to customers' premises, and their much longer loop lengths allow for a significant reduction of central offices. 5G networks have a much denser antennae grid than 4G with backhaul at much higher speeds that in most cases would require a dense fibre network to support 5G backhaul. Therefore, it makes sense to look at FTTP and 5G deployments in a holistic way, that is, to examine the implications of these technologies for the architecture of the entire network.

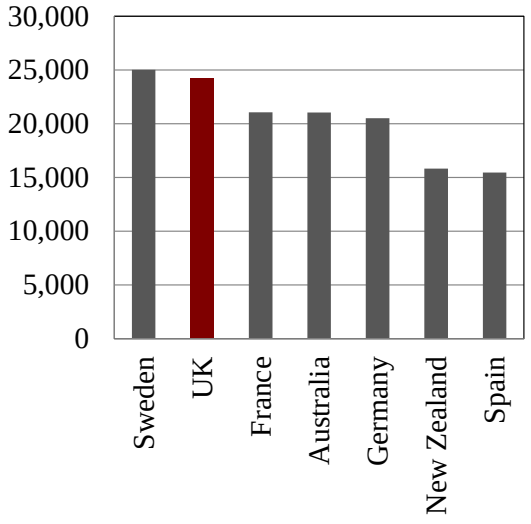
## 2. URBAN FTTP DEVELOPMENT

The starting point of the six countries that we surveyed was very similar. All six had well developed copper networks with universal coverage and populations with high incomes and high usage of the Internet. Further, they all had potential demand for high-speed Internet, the financial resources to fund new investments, and their telecommunications operators had the technical and passive infrastructure resources to deploy fibre networks.

Moreover, all six had competitive telecommunications markets, where the presence of competing cable networks and unbundled local loop ('ULL')-based Internet service providers could put the incumbents' legacy ADSL service at risk if those competitors decided to deploy superior technology. The threat was especially high from cable operators, which after 2006 only needed minor investments to upgrade their networks to DOCSIS 3.0 technologies to provide ultrafast services at speeds higher than 100 Mbps.[3]

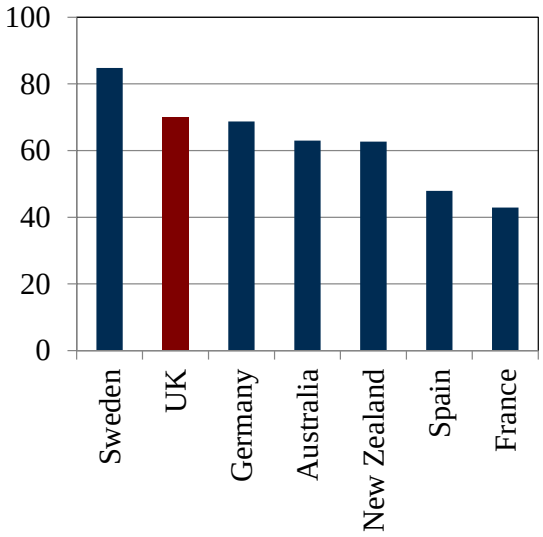
A look at structural factors suggests that the countries best placed for massive FTTP deployment were Sweden, the UK, Australia, and Germany. All four had high income and Internet usage levels by 2005, when fibre deployments began to be considered by telecommunications operators.

**Figure 5. GDP/Capita (2005, GBP)**




Source: TeleGeography

**Figure 6. Internet Users/100 pop, (2005)**




Source: World Bank

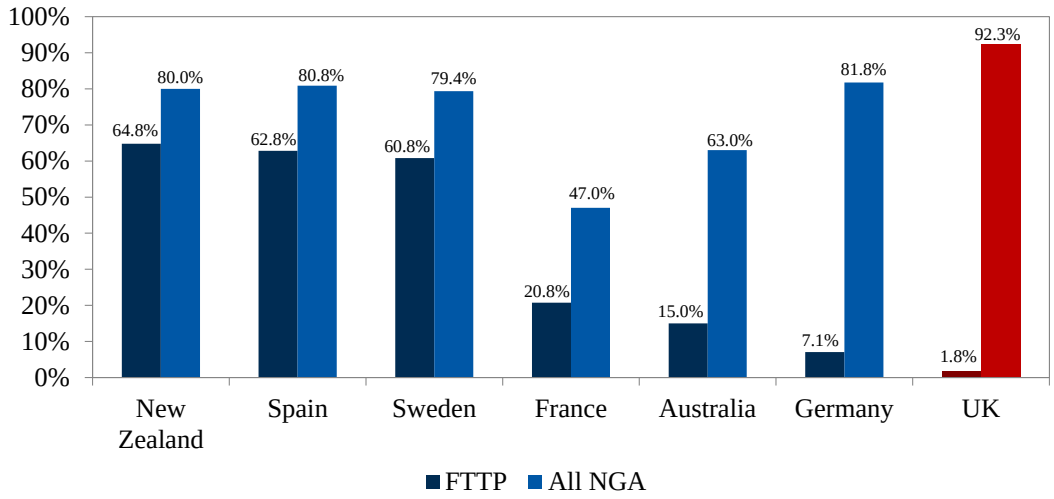
Actual deployment of NGANs followed the expected pattern. As Figure 7 shows, most countries have achieved almost full coverage by some sort of NGAN. As expected, the UK, Germany, and Sweden are among the leaders.

However, FTTP deployment was not the universal solution chosen by operators to deploy NGAN. Incumbent operators in the UK and Germany invested almost exclusively in VDSL solutions. There are large differences in network deployment between the countries that chose FTTP as their preferred technology. As regulation and public policies were different in

[3] See Brady Volpe, DOCSIS 3.0 Tutorial – Downstream Channel Bonding, 18 July 2010. https://volpefirm.com/downstream-channel-bonding/

all seven countries, our hypothesis is that differences in regulation heavily influenced outcomes.

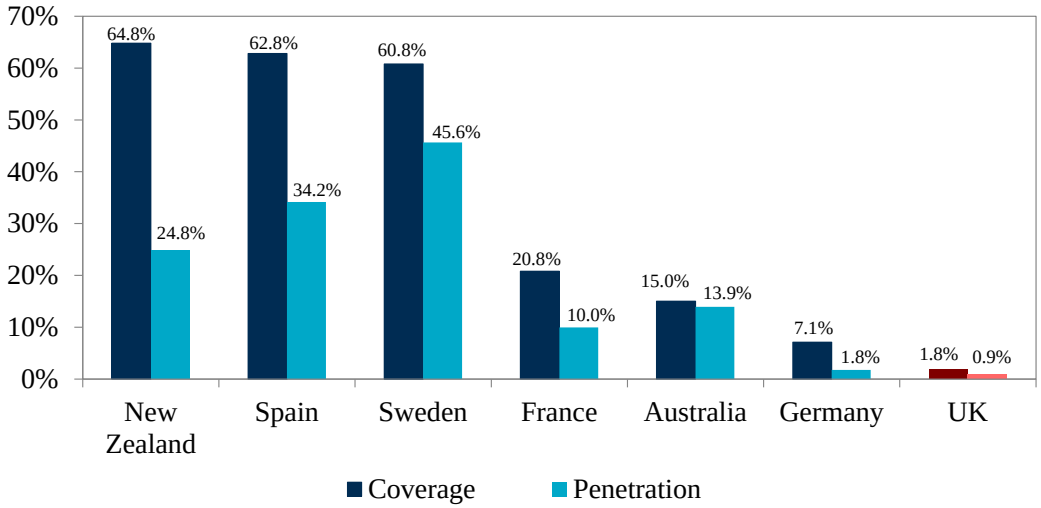
**Figure 7. Network Coverage 2016 (% premises)**




Source: European Commission,[4] NBN, Australian Bureau of Statistics, MBIE,[5] New Zealand dwelling statistics.

In this section, we analyse the regulation and performance of the six target countries for urban residential FTTP networks and services. Figure 8 shows their relative performance, both in terms of network coverage and actual take-up. Three countries show a very good performance in both dimensions: New Zealand, Spain, and Sweden. On the other side, France, Australia, and Germany show only incipient fibre development.

**Figure 8. FTTP Development 2016 (% households)**




Source: European Commission, NBN, Australian Bureau of Statistics, MBIE,[6] New Zealand dwelling statistics.

[4] See European Commission, Broadband Coverage in Europe 2016 - Mapping progress towards the coverage objectives of the Digital Agenda, https://ec.europa.eu/digital-single-market/en/connectivity

[5] See MBIE Broadband Deployment Update.

[6] See MBIE Broadband Deployment Update.

It is interesting to note that the three best performing countries have applied different regulatory approaches:

(1) Unregulated infrastructure competition between private operators in Spain.

(3) Nominated regional networks with public funding in New Zealand.

(4) State-owned regional networks that compete with other networks in Sweden.

Despite the fact that Spain, Sweden, France, and Germany are member states of the European Union and are therefore constrained to enforce the European Regulatory Framework for Electronic Communications, they have adapted it to their national circumstances so that they have different implementations.

European Union membership imposes an additional constraint to ultrafast broadband policies in Member States. When setting the targets of their policies, they have to comply at a minimum with the objectives set in the Digital Agenda policy initiatives.[7] In the time period between 2005 and 2017 that we analyse, the most important policy in the EU was the EUROPE 2020 Strategy that set the following targets for ultrafast broadband:

> The aim is to deliver sustainable economic and social benefits from a Digital Single Market based on fast and ultra fast internet and interoperable applications, with broadband access for all by 2013, access for all to much higher internet speeds (30 Mbps or above) by 2020, and 50% or more of European households subscribing to internet connections above 100 Mbps.[8]

In the remainder of this section, we analyse in-depth each country and how the regulatory model has interacted with the country's market conditions to produce the observable outcomes.

## 2.1. Case Study: Spain

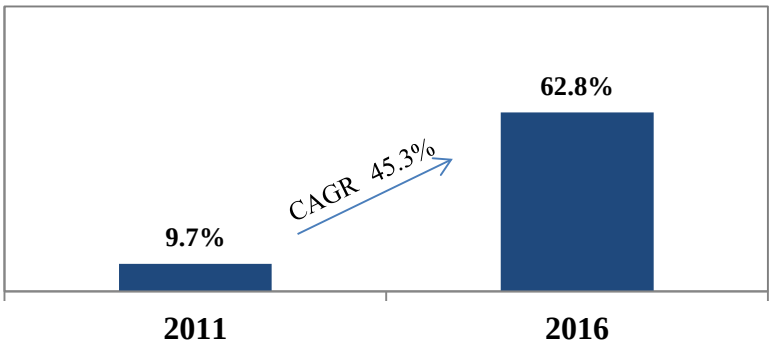
Spain has one of the most highly developed FTTP deployments in Europe. It also has a very high level of network competition, with 58% of households having access to two ultrafast networks,[9] 35% having access to three, and some having access to four networks.

[7] See European Commission, Implementation of the EU regulatory framework for electronic communication, 2015

[8] European Commission, EUROPE 2020 A strategy for smart, sustainable and inclusive growth, Communication from the Commission (Flagship Initiative: "A Digital Agenda for Europe"), COM(2010) 2020, Brussels, 3.3.2010.

[9] In most cases, access consists of FTTP and cable networks and in others two FTTP networks.

**Figure 9. FTTP Coverage in Spain (% households)**




Source: European Commission

### 2.1.1. Targets

Spanish authorities confirmed their commitment to the EU policy targets of having full coverage of broadband at a minimum of 10 Mbps by 2017 and of 30 Mbps to all citizens by 2020.[10] In 2014, they set the additional target of all schools, libraries, and health centres to have connections at 30 Mbps by 2016 and to 100 Mbps by 2020.[11]

### 2.1.2. Regulation and other policy measures

As Telefónica announced its intention to conduct test fibre deployments, alternative broadband operators asked the regulator (by then, the Comisión del Mercado de las Telecomunicaciones or CMT) to extend Telefónica's regulated wholesale access obligations for copper local loops to its new fibre infrastructure. As the broadband market review was very recent, CMT issued an interim provision in 2008, thereby placing superfast services (above 30 Mbps) in the same market as conventional broadband over copper cables. That way, the access regulation of the copper network was only extended to bitstream services below 30 Mbps provided over fibre connections, but not to dark fibre or bitstream services above 30 Mbps. Potential virtual unbundled local access ('VULA') obligations for ultrafast speeds were deferred until the results of the next full market analysis were available.

The regulatory approach adopted in 2008 was based on the following three key regulatory elements:

(1) regulated Telefónica's ducts offer (MARCo);

(2) symmetric in-building wiring access obligations applicable to all operators; and

(3) restricted access to traditional access remedies, i.e. bitstream access service on fibre (NEBA) with speed limitation up to 30 Mbps.[12]

An additional point was that the Spanish Building Code mandates that all buildings constructed after 2000 must have a duct network and collocation space that allows several

[10] See Telegeography, GlobalComms Database – Spain.
[11] Ibid.
[12] See Telegeography, Questionnaire for external experts, Telefónica's answer regarding Spain.

telecommunications operators to collocate equipment and blow cables to each flat.[13] As Spain underwent a construction boom from 2000 to 2008, operators found fibre-ready in-building ducts in a sizeable portion of the residential buildings. In addition, all licensed telecommunications operators are entitled to occupy public and private land to deploy their networks, subject to the general provisions for expropriation because of public interest.[14]

As a significant market power ('SMP') operator, Telefónica provides a wholesale-regulated offer for ducts, poles, and cabinets, allowing operators to deploy their own networks by using infrastructures and ducts from Telefónica in a cost-effective and flexible way.

A 2014 telecommunications law has withdrawn most of the administrative barriers for network deployment, putting in place a lean procedure for getting the necessary permits from local authorities and premises' owners.[15] In addition, since 2016, operators in Spain wanting to roll out a high-speed telecommunication infrastructure are entitled to use any existing suitable duct: lighting system, traffic lights, road, railway, port, or airport infrastructures, etc.[16] However, according to Telefónica, the role of non-telco passive infrastructure has been marginal for fibre roll out to date.[17]

In 2016, the National Regulatory Authority ('NRA') finally conducted the broadband access market analysis. As a result, it deregulated fibre services in competitive areas with three or more NGANs, which covered 66 cities and 35% of the population. In the rest, it imposed access obligations on Telefónica's fibre-to-the-home ('FTTH') network. In the most competitive region (comprising 692 cities, 23% of the population), there was another network and only VULA was mandated. In areas where Telefónica faced no competition from another NGA (42% of the country), bitstream access to FTTH was also mandated with no speed cap. Access regulation of services running on the copper network was maintained.[18]

Public funding for NGA deployment in white areas (where no provider of broadband access services currently is operating) has been a complementary measure that has allowed deployment earlier than initially planned. However, barely 20% of the NGA footprint has been partially financed by public funds.[19]

### 2.1.3. Market dynamics and results

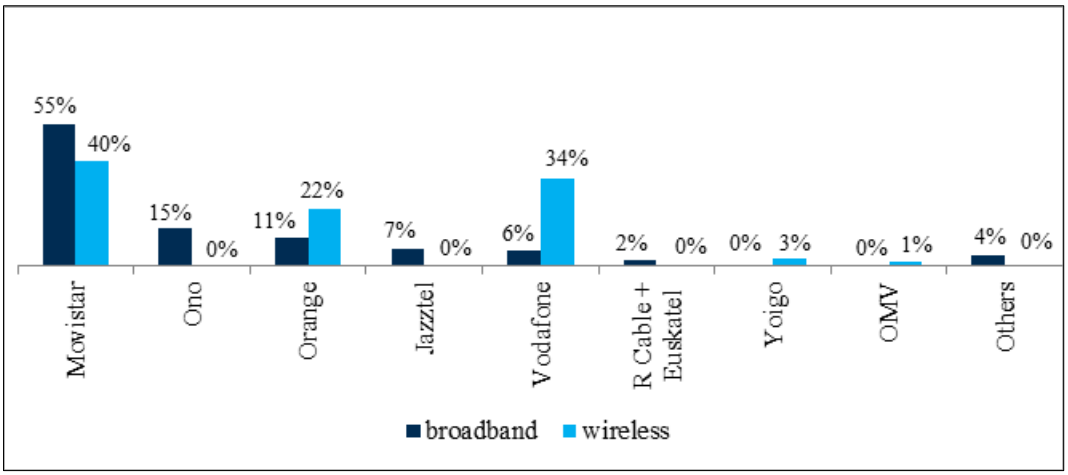
FTTP development happened after 2008 in a relatively challenging environment. By that date, Spain had no meaningful FTTP deployments other than some corporate-focused metropolitan networks in major cities. Its GDP/capita, population density, and Internet penetration rates were the lowest of the five largest EU Member States.

Despite its structural disadvantages, Spain could tap into the expertise and financial resources of three of the largest and most efficient operators worldwide (Telefónica, Vodafone, and

[13] See Real Decreto-ley 1/1998, de 27 de febrero, sobre infraestructuras comunes en los edificios para el acceso a los servicios de telecomunicación, BOE núm. 51, 28 February 1998.
[14] See Ley 9/2014, de 9 de mayo, General de Telecomunicaciones, BOE núm. 114, 10 May 2014.
[15] Ibid.
[16] See Royal Decree 330/2016 of 9 September (a transposition into Spanish Legislation of Directive 2014/61/UE of the European Parliament and the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communication networks).
[17] See Questionnaire for external experts, Telefónica's answer regarding Spain
[18] See Telegeography, GlobalComms Database – Spain.
[19] See Questionnaire for external experts, Telefónica's answer regarding Spain

Orange) and a number of Spanish start-ups that had built competitive and efficient broadband networks (Ono, Jazztel, Euskaltel, R, and Telecable). Forty-eight percent of households enjoyed infrastructure competition from cable operators (Ono, Euskaltel, R, and Telecable), most of them in urban areas.[20] There were also strong competitors that used Telefónica's copper loop to deliver ADSL, the largest being Orange, Jazztel, and Vodafone.

**Figure 10. Industry Structure in Spain 2009**




Source: TeleGeography and CNMC

Retail competition has been a clear incentive for NGA rollout, as a way for competitive differentiation in terms of value proposition to end-clients. xDSL competition was based exclusively in price competition, whereas NGA competition addresses other aspects of the offer, such as bandwidth, resilience, service portfolio, and so on. In response to the NERA survey, Telefonica reported that NGA network rollout has been used as a competitive tool for operators to gain a competitive differentiation from alternative service providers.

> Competitive pressure exerted by both LLU and particularly cable operators can be considered as one of the key drivers for investment in FTTH in Spain. Indeed, competition from cable operators has stimulated Telefónica to invest in NGA in order to provide equivalent services in terms of quality, download speed, availability of PayTV services that couldn't be provided on the cooper legacy network. [21]

A smart pricing policy also played an important role:

> Telefónica doesn't apply a premium price for FTHH services, so that the price of the NGA entry level offer is equal to the equivalent xDSL product. As a result of it, the upgrade of connections to high speed products has been very intense. However, this is more due to successful policies in the supply side than in factors intrinsic to the demand. Moreover, the possibilities offered by the network development are way above the current demand. Despite having a penetration of 45% of fibre customers in FBB, there is only 24% with speeds

[20] See European Commission, Broadband Coverage in Europe 2016 - Mapping progress towards the coverage objectives of the Digital Agenda, https://ec.europa.eu/digital-single-market/en/connectivity

[21] See Questionnaire for external experts, Telefónica's answer regarding Spain.

> above 100 Mbps, that is, almost 50% of the fibre customers have speeds of 50 Mbps.[22]

Telefonica also asserts that its FTTH deployment, combined with regulated duct access further enhanced the attractiveness of investment by alternative operators, since it helped to increase the quality of ducting and duct access processes.

> When Telefonica Spain, as the incumbent, began its FTTH deployment, it industrialised a duct access remedy, clearing, replacing and accurately mapping the street infrastructure – both for its own benefit and for other users of the duct infrastructure under a Duct Access remedy imposed by CNMC, the Spanish regulator.[23]

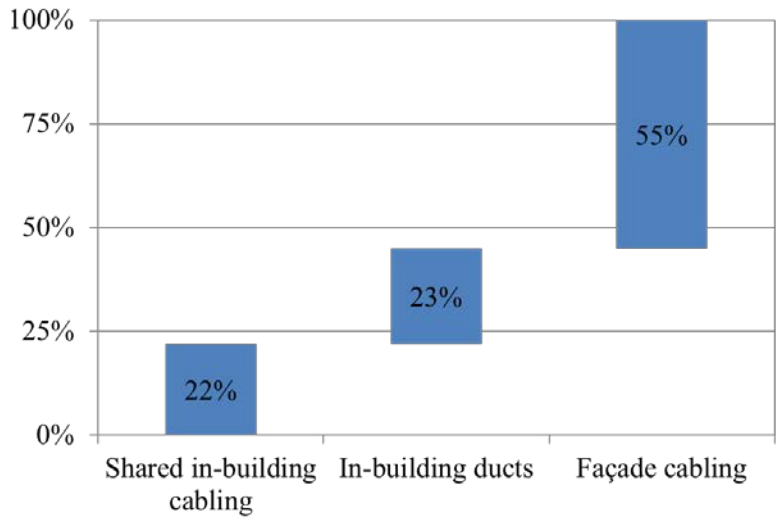
Network deployment also benefited from the consolidation of operators and the launch of converged offers. Consolidation allowed operators to grow in scale and convergence to spread the cost of fibre investments across a revenue pool much bigger than pure wholesale connectivity revenues. Thus, Vodafone acquired cable operator Ono, Orange acquired Jazztel, Euskaltel bought regional cable operators R and Telecable, and MásMóvil acquired mobile operator Yoigo, Orange's legacy fibre assets, and reseller Pepephone.

Another driver of network rollout was the large proportion of the population concentrated in very dense areas. This allowed operators to start their rollouts in areas with relatively low deployment costs and to gain experience and increase efficiency. Still, as deployment expanded into less densely populated areas, the low average density of the country posed significant challenges.

An additional factor was the cost of installing the final drop to customer premises was cheaper than in other European countries because of the general availability of ducts to buildings and favourable regulation of in-building cabling. As Figure 11 shows, the most expensive way of connecting customer premises (constructing in-building cabling without pre-existing ducts) affected less than a quarter of the premises connected by Telefónica.

[22] Ibid.
[23] Ibid.

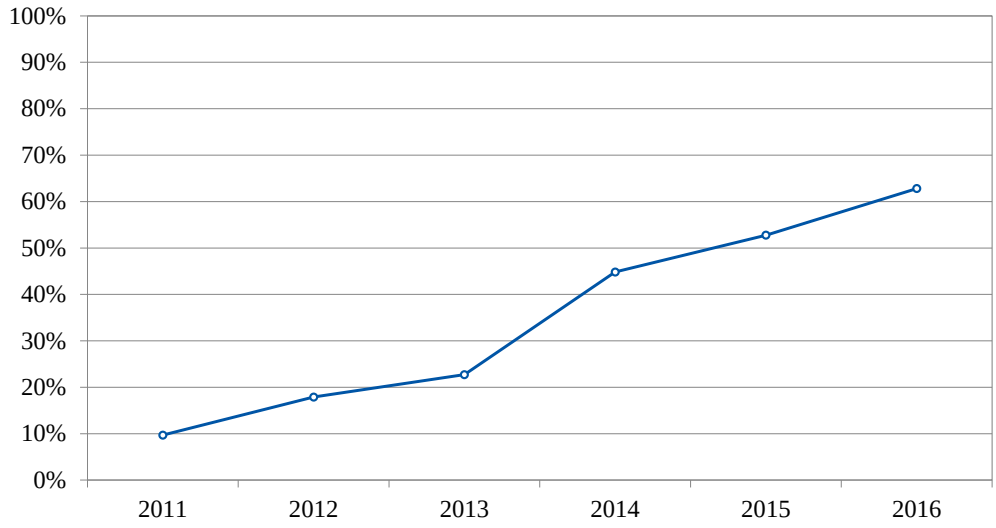
**Figure 11. In-building cabling technique in Telefónica's FTTP network (% premises)**




Source: interviews with Telefónica executives.

The combination of unregulated fibre services, regulated access to passive infrastructure, shared access for in-building, cheap building cabling, retail competition, and convergence resulted in rapid growth in the proportion of households covered by FTTP networks.

**Figure 12. FTTP Coverage in Spain (% households)**



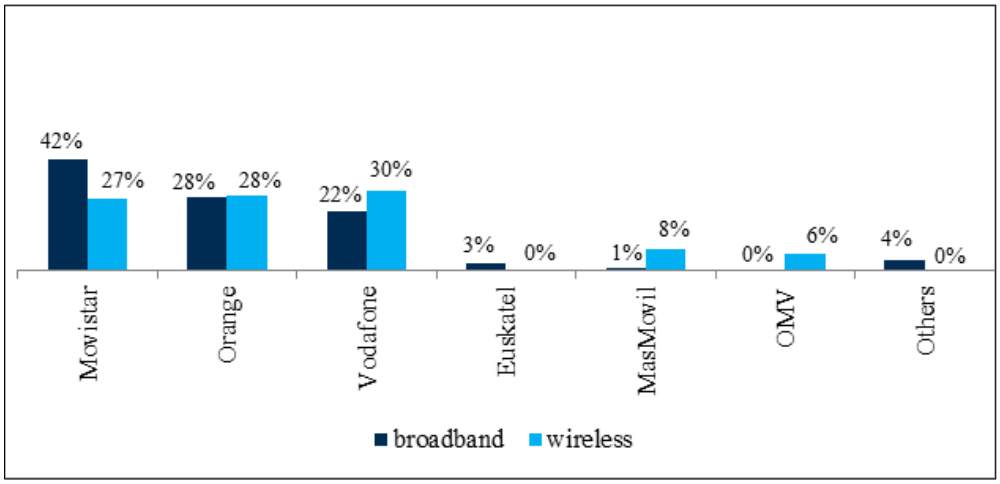

Source: European Commission

Additionally, one of the outcomes of infrastructure competition is that wholesale commercial offers are naturally developing in Spain, e.g. Telefónica struck a co-investment agreement with Jazztel and Orange did the same with Vodafone, Orange provides wholesale service to MásMóvil, and Telefónica provides commercial wholesale services to Vodafone.[24]

[24] See Telegeography, GlobalComms Database – Spain.

Because of those market dynamics, by 2017, four convergent operators competed for most of the Spanish markets. Market shares of pure fixed retailers (regional cable without mobile and resellers) have dropped below 10% as shown in Figure 13.

**Figure 13. Industry Structure in Spain 2016**




Source: TeleGeography and CNMC

Despite changes in regulation and the fact that deployments happen in less dense areas, fibre rollout continues in Spain. However, it is likely that state aid will play a greater role in the future than in the recent past.

### 2.1.4. Conclusions

The key elements behind the success of FTTP in Spain are:

- Favourable economics of final drop installation that in the first stage of the process allowed an efficient start to the rollout, leading to gains in experience and efficiency in later stages: availability of ducts to the buildings, in-building ducts in many cases, and relaxed installation standards, as well as a large proportion of the population concentrated in very dense areas;
- Very strong competition from cable operators and local loop unbundlers in earlier stages, and FTTP operators later on;
- Favourable regulatory regime for incumbent deployments; and
- Very high take up by customers of convergent offers at high speeds that cannot be delivered over ADSL.

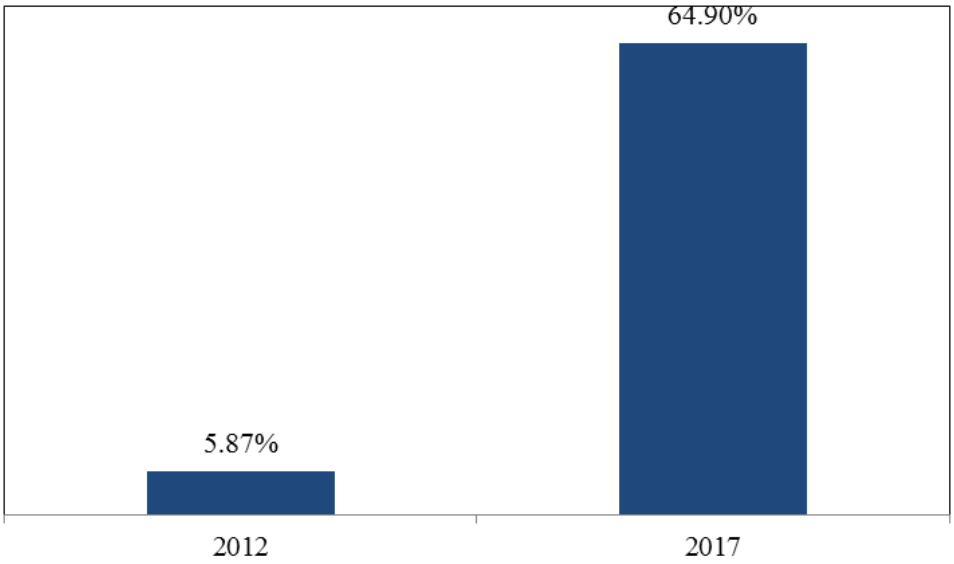
In subsequent stages, as the deployment expands beyond the dense areas, the low average density of the country poses significant challenges.

However, the main operators (Telefónica and Orange) have confirmed their intentions to continue their deployments so that coverage is expected to rise to 92% by 2020, most of it under competition by at least two networks.[25]

## 2.2. Case Study: New Zealand

New Zealand has achieved very high coverage of FTTP networks using Public Private Partnership ('PPP') programmes with substantial funding. However, network competition is limited to a third of the country.

**Figure 14. FTTP Coverage in New Zealand (% households)**




Source: Statistics New Zealand dwelling statistics and MBIE Broadband Deployment update

Fibre development in New Zealand has been based on the Ultra-Fast Broadband ('UFB') programme. 'Crown Fibre Holdings' (CFH) was formed as a Crown-owned company to manage the Government's investment in Ultra-Fast Broadband infrastructure. CFH completed its initial task of selecting partners to participate in the UFB initiative in 2011.[26]

### 2.2.1. Targets

The initial goal of the UFB programme was to build an FTTP network that reached 75% of the population by 2019. The UFB programme was extended in 2017 so that the rollout would

[25] See ADSLZONE, 'The Government wants more fiber and will make it easier for operators', 9 September 2016. https://www.adslzone.net/2016/09/09/el-gobierno-quiere-mas-fibra-y-se-lo-pondra-mas-facil-a-los-operadores/.

[26] The telecommunications industry has recently sought clarification of the subsequent role of CFH over the period during which the Ultra-Fast Broadband (UFB) network is being built, and around the setting of prices on the UFB network.' (Ministry of Business, Industry & Employment, 'Policy and Regulation', http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/fast-broadband/policy-and-regulation. )

be accelerated by two years and reach 87% of the population by 2022 (the extension is known as UFB2).[27]

### 2.2.2. Policy measures

The UFB programme was developed in the context of four issues:

(1) economic concerns about New Zealand's international competitiveness and the global financial crisis;

(2) confidence in UFB's potential to transform New Zealand;

(3) scepticism that the private sector would, without government involvement and funding, undertake the necessary investment itself; and

(4) governmental belt-tightening and the need to ensure public funding was targeted and designed to secure value for money.[28]

The genesis of the UFB programme was competing political proposals for government fibre investment from the incumbent Labour government and the opposition National party in the lead up to the 2008 election, which the National party won.

Prior to the 2008 general election, the incumbent Labour government initiated a grant programme known as the Broadband Investment Fund ('BIF'). This programme was to provide operational grants (totalling $325 million dollars over five years) and was aimed at 'facilitating high speed connections to businesses and key public users in urban centres through the deployment and wholesaling of open access passive broadband infrastructure'.[29]

The opposition National party campaigned on a promise of direct investment by the government in partnership with the private sector that would result in FTTP to 75% of the population over a 10-year period. The Labour proposal therefore was more targeted to high-value users (businesses/schools), whereas the National proposal was much broader in its scope. As the National party won the 2008 election, no grants were paid under the BIF, and the UFB proposal was more fully designed and implemented. The UFB programme is in effect a Public-Private Partnership ('PPP'), whereby the government co-invests (up to 1.35b NZD for UFB1) with private partners (the 'Partners') in companies called 'Local Fibre Companies' ('LFC') to build and operate an open-access wholesale-only FTTP network in a designated area. The country was divided in several regions, and separate tenders were held to select a partner for the LFC in each region.

LFCs are prohibited from providing retail services. Therefore, to participate in the UFB programme, the former vertically integrated Telecom New Zealand voluntarily demerged into a wholesale-fixed-network business (Chorus) and a retail-fixed-line business that also owns a mobile network (Spark). The other partners are electricity companies (Northpower and WNL) and an existing broadband network owned by the Christchurch City Council.

[27] See Crown Infrastructure Partners, 'Ultra Fast Broadband Extension (UFB2)', 30 August 2017, https://www.crowninfrastructure.govt.nz/ufb-initiative/ultra-fast-broadband-extension/.

[28] See M. Webb, M. Toner, and J. Cox, 'Taking the initiative: lessons from New Zealand's experience with the ultra-fast broadband initiative', *Int. J. Technology Policy and Law*, Vol. 1, No. 4, 2014, pp. 317–334.

[29] See MED (2008), *Broadband Investment Fund: Draft Criteria and Proposed Process for Consultation*.

Specific funding mechanisms for the government's investment vary for each of the LFCs. The general rule is that Crown Fibre Holdings ('CFH') is to fund the cost of 'passing' the premise, and the Partner is to fund the costs of 'connecting' the premise, i.e. the connection from the premise to the fibre in the street as each customer hooks up.

Each time a LFC other than Chorus connects a premise, the LFC pays back CFH the cost of passing that premise. This means that the other LFCs do not bear much demand risk and that CFH effectively gets its capital returned each time a premise connects, allowing that money to be 'recycled'. A different arrangement was concluded with Chorus, by which CFH acquired a stake in Chorus' capital.

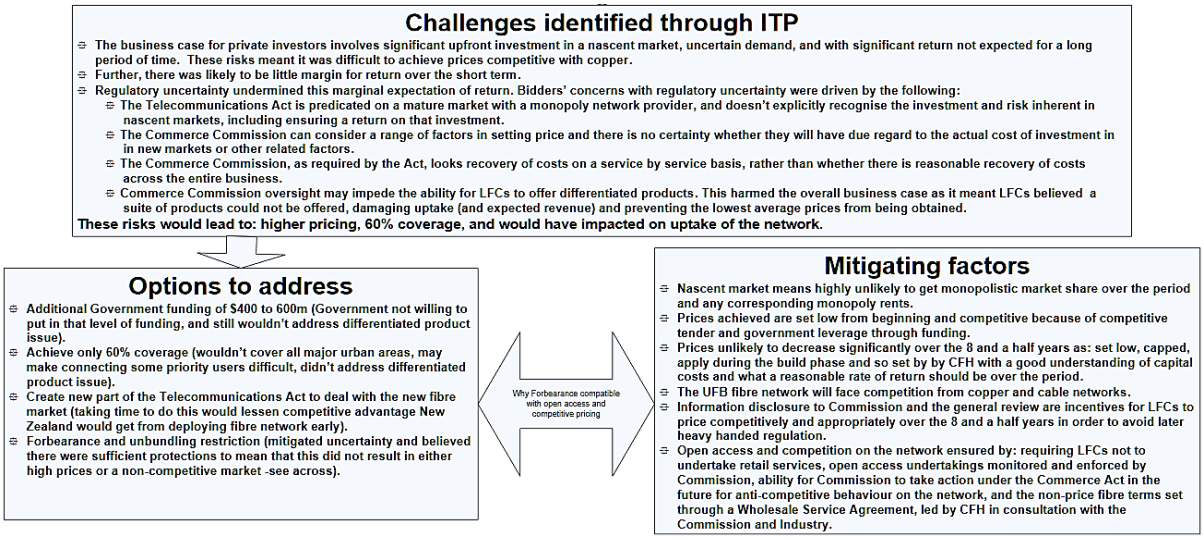
Since they are wholesale-only companies LFCs and Chorus sell wholesale services to retail service providers ('RSPs') that in turn sell services to final customers. The wholesale prices LFCs/Chorus can charge RSPs are set by the contract between each LFC and CFH. These prices apply across each entire UFB area (i.e. are geographically averaged). The products included in the contract with CFH are an entry level 30 Mbps and an advanced 100 Mbps bitstream product. Fibre operators are free to offer other commercial products in addition to those products.

### 2.2.3. Regulation

Prior to the introduction of UFB, Chorus (then the vertically integrated Telecom New Zealand) was required to provide both ULL and bitstream access to its copper network on regulated prices set by reference to total service long-run incremental cost ('TSLRIC').

Regarding UFB, it is in some ways a form of regulation by contract, as the wholesale access prices are set via a contract between the LFCs and the Government. During the initial negotiations for the UFB contracts, the government did not receive satisfactory bids (only 60% coverage would have been achieved, rather than the targeted 75%). This was largely due to perceived regulatory uncertainty, as set out in the diagram below from the Ministry of Business, Innovation & Employment ('MBIE') advice to the Government.

**Figure 15. Challenges to FTTP deployment identified in New Zealand**




Source: MBIE[30]

The initial government proposal for regulatory forbearance (i.e. preventing the UFB network from having regulation applied to it during the initial contract term) was controversial and eventually abandoned. It was replaced with a contractual compensation mechanism, whereby the Government would compensate the LFCs if regulation was introduced that reduced prices below the contractual cap.[31] Dark fibre unbundling was deferred until 2020. The combined effect of these two measures reduced the risk to LFCs, and the Government received satisfactory bids in subsequent negotiations. While this provided certainty for the initial term of the contract through to 2020, after that point, pricing and the regulatory regime are uncertain.

MBIE has recently completed its consultation on what the 'Post 2020' regime will be. For Chorus, its fibre assets will transition to a hybrid building blocks regulatory model with an overall revenue cap and price-capped anchor products.[32] The copper network will be deregulated inside UFB areas and remain regulated outside UFB areas.[33] This is summarised in the diagram below from MBIE's decisions paper.

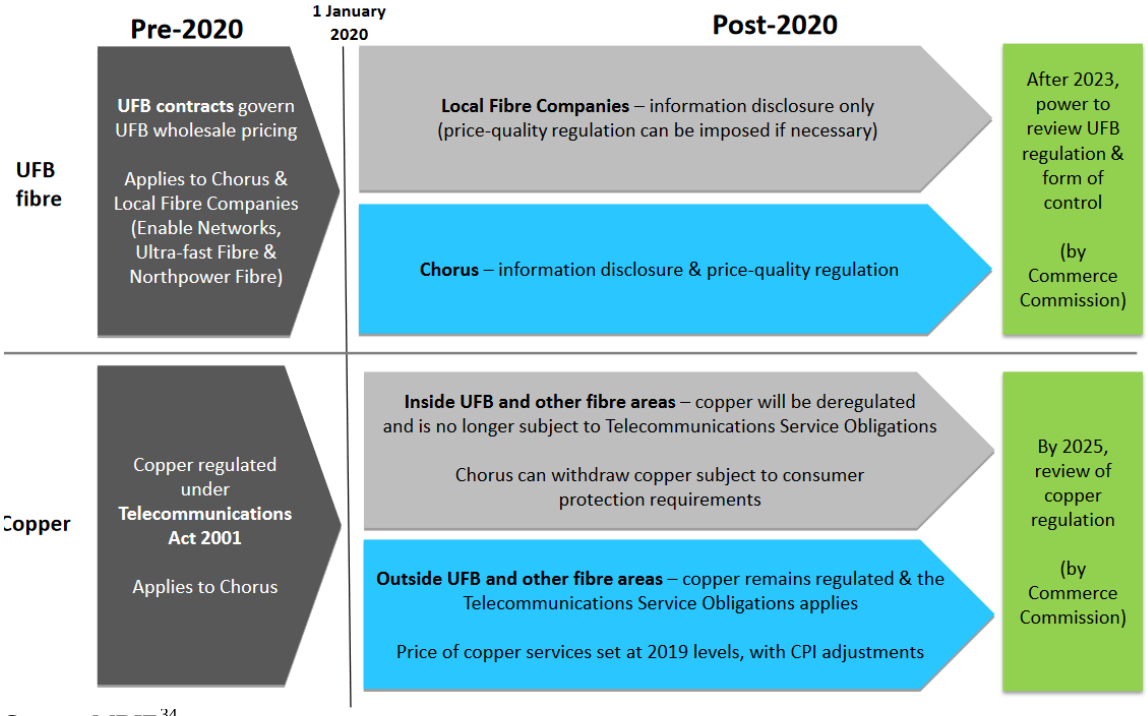
[30] See 49SCFE-ADV-00DBHOH-BILL 10470-1-A181779, https://www.parliament.nz/resource/en-NZ/49SCFE_ADV_00DBHOH_BILL10470_1_A181779/95cfc977b071b536e9e094728040600bf73c7eed.

[31] See Beehive.gov.nz, 'Regulatory forbearance to be replaced', 18 May 2011, https://beehive.govt.nz/release/regulatory-forbearance-be-replaced.

[32] The other LFCs will only be subject to information disclosure regulation.

[33] See Ministry of Business, Innovation & Employment, 'Final decisions (June 2017)', http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/communications/regulating-the-telecommunications-sector/review-of-the-telecommunications-act-2001/final-decisions-june-2017.

**Figure 16. New Zealand regulatory framework post-2020**




Source: MBIE[34]

The product definition and pricing methodology for the anchor product are still being determined. The other LFCs are subject only to information disclosure, partly because they generally face competition from Chorus' copper network.

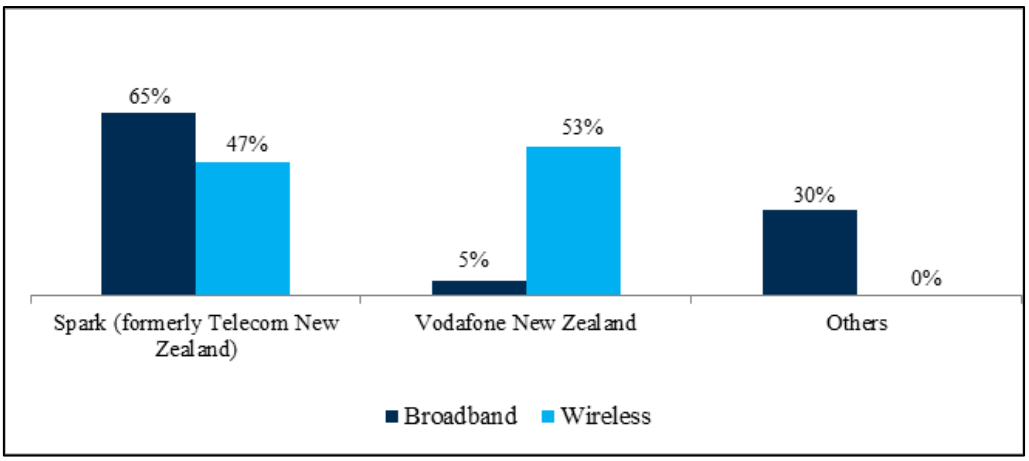
Also post 2020, Chorus will be required to offer a price capped dark fibre access product ("Direct Fibre Access Service", aka DFAS). DFAS is used by RSPs for backhaul and to supply large commercial customers, and by mobile network operators for fixed wireless services.
.

### 2.2.4. Market dynamics and results

Before the UFB programme was implemented, Spark (then the vertically integrated Telecom New Zealand) dominated the New Zealand telecommunications market, except for mobile services where it faced strong competition by Vodafone.

[34] See Ministry of Business, Innovation & Employment, Review of the Telecommunications Act 2001, http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/communications/regulating-the-telecommunications-sector/review-of-the-telecommunications-act-2001/telco-review-diagram.pdf

**Figure 17. Industry Structure in New Zealand 2005**




Source: TeleGeography

The UFB programme was implemented by seeking tenders from private participants. The tender split the country into different regions and allowed bids for individual regions and national bids. This created tension on Chorus by allowing electricity companies to bid in their network areas individually or as part of consortium bidding for multiple regions. This resulted in four different UFB providers (the 'Partners') that have partnered with CFH:

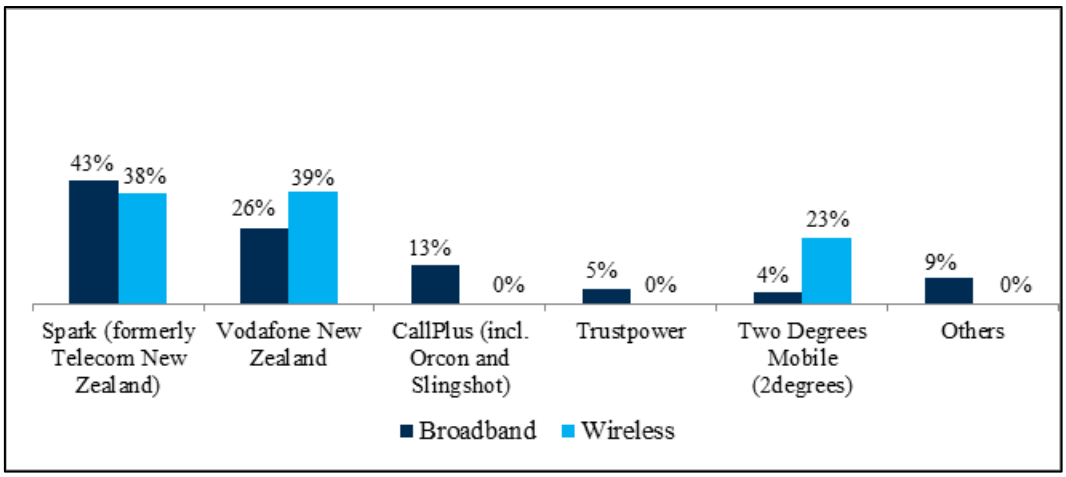
- Chorus (69.4% of UFB coverage);
- Northpower (1.6% of UFB coverage);
- Enable Services Limited (15.3% of UFB coverage); and
- Waikato Networks Limited (13.7% of UFB coverage).

Except for Chorus, the partnership resulted in a new company being created, i.e. the 'local fibre company' or LFC, which is co-owned by the partner and CFH. In the case of Chorus, the Crown has invested directly into Chorus using a 50:50 mix of debt and equity.

As already mentioned, because LFCs are prohibited from providing retail services Telecom New Zealand voluntarily demerged into a wholesale fixed network business (Chorus) and a retail fixed-line business that also owns a mobile network (Spark). The other LFC partners are electricity companies (Northpower and WNL) and an existing broadband network owned by the Christchurch City Council.

The open access nature of the UFB programme and disaggregation of the incumbent has arguably led to a less concentrated market structure at retail, with Spark's market share now 43% compared to 65% in 2005, and a number of smaller players having entered the market.

**Figure 18. Industry Structure in New Zealand 2017**




Source: TeleGeography

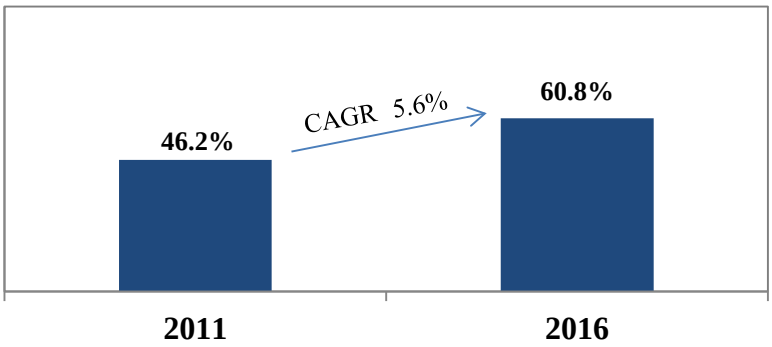
### 2.2.5. Conclusions

New Zealand has had success in rolling out FTTP for a number of reasons. First, the competitive tender process helped efficient new entrants to enter the market and prompted the incumbent to invest in FTTP. Second, the targeted nature of the UFB initiative (75% of the population for UFB1 and then 87% for UFB2) did not include the least urban/most expensive customers and therefore kept costs down. Third, the government bearing demand risk resulted in lower bid prices than would have occurred if the private sector bore that risk. Fourth, flexible regulatory conditions allowed operators to run their businesses in the most efficient way while meeting the Government's objectives. Finally, innovative funding mechanisms allowed the government to 'recycle' its funds multiple times, thus reducing the upfront funding obligation on the government.

## 2.3. Case Study: Sweden

Sweden is among the leading Member States of the European Union in fibre penetration: FTTP penetration was 45.6% in 2017, while coverage was 60.8% by the end of 2016.[35]

**Figure 19. FTTP Coverage in Sweden (% households)**




Source: European Commission

[35] See European Commission, Broadband Coverage in Europe 2016 - Mapping progress towards the coverage objectives of the Digital Agenda, https://ec.europa.eu/digital-single-market/en/connectivity

Regarding speed, Sweden's case also stands out: among all analysed countries, Sweden presented the highest download speed registered in 2017 (considering average speed and peak connection speed).[36]

### 2.3.1. Targets

In 2009, the government set a target of providing broadband at least at 100 Mbps to 90% of the population by 2020 (either by fixed or wireless networks).[37]

In 2016, the government adjusted the goals of the national broadband strategy by releasing the Completely Connected Sweden strategy 2025 update, which aimed at extending broadband coverage with a minimum download link of 100 Mbps to 95% of all households and business by 2020. In addition, 98% of Swedish households should have access at 1 Gbps no later than 2025.[38]

### 2.3.2. Regulation and other policy measures

Telia, a dominant telephone company and mobile network operator, has been subject to ex-ante access regulation to provide unbundled local loop access since 2004 and bitstream access to its network since 2007, and it was forced to functionally separate its fixed network in 2008. In 2010, its unbundling obligations were explicitly extended to its fibre local loops.[39]

Access to passive infrastructure is mandated to the incumbent. Based on the remedies imposed in February 2015 by the NRA on the local broadband access market, TeliaSonera is obliged to provide duct access at cost-oriented prices upon a reasonable request if it has accessible ducting and the right to provide a sub-lease to the access seeker. However, due to legal and technical difficulties, TeliaSonera is not obliged to publish a reference offer for duct access.[40]

Telia won some regulatory flexibility in 2014, when bitstream was deregulated because of competition from other operators.[41] In 2016, the regulated pricing of fibre services was eased, but a duct access obligation was imposed on Telia.

### 2.3.3. Market dynamics and results

One unique feature of Sweden is the importance of municipal fibre companies ('stadsnat'). The majority of stadsnats operate as pure wholesale open access networks that sell their services to multiple service providers on a 'neutral' basis, which in turn provide end users with a range of broadband, telephony, and TV services. One of the largest stadsnats is the municipal network in Stockholm, Stokab, which leases dark fibre and covers almost all multi-dwelling and commercial units in the city.

[36] Most recent data: first quarter of 2017, extracted from Akamai's State of Internet , Q1 2017 report. Available at https://www.akamai.com/uk/en/about/our-thinking/state-of-the-internet-report/archives/state-of-the-internet-security-reports-2017.jsp

[37] See Telegeography, GlobalComms Database – Sweden.

[38] Ibid.

[39] Ibid.

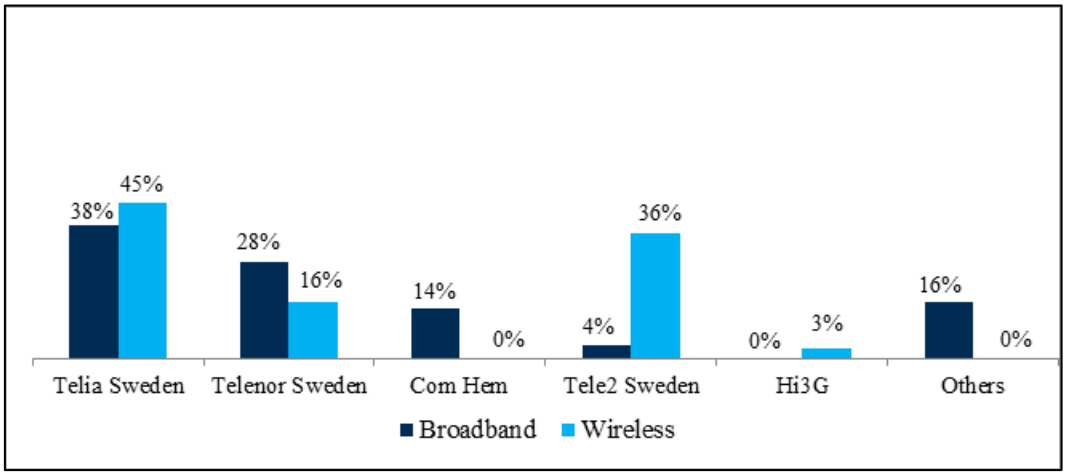
[40] European Commission, Implementation of the EU regulatory framework for electronic communication, 2015.

[41] See Telegeography, GlobalComms Database – Sweden.

Stadsnats started deploying fibre in the late 1990s, giving Sweden a head start in the race for fibre. Municipalities were very active in the process, because they control many critical pointes: they are responsible for providing a significant proportion of all public services and utility infrastructure and they are in charge of issuing permits and acting as market operators and property owners.[42]

Looking at the retail market, by 2005, incumbent Telia had already lost a large market share to cable operators Telenor and Com Hem and to alternative providers that provided services over the stadnats or Telia's unbundled copper services.

**Figure 20. Industry Structure in Sweden 2005**



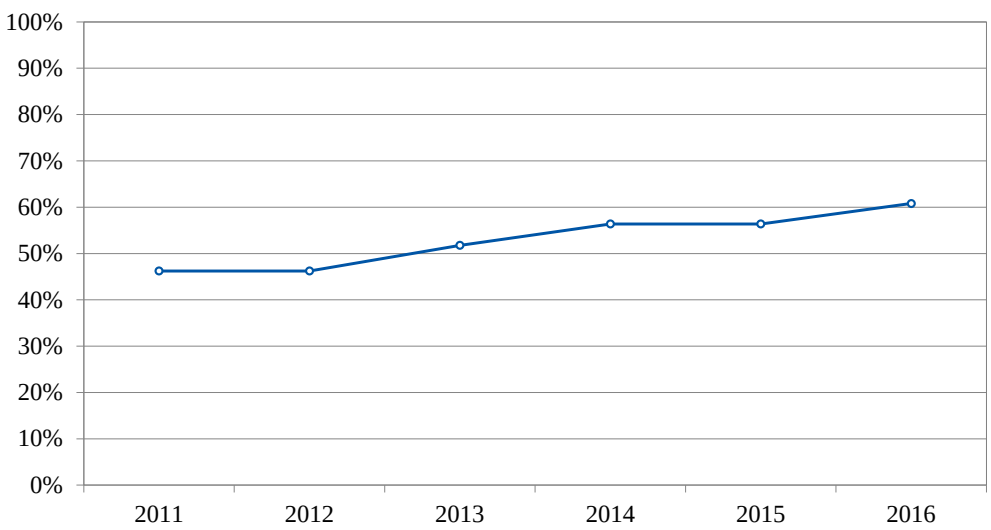

Source: TeleGeography

Beyond the stadsnats, however, fibre deployment by other operators has been relatively slow. As noted above, the incumbent Telia is under heavy access regulation and was forced to functionally separate its fixed network in 2008. At the beginning, it focused mostly on VDSL to compete with cable and municipal fibre and only started large-scale deployments of fibre by 2009. Telia started fibre deployment to multi-dwelling units only, but in 2014, it started to connect single-family homes.

Growth in the Swedish fixed broadband Internet access market has continued to be driven by high-speed service take-up on fibre/LAN, HFC cable, and VDSL networks. After annual growth had slowed to a crawl in 2011, the year-on-year rate began increasing again.

[42] Deployment of municipal fibre networks was not subject to the EC's guidelines of state aid in telecommunications because it began before their publication. See Telegeography, GlobalComms Database – Sweden.

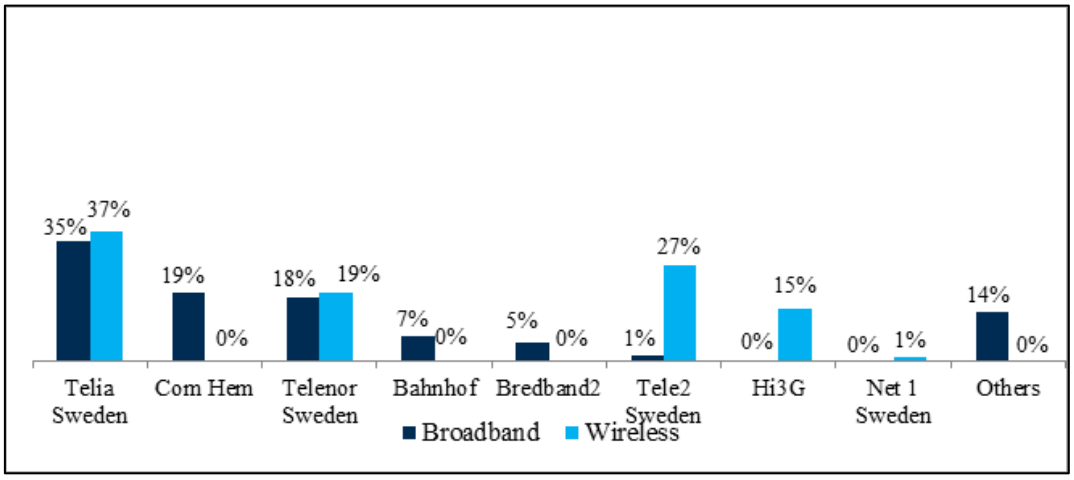
**Figure 21. FTTP Coverage in Sweden (% households)**




Source: European Commission

At the end of 2017, Telia served around 35% of all retail broadband subscribers.[43] Along with Telia, Com Hem Holding and Norwegian-owned Telenor Sverige are the leading retail broadband players. However, the weight of convergent fixed-mobile operators has not changed very much since 2005. Fixed-only and mobile-only operators still command a sizable market share in both market segments.

**Figure 22. Industry Structure in Sweden 2017**




Source: TeleGeography

Thanks to intense network competition, two-thirds of Swedes can choose between two high-speed network providers[44], and in areas where cable is present even three. Most recent data indicates that 73.3% of households in Sweden had access to the speed set as target in the Completely Connected Sweden by 2025 programme, including 22.3% of rural households.

[43] See Telegeography, GlobalComms Database – Sweden.

[44] In some areas the can choose between two FTTP networks (Telia Skanova and the local stadsnat) and in others between the local stadsnat FTTP network and Telia Skanova VDSL.

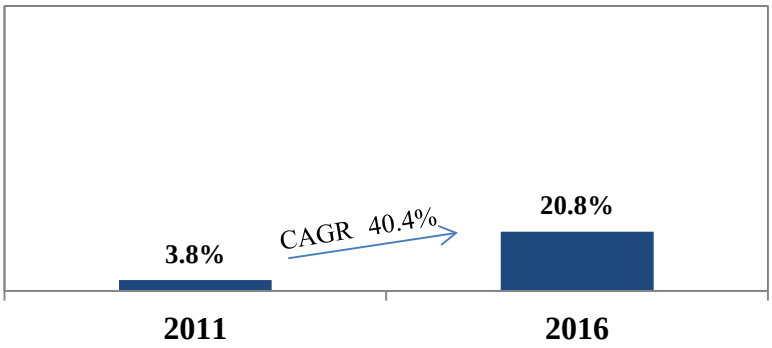
### 2.3.4. Conclusions

Sweden's high development and take-up of FTTP services was fuelled by high Internet penetration and early public investments in municipal fibre networks. However, deployments by the incumbent Telia, which had its fibre network separated and regulated, have grown only slowly despite strong competition by municipal fibre and cable companies.

## 2.4. Case Study: France

Despite extensive political attention, the availability of public funding, and competition amongst strong private operators, FTTP deployments in France have been relatively slow.

**Figure 23. FTTP Coverage in France (% households)**




Source: European Commission

### 2.4.1. Targets

Fibre network deployment became a national priority in 2008, when regulation was introduced with the aim of allowing as many operators as possible to deploy fibre networks.[45] In 2013, the government launched the 'Très Haut Débit ("THD")' national broadband strategy. It set the following targets beyond those of the Europe 2020 strategy:

- 50% of the country covered by NGAN by mid-2017; and
- 100% of the country eligible for ultrafast broadband services by 2022.[46]

### 2.4.2. Regulation and other policy measures

The French regulatory model is based on a segmented understanding of the economics of fibre networks. It assumes that some parts of the network have the potential for competitive deployments, while others are too expensive to support several parallel infrastructures. It also recognizes the role of population density on network economics, thus giving a different treatment to dense and less dense areas.

As a result, the regulatory framework enacted in 2008 stipulated:

- regulated access to Orange's passive infrastructure;

[45] See Telegeography, GlobalComms Database – France.
[46] See Arrêté du 29 avril 2013 relatif à l'approbation du cahier des charges de l'appel à projets « France très haut débit - Réseaux d'initiative publique ». JORF n°0102 du 2 mai 2013 page 7537.

- symmetric access to the terminal portion of fibre infrastructure of each operator (the portion of the local loop under symmetric access, or the 'mutualized' part). The mutualized part varied depending on population density. It included only the in-building cabling in very dense areas (6 million premises) to in-building and feeder cabling covering up to a few hundred households in dense areas (12 million premises) and the whole town in rural areas (15 million premises); and
- other portions of fibre infrastructure were not to be regulated.[47]

However, those measures took some time to be implemented in practice. Many specific details had to be agreed upon by operators or decided by the regulator before investment decisions could be made. That included the list of municipalities considered to be in very dense, dense, and less dense areas; the prices and technical specifications of regulated access to contents and mutualized parts of the network; and coordination rules for network rollouts. The first rules were issued year-end 2009 and the last in 2015.

Public funding plays an important role in French fibre policy. In addition to deployments by private operators, since 2004, French legislation has allowed local governments to deploy and operate telecommunications infrastructure called 'Public Initiative Networks' within their territories.[48] There were deployments already for ADSL. In 2015, the FTTH Public Initiative Networks were made subject to ex-ante regulation, which specified that their prices should be similar to those of equivalent commercial wholesale services.[49]

The THD national broadband plan previews the respective roles of both market competition and public initiative to achieve full fibre coverage. The planned split is:

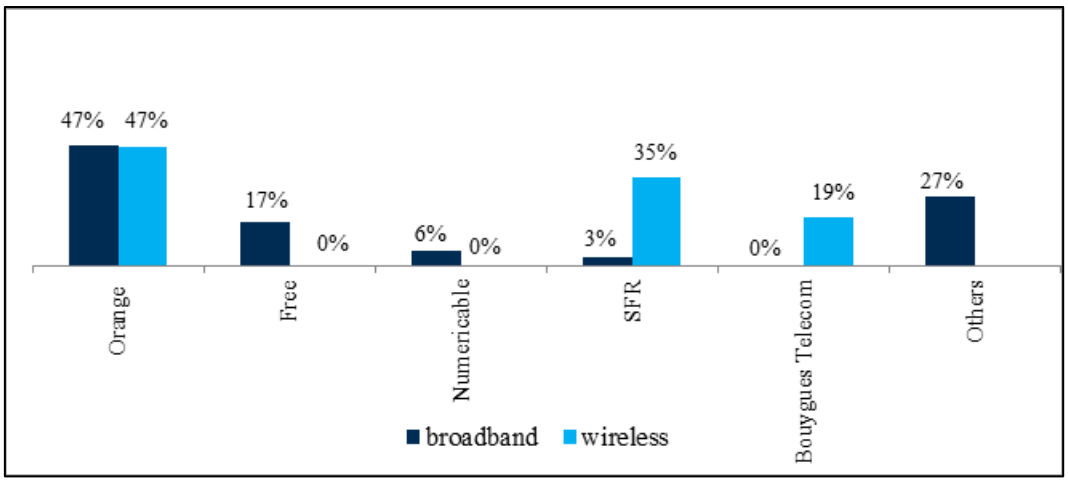
- 57% of premises will be covered by 2022 by private investment; and
- 43% of premises will get some public funding from local authorities, with more than half of them being operated by public-private partnerships and the rest (in rural areas) by national and local governments.[50]

### 2.4.3. Market dynamics and results

Prior to the launch of ultrafast networks, incumbent Orange was by far the largest operator in both fixed and mobile markets. It faced competition by two almost purely mobile operators (SFR and Bouygues) and a large number of fixed broadband operators. With the exception of cable operator Numéricable, most of Orange's fixed-line competitors were resellers providing ADSL services over Orange's copper ULL. However, cable coverage in France was limited, reaching only 27.9% of households in 2011. As Figure 24 shows, the DSL segment was evenly split at 47% market share between incumbent Orange and a large number of ULL providers, while cable was marginal with only 6% of connections.[51]

[47] See Telegeography, GlobalComms Database – France
[48] In French, *Réseaux d'Initiative Publique*, or RIP.
[49] See Telegeography, GlobalComms Database – France.
[50] See Telegeography, GlobalComms Database – France. See also the Plan THD website http://www.francethd.fr/le-plan-france-tres-haut-debit/qu-est-ce-que-le-plan-france-tres-haut-debit.html
[51] See Telegeography, GlobalComms Database – France.

**Figure 24. Industry Structure in France 2005**




Source: TeleGeography

In the years after fibre regulation was put in place, large French operators began to deploy their ultrafast networks.

Cable operator Numéricable (now part of the Altice group) was the pioneer when it upgraded most of its cable network to DOCSIS 3.0. This early advantage has put it in a leadership position for ultrafast services. Despite covering a much smaller proportion of premises, Numericable currently passes approximately as many homes with ultrafast service as Orange and other telco providers pass with FTTP.

The first fibre deployments happened in Paris on a purely competitive basis in 2006, both by Orange and by large ULL operators Iliad, SFR and Bouygues. After that, the push to deploy fibre slowed for some time until investment conditions become clear. The economics of the business and the obligation to coordinate in "mutualized" areas led the main private operators to close co-investment and other wholesale agreements between them. Such agreements have been signed, amongst others, between Orange and Iliad, Orange and SFR, Numéricable and Bouygues, and SFR and Bouygues. In parallel, large ULL providers acquired most of the smaller ones.

While private operators' deployed FTTP networks mostly in urban areas, some 100 local authorities have set up RIPs to provide fibre coverage in their territories. They covered over one million households in 7400 towns by end-2016, of which 835,000 in less densely populated rural areas.[52]

Despite these initiatives, overall fibre deployment continues to lag for two primary reasons. First, deployment has been slowed by the need for lengthy discussions on regulatory terms and conditions and the negotiation of investment commitments.[53] Second, some broadband operators have pursued aggressive pricing strategies which have made it uneconomic for infrastructure-based providers to deploy FTTP outside of specific areas.[54] In addition to prompting customers to a relatively high take-up of fibre services and triggering market

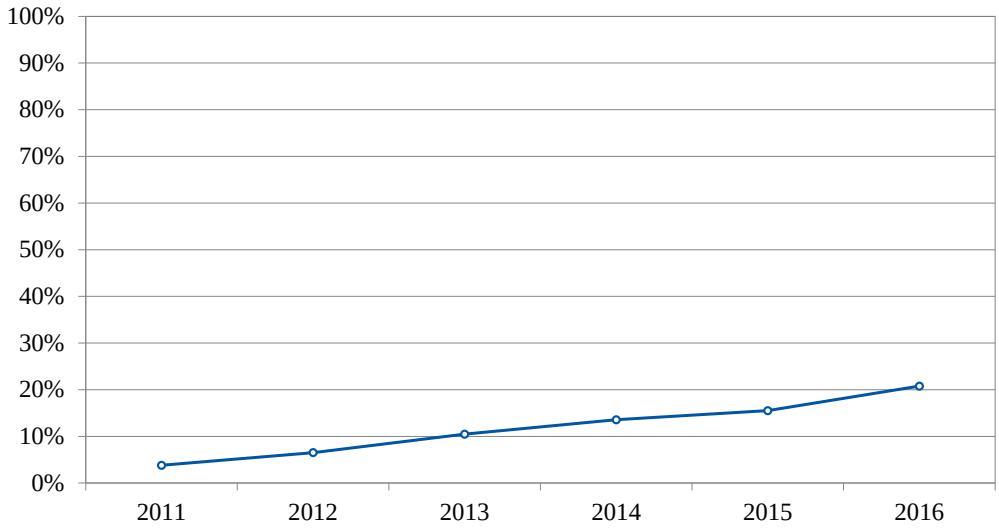
[52] Ibid.

[53] "Programming and monitoring deployment charters" (in French *Conventions de programmation et de suivi des déploiements (CPSD)*), signed by the operators and local authorities. See Plan THD - Reference documents http://www.francethd.fr/ressources/documents-de-reference.html

[54] See Telegeography, GlobalComms Database – France.

consolidation, low prices may have influenced operators to delay their investments in fibre networks.

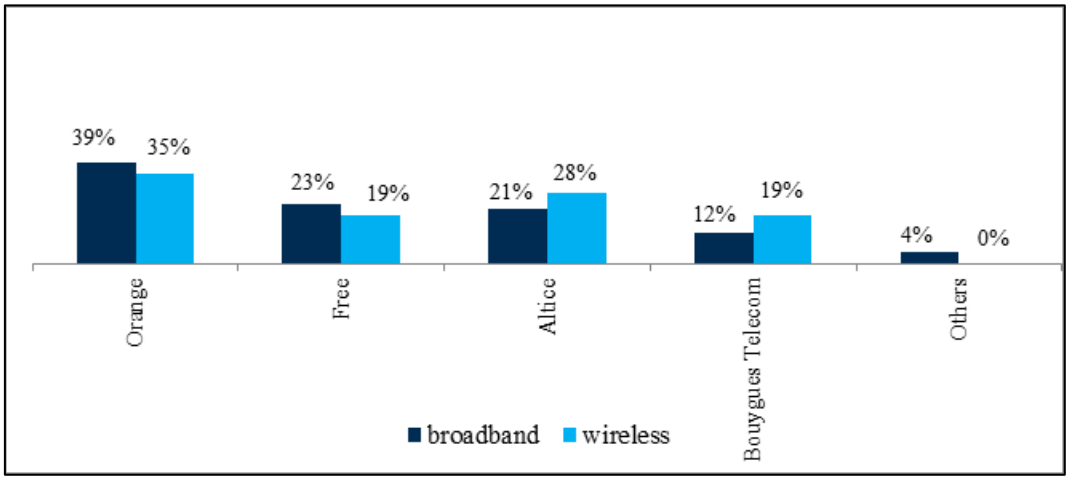
**Figure 25. FTTP Coverage in France (% households)**




Source: European Commission

The four leading French operators (Orange, Free, Altice and Bouygues) also implemented convergent strategies by launching convergent fixed-mobile and Pay TV bundles. At the same time, Iliad got a mobile licence and cable operator Numéricable acquired mobile and ULL operator SFR to become Altice France. As a result of market consolidation and fixed-mobile convergence, four convergent operators competed for most of the French market in 2017.

**Figure 26. Industry Structure in France 2017**




Source: TeleGeography

The French scheme was briefly challenged in 2017, when Altice offered to cover 100% of French premises with FTTP by 2025 without any public subsidy.[55] This triggered a lively

[55] See 'Fibre : SFR propose d'investir seul dans un réseau couvrant la France entière', Le Figaro, 12 July 2017. http://www.lefigaro.fr/secteur/high-tech/2017/07/12/32001-20170712ARTFIG00153-fibre-sfr-propose-d-investir-seul-dans-un-reseau-couvrant-la-france-entiere.php

discussion with other operators and local and national authorities, until financial troubles prompted the Altice Group to withdraw its proposal.[56]

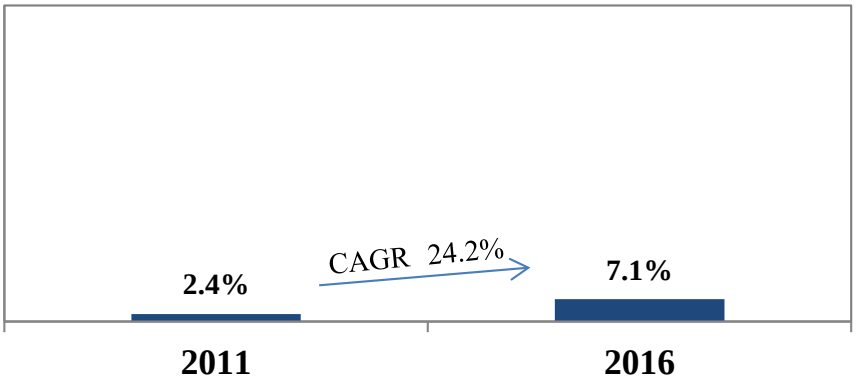
### 2.4.4. Conclusions

The French regulatory and institutional framework has a very complex design that, coupled with price wars in retail markets, has led to a slow start of ambitious FTTP plans. It has taken several years for operators and public administrations to begin FTTP rollouts. However, record investments in 2017 suggest that all agents are committed to the objectives of the THD Plan.

## 2.5. Case Study: Germany

Germany is the largest economy in the European Union and has a relatively robust Internet ecosystem. However, FTTP deployment has been meagre. High-speed broadband coverage and penetration is high, but most superfast broadband connections run over VDSL or cable.

**Figure 27. FTTP Coverage in Germany (% households)**




Source: European Commission

### 2.5.1. Targets

The National Broadband Strategy published in 2009 set two objectives: accelerating the rollout of high-speed networks across the country and the deployment of broadband in rural areas.

The NBS set the following targets.

- Eliminating rural 'white spots' by making mobile broadband available nationwide by the end of 2010
- Ensuring that 75% of households had access to connections with download speeds at least 50 Mbps by 2014[57]. This objective is technology-neutral and does not rule out VDSL or any other technology.

[56] See 'SFR renonce à équiper toute la France en fibre Internet', Le Monde, 13 December 2017. http://www.lemonde.fr/entreprises/article/2017/12/13/sfr-renonce-a-equiper-toute-la-france-en-fibre-internet_5229144_1656994.html#1HUbSQzOgvgskY7F.99

[57] See Telegeography, GlobalComms Database – Germany.

### 2.5.2. Regulation and other policy measures

The incumbent operator in Germany is Deutsche Telekom ('DT'). All of Deutsche Telekom's (previously the state-owned and operated telephone company) broadband services (ADSL, VDSL, and eventually FTTP) have been subject to access regulation since 2006.[58]

The German Government and Parliament attempted to deregulate superfast and ultrafast services by amending the Telecommunications Act in December 2006.[59] However, the European Commission successfully challenged this amendment and the European Court of Justice repealed it in 2009.[60] The German regulator BNetzA confirmed in 2010 and 2011 that eventual FTTP networks deployed by DT will be subject to access regulation.[61]

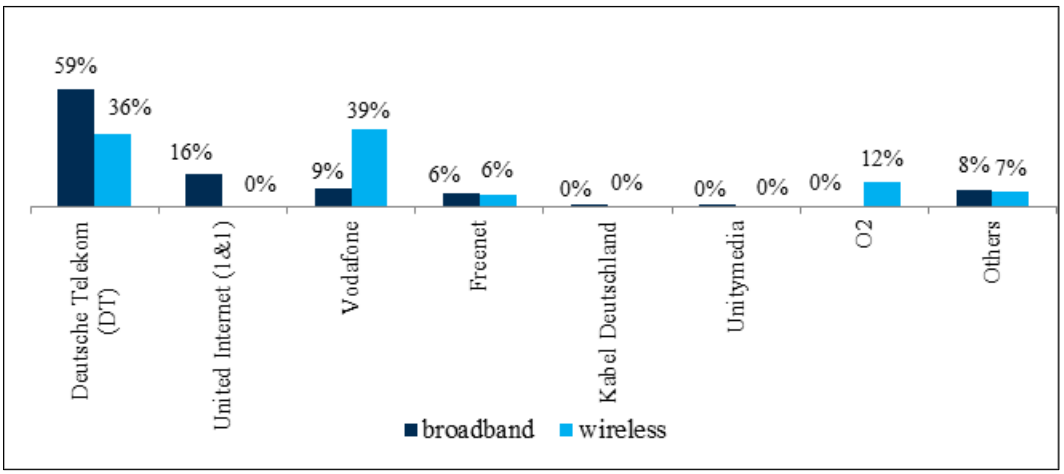
At the same time, however, regulation of local loop unbundling was relaxed for VDSL services. DT claimed that sub-loop unbundling ('SLU') was not compatible with the vectoring technology it intended to use to boost the speed of its VDSL network. As a result, SLU was not required in street cabinets where vectoring was implemented, although vectoring operators had the obligation to offer an active bitstream service to other operators.

An obligation to grant duct access was also imposed on Deutsche Telekom, but the regulator did not force DT to issue a detailed reference offer with well-defined quality parameters. Access seekers can refer any dispute to BNetzA that will settle complaints on a case-by-case basis.

### 2.5.3. Market dynamics and results

In 2005, DT was the clear leader of the German market, both in fixed and mobile. In addition to Vodafone, it faced competition from many small players that focused on either fixed or mobile offers. Alternative providers for fixed network services mostly used DT's unbundled local loops, except a few regional fibre operators.

**Figure 28. Industry Structure in Germany 2005**




Source::TeleGeography

[58] Ibid.

[59] Deutscher Bundestag, "Entwurf eines Gesetzes zur Änderung telekommunikationsrechtlicher Vorschriften", September 14th, 2006. http://merlin.obs.coe.int/iris/2007/1/article8.en.html

[60] See Telegeography, GlobalComms Database – Germany.

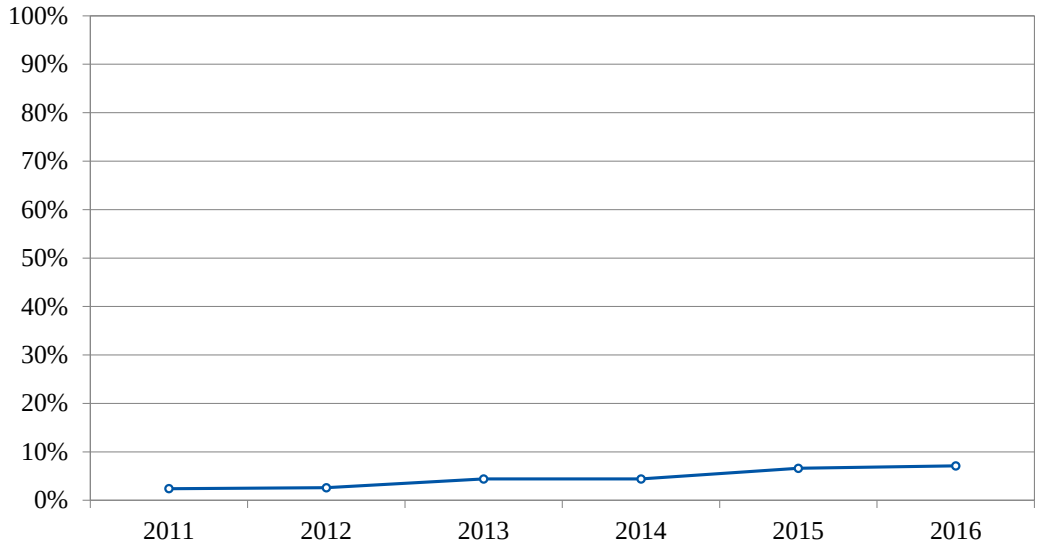
[61] Ibid.

DT chose to upgrade its network to VDSL instead of FTTP and launched an ambitious investment plan, which resulted in more than 80% of German premises covered. Most alternative ADSL providers migrated to VDSL, in some cases by deploying equipment in DT's street cabinets, but in most cases they migrated from local loop unbundling (LLU) to a bitstream service.

Cable operators also entered the broadband market after 2005. Because of historical reasons, most of the cable plant in Germany was still analogue at this time. Cable operators invested heavily after 2005 to upgrade their networks with bidirectional equipment that allowed them to offer broadband services. After 2009, they deployed DOCSIS 3.0 technology to deliver ultrafast services to customers. Cable companies have now fully upgraded their networks and have become major players in the broadband market. They are also slowly expanding their coverage with some FTTP deployments in association with municipalities and housing associations. In 2014, Vodafone acquired Kabel Deutschland and became a major convergent player.

A few regional operators offer FTTP services. Most of them belong to local utilities that deployed FTTP networks using their existing passive infrastructure just after market liberalization in 1998.[62] Fibre operators have increased their footprint beyond their original areas since 2011, but they still covered less than 10% of households by 2016.[63]

**Figure 29. FTTP Coverage in Germany (% households)**




Source: European Commission

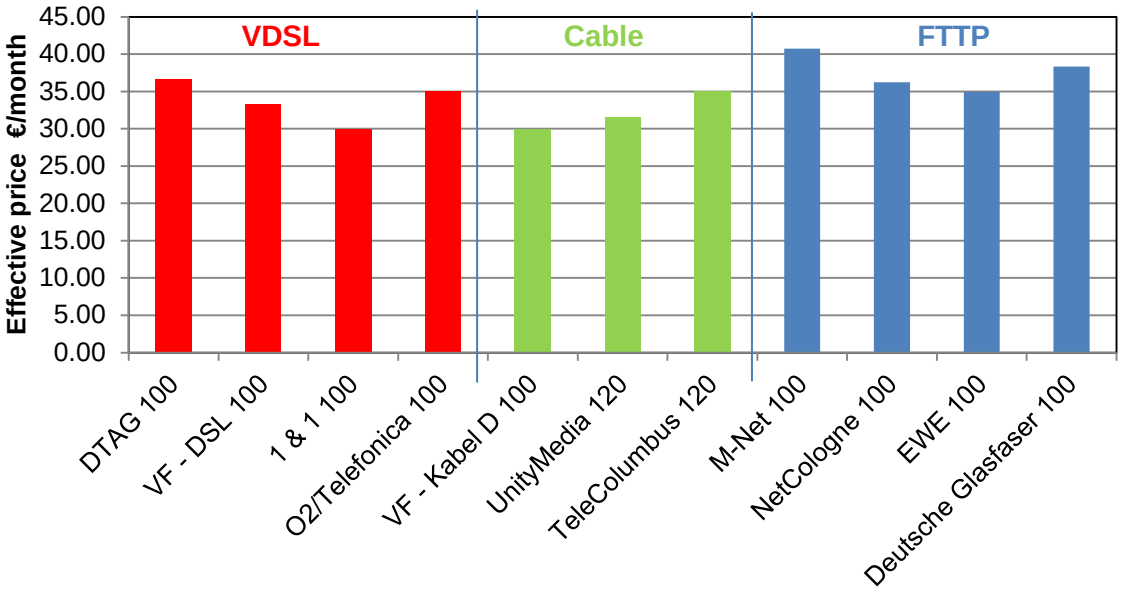
DT has claimed in public statements and conferences that its decision not to move to FTTP was based on several factors.[64] These factors being ex-ante regulation of fibre services, flexible regulation of VDSL, good technical performance of VDSL services, lack of customer demand for higher speed services, and especially the high cost and time required to deploy FTTP in Germany because of the lack of duct infrastructure beyond street cabinets and restrictive building policies.

[62] The largest utility-backed regional FTTP providers are NetCologne, M-Net and EWE.
[63] See Telegeography, GlobalComms Database – Germany.
[64] See, e.g. the panel debate 'Germany after the general election – getting real about Gigabit?' at the FTTH Council Europe Conference 2018, Valencia, 13 February 2018.

Another factor identified by all German operators is supply constraints by construction companies. There are few construction companies in Germany capable of deploying fibre networks. Every time there is a surge in construction activity, such as during the White Spots subsidy programme, prices for constructions services rise.[65]

FTTP take-up has grown slowly, and at 1.8% is about 25% penetration in coverage areas. Several reasons that may explain this relatively low take-up are the stronger marketing capabilities of large national players, the relatively recent deployment in many areas, and the fact that most operators price FTTP services at a small premium over same speed cable or VDSL, as shown in Figure 30.

**Figure 30. Average prices for 100 Mbps services in Germany (September 2017)**

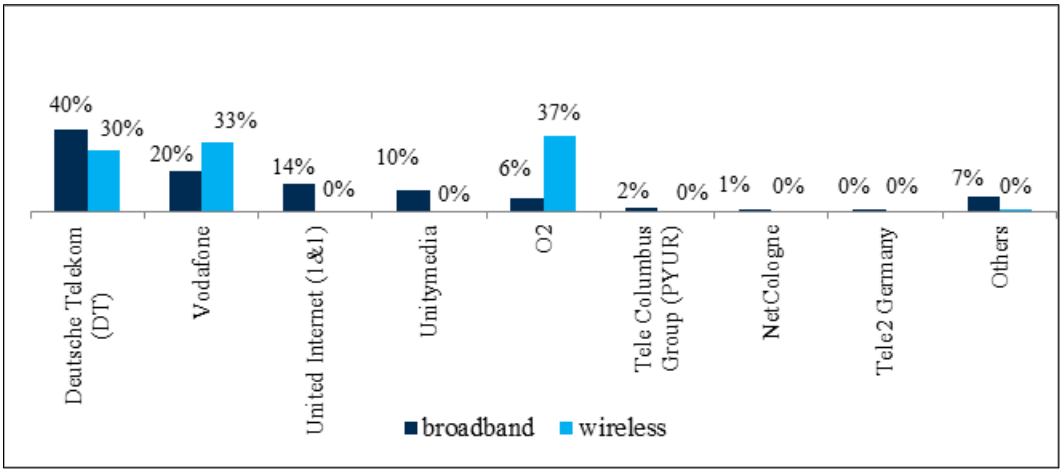



Source: NERA analysis based on data from operator's commercial websites

Consolidation has advanced in the mobile segment as well as fixed-to-mobile convergence. There are now two sizable convergent operators instead of one. However, there are still strong operators that are purely fixed, and the leading mobile operator has only a small presence in the fixed market.

[65] Ibid.

**Figure 31. Industry Structure in Germany 2017**




Source: TeleGeography

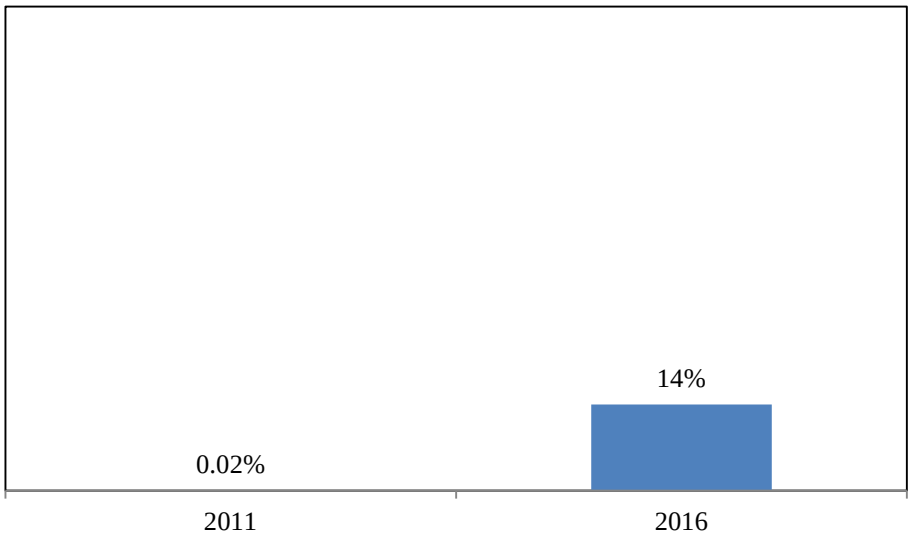
### 2.5.4. Conclusions

The combination of a favourable regulatory regime for VDSL wholesale services, the ex-ante regulation of wholesale fibre services and challenging economics for fibre deployment from street cabinet to customer premises has prompted incumbent Deutsche Telekom to make strong investments in VDSL but almost none in FTTP. Furthermore, alternative ULL operators have not engaged in competitive FTTP deployments but have relied on regulated wholesale VDSL services. The only significant FTTP deployments have been carried out by utility-backed regional fibre operators, which are extending the networks they deployed in the early 2000s.

## 2.6. Case Study: Australia

Australia decided to forgo network competition to achieve full country FTTP coverage through a state-owned wholesale-only monopoly network operator. It has not met the expected results and has pulled back to a multi-technology network architecture where VDSL and cable will be used instead of FTTP in many areas.

**Figure 32. FTTP Coverage in Australia (% households)**




Source: NBN Annual Reports and Australian Bureau of Statistics residential dwelling data

### 2.6.1. Targets

NBN Co Ltd ('NBNco'), an Australian government-owned corporation, was established in 2009 to design, build, and operate Australia's new fast, wholesale local access broadband network. NBNco's key objective is to ensure 'all Australians have access to very fast broadband as soon as possible, at affordable prices, and at least cost to taxpayers'.[66]

The government defines 'very fast broadband' to be 50 Mbps or more. Government expects the network will provide peak wholesale download data rates (and proportionate upload rates) of at least 25 megabits per second to all premises, and at least 50 megabits per second to 90 per cent of fixed line premises as soon as possible.[67]

### 2.6.2. Regulation and other policy measures

In 2005, Telstra, the leading Australian communications provider, planned to roll out a fibre-to-the node ('FTTN') network in metropolitan areas but ended up not going ahead as talks between Telstra and the Australian Competition & Consumer Commission ('ACCC') broke down over the terms of the new network, including conditions on allowing third-party access and pricing.[68]

A collection of other telecommunications companies, including Optus, also proposed their own FTTN networks in 2007, but this was also rejected by the ACCC on access conditions stating that the collection had too much freedom to set prices.[69] After the failure to come to an

[66] NBN Co Ltd, 'Statement of Expectations', 24 August 2016, p. 1, https://www.nbnco.com.au/content/dam/nbnco2/documents/soe-shareholder-minister-letter.pdf

[67] Ibid.

[68] See Renai LeMay, 'Telstra fibre talks break down,' *ZDNet*, 7 August, 2006, http://www.zdnet.com/article/telstra-fibre-talks-break-down/.

[69] See 'G9 telcos release Aussie broadband plan', *Sydney Morning Herald*, 20 April 2007, http://www.smh.com.au//national/g9-telcos-release-aussie-broadband-plan-20070420-8pe.html; see also Jo Best, 'Telstra: ACCC is fighting to keep G9 in fibre race', *ZDNet*, 5 February 2008, http://www.zdnet.com/article/telstra-accc-is-fighting-to-keep-g9-in-fibre-race/.

agreement with any party on access conditions, the government proposed NBNco as the provider of a wholesale open-access data network at uniform prices and to prioritise identified underserved areas.

NBNco was thus established as a state-owned enterprise to build a wholesale-only open-access FTTP network in Australia. NBNco is to provide access to its network on equivalent terms to all retail phone and Internet providers,[70] and a special access undertaking ('SAU') sets out price and non-price terms that NBNco can impose.

NBNco's mandate is to charge nationally uniform prices, which are to be funded through cross-subsidies,[71] including across geographic areas and across all technologies.[72] The April 2014 Statement of Expectations requests NBNco to 'prioritise areas identified as poorly served by the "Broadband Availability and Quality Report" published by the Department of Communications in February 2014 [...] to the extent commercially, and operationally feasible'.[73]

The NBN was announced in 2007 by the opposition Labour government in the run up to the 2007 federal election. When Labour won that election, planning started; the government released a request for proposals in 2008, which was never completed as none of the proposals met the requirements. In 2009, the government announced the original plan for the NBN, which was to provide a wholesale open-access network to deliver FTTP reaching 90% of premises in eight years and to deliver wireless or satellite services for the remaining 10%. The NBN was to be paid for by selling off the governments remaining shares in Telstra. NBNco was established soon after in 2009 to design, build, and operate the NBN.

Tasmania was chosen to be the trial deployment of the NBN, and this rollout started in 2010. In 2011, the first mainland customers were connected in New South Wales.

After the 2013 election, Labour was put out of government. the new government announced changes to the NBN. The NBN was to move towards a Multi-Technology Model ('MTM') using FTTN over the legacy copper and hybrid fibre-coaxial ('HFC') cable networks. This was due to a combination of a change in government, roll out delays, and increasing costs.

NBNco is funded through a mixture of equity from the government and private debt.[74] The government provides equity funding to the NBN, and the funding requirement is reviewed each year. The public equity capital limit is $29.5 billion (as of 2016).[75]

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[70] See, 'About nbn', *nbn*, https://www.nbnco.com.au/corporate-information/about-nbn-co.html.

[71] See Australian Competition & Consumer Commission, 'Communications Sector Market Study Draft report', October 2017, https://www.accc.gov.au/system/files/Communications%2520Sector%2520Market%2520Study%2520Draft%2520Report.pdf.

[72] See Matthew L. James, 'National Broadband Network (NBN) Budget Review 2013–14 Index', *Parliament of Australia*, https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/BudgetReview201314/NBN.

[73] NBN Australia's broadband network, 'Corporate Plan 2016', https://www.nbnco.com.au/content/dam/nbnco2/documents/nbn-corporate-plan-2016.pdf.

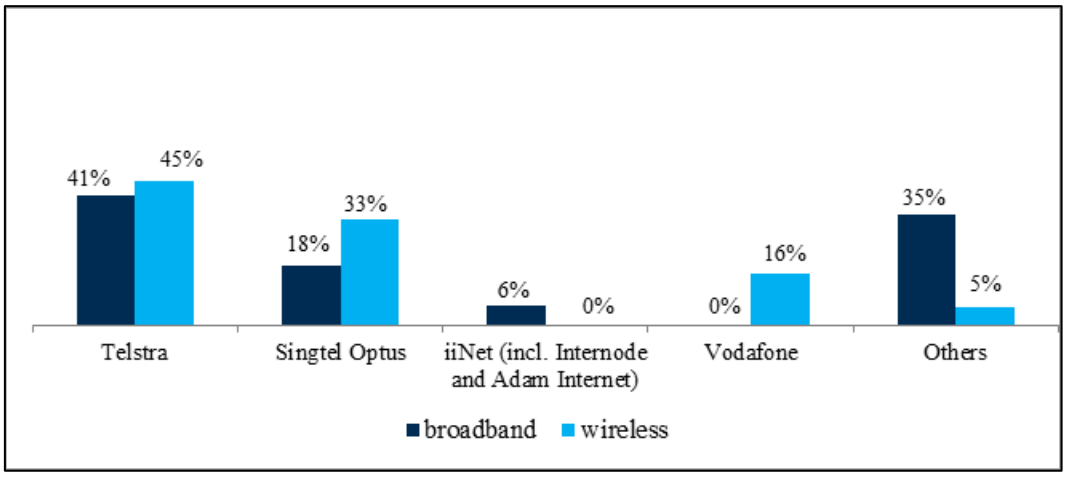
[74] There is a limit on the public equity capital of $29.5 billion (as of 2016). See NBN Australia's broadband network, 'Corporate Plan 2016', https://www.nbnco.com.au/content/dam/nbnco2/documents/nbn-corporate-plan-2016.pdf.

As the sole shareholder, the Australian government determines NBNco's direction through issuing a 'statement of expectations' ('SOE').[76] NBNco's price and non-price terms are governed by a 'special access undertaking' ('SAU'), which is enforced by the ACCC. NBNco charges a geographically averaged wholesale price, which does not vary geographically or by technology.

### 2.6.3. Market dynamics and results

At the time when NBN was set up, Telstra was the vertically integrated incumbent. Telstra owned the copper access network for which it was/is required to provide access to on regulated terms. Optus was the other major existing player that was vertically integrated into wholesale through its ownership of an HFC cable network.

**Figure 33. Industry Structure in Australia 2005**




Source: TeleGeography

Telstra is the incumbent telecommunications company, a former government-owned original network monopoly, owning the legacy copper network. Telstra has copper and hybrid fibre-coaxial cable networks, and it provides both wholesale and retail services and also uses wholesale services on the NBN.

Optus is the second largest private telecommunications company in Australia, originally government owned before it was privatised. Optus operates on its own infrastructure, which includes hybrid fibre-coaxial cable, satellite, and copper, and it uses the wholesale services from Telstra and the NBN.

The legacy networks in Australia are mainly copper and hybrid fibre-coaxial cable networks. In the late 1990s, both Telstra and Optus built separate cable Internet networks to provide broadband.[77] Telstra also provided ADSL and upgraded ADSL2+ services through its copper network. Telstra was mandated to allow wholesale access of its copper network to other providers at regulated prices. This saw a number of providers taking advantage of local loop unbundling and offering retail ADSL broadband services.

[75] Ibid.
[76] Australian Government, Department of Communications and the Arts, 'Statement of Expectation', 24 August 2016, https://www.communications.gov.au/publications/nbnstatementofexpectations.
[77] 'Internet in Australia', https://en.wikipedia.org/wiki/Internet_in_Australia.

Broadband is also available through satellite, fixed wireless networks, and mobile wireless networks, which are well suited to provide broadband access to rural areas in Australia with lower population densities. Telstra and other mobile providers also offer mobile wireless broadband through the 3G and 4G networks.

Telstra has faced regulation relating to the wholesale provision of copper network services to access seekers wanting to buy wholesale ADSL services.[78] A Final Access Determination ('FAD') by the ACCC in 2012,[79] as a response to complaints from access seekers, set the wholesale prices to be used when parties did not reach an agreement on access conditions. The prices were assessed and some adjusted in 2014 and 2017. The current declaration is valid through to 2022.[80] These regulated prices only apply to Telstra and not to other operators as they are constrained in supply through competition with Telstra.

NBNco was overbuilding because of the incumbent legacy networks, which were its competitors, so the government did a deal with Telstra and Optus to shut down their copper and hybrid fibre-coaxial cable networks once the NBN was in the relevant area. This involved a deal with Telstra in which Telstra would disconnect copper and hybrid fibre-coaxial cable networks within 18 months once the NBN entered an area along with leasing dark fibre, exchange space, and ducts to NBNco and other conditions. Telstra could continue to use the hybrid fibre-coaxial cable network to deliver pay TV services. The original deal in 2011 was $11 billion for Telstra to decommission copper and hybrid fibre-coaxial cable networks when NBN arrived in an area to ensure that the NBN did not face competition from the services provided over the copper network.[81] Optus also had a deal with the NBN. Originally, like the Telstra deal, Optus would decommission hybrid fibre-coaxial cable where NBN was in an area for $800 million.

In 2013, an expert panel commissioned a Strategic Review. This review found that the NBN would require an extra $73 billion of funding and take an extra three years to complete compared to the original plan.[82] As a result of this review (and a change of government), the NBN is now transitioning to a multi-technology mix ('MTM') model, which focuses on upgrading existing networks instead of building a new network. This change aims at faster rollout and reducing peak funding of the NBN to no more than $56 billion.[83] The MTM model emphasizes FTTN (VDSL and cable) rather than FTTP to connect customers, with

[78] See Australian Competition & Consumer Commission, 'Public inquiry to make a final access determination for the Wholesale ADSL service Final Report', May 2013, https://www.accc.gov.au/system/files/Final%20report%20-%20FAD%20for%20wholesale%20ADSL%20-%20public%20version.pdf.

[79] See Australian Competition & Consumer Commission, 'Declaration of the wholesale ADSL service under Part XIC of the *Competition and Consumer Act 2010* Final Decision', February 2012, https://www.accc.gov.au/system/files/Declaration%20of%20the%20wholesale%20ADSL%20service%20-%20final%20decision%20paper.pdf.

[80] See Australian Competition & Consumer Commission, 'Wholesale ADSL service declaration inquiry Final decision', February 2017, https://www.accc.gov.au/system/files/Wholesale%20ADSL%20service%20declaration%20inquiry%20-%20final%20report%20-%20public%20version_0.pdf.

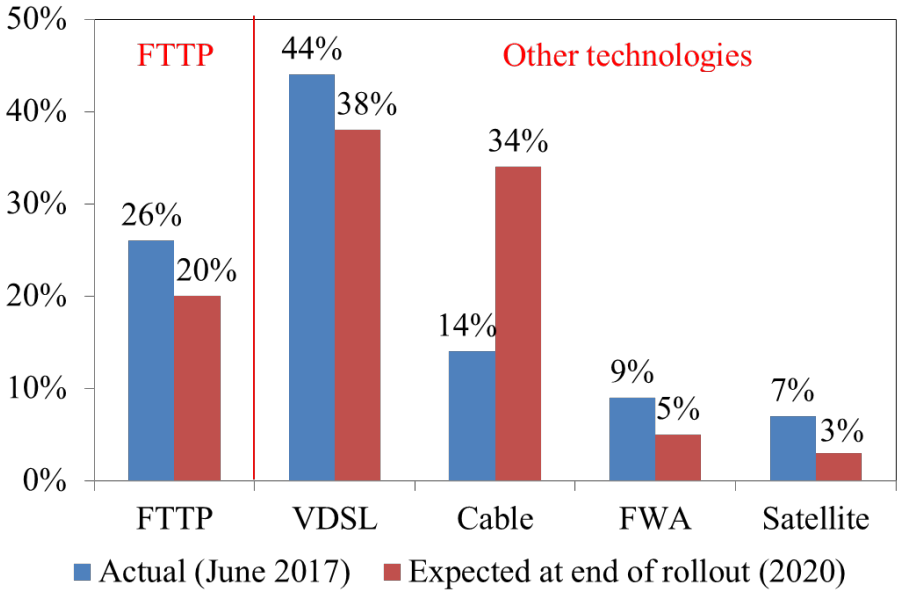
[81] See Lexi Methrell, 'Copper network switch-off begins as Telstra hands over infrastructure to NBN Co', *ABC News*, updated 22 May 2014, http://www.abc.net.au/news/2014-05-22/telstra-copper-network-switch-off-nbn-handover/5471150

[82] NBNCo, 'Strategic Review: Comments in Confidence – Final Report', Version: 12 December 2013, p. 113.

[83] See NBN Australia's broadband network, 'Corporate Plan 2016'.

FTTP expected to lose relevance as rollout is completed. FTTP covered 26% of the 5.7 million premises passed in June 2017, and NBN plans to cover with FTTP only 20% of a total 11.9 premises by 2020. [84]

**Figure 34. Technology mix in Australia's NBN under the MTM model (% premises passed)**




Source. NBN

Because of the change in approach, in 2014, the deals with Telstra and Optus were modified to transfer Optus' and Telstra's legacy networks to NBNco rather than decommission them. The new deal with Telstra in 2014 saw Telstra transfer ownership to NBNco of copper or hybrid fibre-coaxial networks to be used in the NBN's MTM.[85] The new deal with Optus partially hands over the Optus hybrid fibre-coaxial cable network to the NBN, with Optus and the NBN sharing the bandwidth.[86] Once the NBN comes to an area, at the disconnection date 18 months after, around 75% of eligible consumers had not migrated to the NBN.[87]

As of 2017, 5.7 million premises were ready for service ('RFS') on the NBN considering all technologies. Of these, 2.4 million premises are activated on the NBN, suggesting an actual uptake rate of around 42%. This RFS rate is higher than the forecasts from the 2016 and 2017 corporate plans, which forecasted around 5.4 million. The story is similar for the forecasts for activated premises, with estimates around 2.3 million, with the 2016 and 2017 corporate

[84] See 'NBN Annual Report 2017', 'NBN Corporate Plan 2016'

[85] See Allie Coyne, 'Telstra hands over copper, HFC in new $11bn NBN deal', *itnews*, 14 December 2014, https://www.itnews.com.au/news/telstra-hands-over-copper-hfc-in-new-11bn-nbn-deal-398793 ; see also Luke Hopewell, 'Telstra Signs New $11 Billion Agreement with NBN Co, *Gizmodo*, 14 December 2014, https://www.gizmodo.com.au/2014/12/telstra-signs-new-11-billion-agreement-with-nbn-co/.

[86] See Andrew Sadauskas, 'ACCC approves Optus HFC NBN deal, *itnews*, 28 August 2015, https://www.itnews.com.au/news/accc-approves-optus-hfc-nbn-deal-408541.

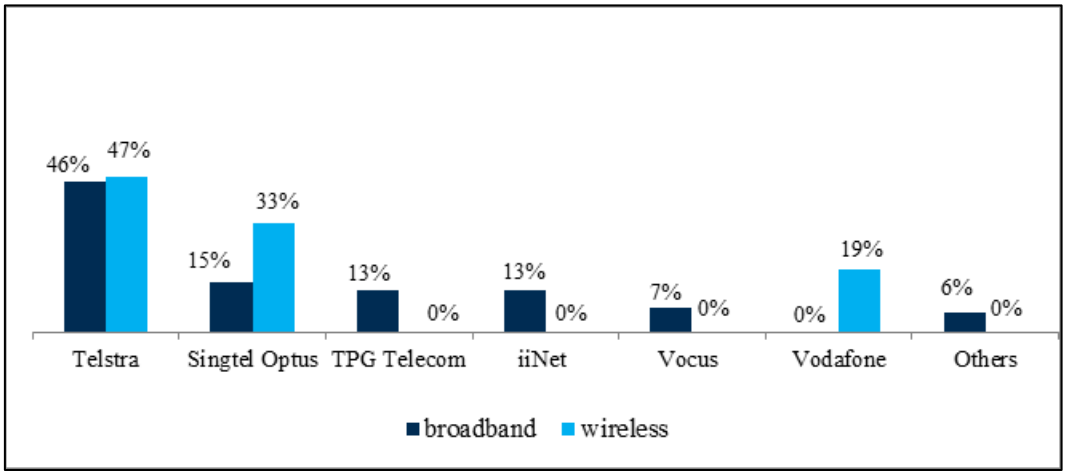
[87] See Mr Bill Morrow, Chief Executive Officer, NBNco, Proof Committee Hansard, 1 August 2017, pp. 81–82, http://parlinfo.aph.gov.au/parlInfo/download/committees/commjnt/be5b2953-7402-482b-8728-fa9a9c888ff7/toc_pdf/Joint%20Standing%20Committee%20on%20the%20National%20Broadband%20Network_2017_08_01_5304_Official.pdf;fileType=application%2Fpdf.

plans being slightly lower than the actual activation rates. In previous years, the actual figures for NBN coverage and uptake were falling behind estimates, but these figures seem to have caught up to the new less optimistic forecasts in recent years. Actual revenue for the NBN hit $1 billion in 2017, a year earlier than most previous forecasts.[88]

As of 1st April 2017, NBN implemented a $300 charge for all connections made in areas they have identified as within the boundary of a new development. The decision was made to shift the cost of infrastructure onto the "parties that use or benefit from them". The charge is a partial recovery cost for NBN for providing telecommunications infrastructure in new development areas.[89] Because this measure is very recent and new developments affect only a limited number of premises, we have no information whether this new charge is having any impact on take-up figures.

Developments in Australian market have not driven relevant changes in industry structure. Convergent players Telstra and Optus remain leaders; the only perceptible change being slightly increased concentration among fixed line resellers.

**Figure 35. Industry Structure in Australia 2017**




Source: TeleGeography

## 2.6.4. Conclusions

Australia is falling short of the ambitious FTTP objectives set by the government in 2007. The government and the regulator decided that they preferred a state-owned fibre operator rather than lightly regulated private ones. However, after huge investments and re-monopolization of telecommunications networks, the NBN has been unable to deliver the national FTTP network that justified its creation. Australian customers now have access to FTTP, VDSL, or cable depending on the area they live or have their businesses.

[88] See Andrew Sadauskas, 'ACCC approves Optus HFC NBN deal, *itnews*, 28 August 2015, https://www.nbnco.com.au/content/dam/nbnco2/documents/Corporate-Plan-2018-2021.pdf.

[89] See Australia Broadband, What is the nbn™ New Development Charge?, 1 February 2017, https://www.australiabroadband.net.au/help/article/nbn-new-development-charge/

## 2.7. Cross Country Comparisons of Relevant Issues

We have identified some common trends across countries. In the following points, we shall discuss the most important. The evidence we show is consistent with the conclusions we arrived at, but given the small size of the sample of countries that we have analysed we have not been able to run robust quantitative analyses to prove our conclusions.

The experience of the countries in our sample suggests that two policy models have delivered wide coverage of FTTP networks: unregulated competition with duct access (Spain and dense areas in France) and wholesale-only deployment with public funding (Sweden and New Zealand).

Those two models were driven by a number of features that we discuss in the remainder of this section:

- Infrastructure competition;
- Favourable population density and housing types
- Passive infrastructure initial situation, access and regulation, especially in the final drop;
- Deregulation of fibre services, even if temporary and/or different from that of copper-based legacy services;
- Wholesale services, either commercial or regulated;
- Consolidation of alternative operators and fixed-to-mobile convergence;
- Network separation and public funding; and
- Flexibility of administrative processes.

### 2.7.1. Infrastructure competition

Where properly implemented, FTTP deployment has usually led to an increase in network competition. It has allowed both existing alternative operators (by using incumbents' ducts) and new entrants (using their own ducts) to engage in infrastructure competition with the incumbent telecommunications and cable operators.

**Table 1. Evolution of Network Competition across Countries**

| Country | Customers with Access to Competing Fixed Broadband Networks (% households) | | | | | |
|---|---|---|---|---|---|---|
| | 2005 | | | 2017 | | |
| | 1 network | 2 networks | 3 or more | 1 network | 2 networks | 3 or more |
| Spain | 52% | 48% | | 42% | 23% | 38% |
| New Zealand | 100% | | | 69% | 31% | |
| Sweden | 62% | 38% | | 39% | 25% | 36% |
| France | 61% | 29% | | 61% | 11% | 18% |
| Australia | 90% | 10% | | 100% | | |
| Germany | 37% | 63% | | 32% | 59% | 8% |

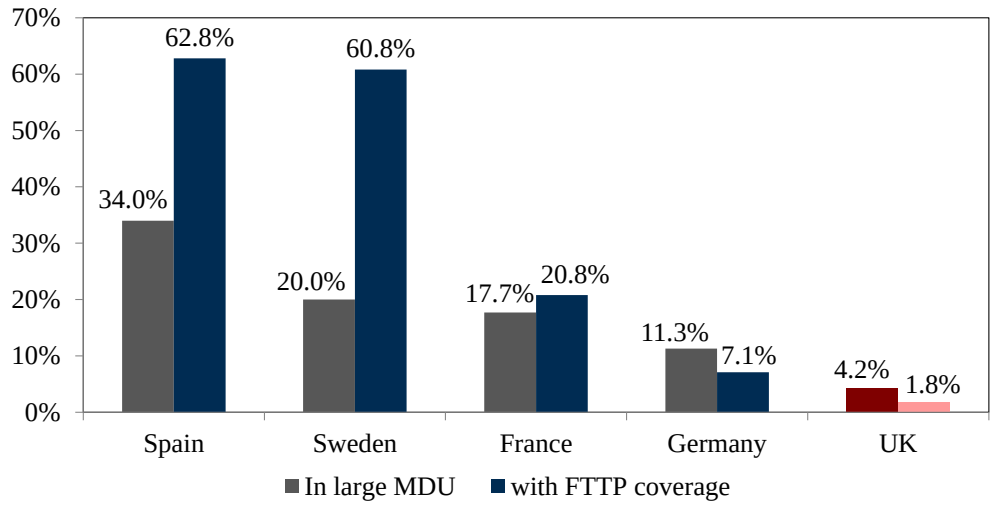
Source: Telegeography, except NERA estimates for Germany (2017) based on Breitbandatlas data; France (2017), based on ARCEP data; and Sweden (2017) based on European Commission data.

### 2.7.2. Population density and housing types

A high proportion of homes in large multiple-dwelling unit ('MDU') is helpful to trigger FTTP development, but it is not a necessary condition for mass development.

Spain is a case in point. There is high-density urbanization in urban areas, so that the percentage of people living in flats in buildings with 10 or more dwellings is amongst the highest in Europe (see Figure 36). In the first stage of the process, this allowed the start of the rollout in an efficient way and further permitted a gain in experience and efficiency. However, in a subsequent stage, deployment expanded beyond the dense areas, and operators were able to cope with the challenges they posed. This was also the case in Sweden, where FTTP networks reach areas beyond high-density MDUs.

**Figure 36. FTTP coverage and building size 2016 (% Households)** [90]




Source: Eurostat, European Commission, NBN, Australian Bureau of Statistics, MBIE, New Zealand dwelling statistics

### 2.7.3. Passive infrastructure situation, access and regulation

Passive infrastructure is a critical element of FTTP network projects. It commands the largest part of investment,[91] and if built from scratch its construction would take the longest time of all other tasks. Therefore, when fibre operators gain access to existing passive infrastructure, it greatly improves both the business case and the lead-time of their FTTP projects, which results in more projects being undertaken and faster delivery to end users.

Access to existing passive infrastructure is a common pattern used by all the FTTP operators that we have identified in the six target countries. Table 2 shows that few if any operators are building greenfield passive infrastructure on their own.

[90] We consider a large MDU to be an MDU with 10 or more flats.
[91] Passive infrastructure usually amounts for 50% to 75% of total investment in greenfield projects.

**Table 2. Passive infrastructure Used by FTTP Operators**

| Country | Operator | Passive infrastructure | | | | |
|---|---|---|---|---|---|---|
| | | Own Telco | Own Other | Leased Telco | Leased Other | New Build |
| Australia | NBN | x | | | | |
| France | Bouygues Telecom | | | x | | |
| | Iliad (Free) | | | x | x | |
| | Orange France | x | | | | |
| | SFR Group | x | | x | x | |
| Germany | Deutsche Glasfaser | | | | n.d.[92] | |
| | M-net | | x | | | |
| | NetCologne | | x | | | |
| | QSC | | | | x | |
| | Tele Columbus Group (PYUR) | x | | | | |
| | Deutsche Telekom | x | | | | |
| | Unitymedia | x | | | | |
| | Vodafone | x | | x | | |
| New Zealand | Chorus | x | | | | |
| | Enable Networks | | x | | | |
| | Northpower Fibre | | x | | | |
| | Trustpower | | x | | | |
| | Ultrafast Fibre | | | | | x |
| | Vocus Communications | | x | | | |
| | Vodafone | x | | | | |
| Spain | Adamo Telecom | | | x | x | |
| | Euskaltel | x | | | | |
| | MásMóvil | | | x | | |
| | Orange | | | x | | |
| | Telefonica | x | | | | |
| | Vodafone | x | | x | | |
| Sweden | Com Hem | x | | | | |
| | IP-Only | x | | | | |
| | Stadsnats | | x | | | |
| | Stokab | | x | | | |
| | Telenor Sweden | x | | | | |
| | Telia | x | | | | |

Source: Telegeography, operator websites

Policies intended to foster FTTP deployment have fostered would-be fibre operators to access existing passive infrastructures. As summarized in Table 3, this can be achieved by fostering entry by infrastructure-owning organizations and/or by enabling would-be operators to access third-party infrastructure.

[92] Information in Deutsche Glasfaser website suggests they lease ducts from utilities.

**Table 3. Fibre Operators' Techniques to Gain Access to Passive infrastructure**

| Reusing passive infrastructure already owned | Accessing third-party passive infrastructure |
|---|---|
| Telecommunications incumbents | Co-investment |
| Cable operators | Regulated access to incumbent's ducts and poles |
| Electricity companies | Partnerships with utilities and municipalities |
| Municipalities | Regulated access to utilities and municipalities infrastructure |

Countries in our sample have resorted to both techniques. Spain, France, Germany, and Sweden have implemented regulated duct and pole access, first to the incumbent telco and after to other utilities and municipalities.[93] Duct and pole access has been used by retailers such as Orange, Vodafone, or MásMóvil in Spain or Iliad, SFR, and Bouygues in France to integrate vertically into FTTP networks.

In other cases, non-telecommunication infrastructure owners have entered the broadband market. This was the case with electricity companies, such as Northpower and Waikato Networks Limited in New Zealand and NetCologne and M-Net in Germany. This was also the case with municipal networks in Sweden and rural parts of France.

Passive infrastructure has very different economics, technical and legal features in two sections of telecommunications access networks: the feeder network and the final drop. The feeder network goes from the central office to the street cabinets (or equivalent splicing boxes) and the final drop goes from the street cabinet to the customer premises.

The feeder network is usually equipped with ducts in all countries. Access to those ducts is used by alternative operators to connect to colocation space in or near street cabinets and (where allowed) to deploy fibre for mobile backhaul.

The most critical part of the network is the last drop. Because of its capillarity, the need to access private property and synchronize deployment with many tenants, it is the most expensive and time-consuming part of the network.

The last drop is the most differential feature for operators when they have to decide whether to upgrade their copper of cable networks to VDSL/DOCSIS 3.0 or to FTTP. FTTP requires a complete overbuild of cabling, while VDSL and DOCSIS 3.0 only require working at the street cabinet and replacing the customer premises equipment. Therefore, the higher the portion of passive infrastructure that can be reused in the last drop, the more attractive FTTP deployment would be.

Passive infrastructure elements that can be reused where existing are street cabinets, ducts or poles to the building and in-building ducts.

- Existing street cabinets tend to favour VDSL, because FTTP does not need active elements mid-way to customers. One of the reasons why Telefónica decided to deploy FTTP was that they had no pre-existing street cabinets and if they had decided to go for

[93] Access to infrastructures other than the incumbent's has been mandated in EU countries after Directive 2014/61/EU. However, market players state that this has not yet had time to have any meaningful impact on the market.

VDSL, they would have needed to invest heavily in an infrastructure that was not needed for FTTP. However, DT had a very well developed street cabinet infrastructure in its copper network.

- Existing ducts to buildings also save a lot of time and money that improve the business case for FTTP. Again, widespread availability of ducts to building is one of the reasons of the success of Spanish operators and Swedish municipal networks. And its absence is one of the reasons DT claims is pushing back FTTP deployment in Germany.
- In-building ducts also greatly improve the FTTP business case, when available. In Spain, for instance, construction codes since 2000 mandate builders to include telecommunications ducts or even to install fibre cabling.[94] In Sweden, building owners have been mandated to provide access to in-building infrastructure to operators since 2016.[95] Again, this contrasts with the situation in Germany, where landlords have no obligation to prepare their buildings to ease deployment of telecommunications cables.[96]

Regulation also plays a key role to ease fibre cabling and decrease its cost. It may affect several elements of fibre projects:

- Rights-of-way over public domain and private land. The Law grants operators in some countries (Spain, France, the US) the right to use public and private domain to deploy their networks, subject to regulated fair compensation. This saves time and money that would otherwise be spent in lengthy negotiations with land owners.
- Regulations can also force landlords to allow connecting their buildings to a network in case any of the tenants request it.
- Telecommunications regulation can mandate symmetric access to in-building cabling, such as in Spain and France.
- Municipal regulation can allow faster and cheaper deployment techniques (e.g. micro trenching, outside cabling through façades or poles) or restrict their use and mandate more expensive ones.
- Construction coordination with other operators or utilities can decrease the cost of constructing ducts to buildings, but if improperly managed can delay network building.

As an example of the influence of final drop status on operators' decisions to opt for FTTP or VDSL, it can be noted that the main differences between the situation in Spain and Germany were two: deregulation of fibre services in Spain versus ex ante regulation in Germany; and very favourable final drop economics and regulation in Spain versus very unfavourable ones in Germany.

### 2.7.4. Deregulation of fibre services

Deregulation of fibre services is associated with widespread FTTP deployments by private operators in Spain and dense regions of France. This is also the case in many other countries outside our sample where competing private operators have deployed sizable FTTP networks,

[94] For example, the Spanish Building Code mandates that all buildings constructed after 2000 must have a duct network that allows several telecommunications operators to collocate equipment and blow cables to each flat. See Real Decreto-ley 1/1998, de 27 de febrero, sobre infraestructuras comunes en los edificios para el acceso a los servicios de telecomunicación, BOE núm. 51, 28 February 1998.

[95] Act (2016:534), supplemented by Ordinance (2016:538).

[96] Source: interviews with German telecommunications executives.

such as Portugal, the US, Brazil or Chile. It has to be noted that deregulation of fibre services is often coupled with regulated access to ducts and poles.

Deregulation of fibre fosters investments by incumbents and alternative operators alike. In the words of the FTTH Council Europe:

> The absence of virtual access remedies incentivises access seekers to build out their own networks and incumbent telecom operators, being confronted with less regulation and more regulatory certainty, to react by building their own FTTH networks. Telefonica in Spain seems to have spotted that trend early judging by the rapidity with which it reacted once its competitors started to deploy FTTH at scale.[97]

This is in line with the claims of incumbent operators. They often claim that asymmetric access obligations on their broadband networks make it unprofitable to invest in new technologies, such as FTTP. From the incumbents' perspective, VDSL has several advantages over FTTP when responding to competition from ultrafast cable services: the upfront investment needed is smaller, vectoring technologies may justify deregulation of sub-loop unbundling, and VDSL bitstream commands a larger portion of costs (and thus revenues) of the wholesale market than ADSL bitstream. To the contrary, FTTP puts more capital at risk and allows for deeper unbundling levels than VDSL.

Our findings suggest that incumbent operators' behaviour is consistent with this view of their incentives to invest. Incumbent operators in the countries in our sample have invested in FTTP only where fibre services were not regulated (Spain's and France's densest areas) or where they got public-private partnerships that guaranteed some degree of exclusivity and decreased the amount of capital at risk (New Zealand's and France's less dense areas).

On the other side, Telia in Sweden has deployed a limited amount of FTTP, even when facing competition by two other ultrafast network operators (stadsnats and cable), and Deutsche Telekom has not undertaken any meaningful FTTP deployment yet. However, DT has upgraded most of its network to VDSL, and Telia's network has large amounts of VDSL. Telstra and Optus in Australia announced that they were ready to invest in fibre provided it was not subject to regulation. However, when the authorities insisted on regulating fibre services, these companies changed their plans.

Alternative operators also share the view that deregulation provides them with incentives to invest in their own FTTP networks, because the lower regulatory pressure on prices allows them to make a better margin on their investments and reduces the risk of politically-driven price changes eroding the profitability of already deployed networks. Alternative operator Stokab from Sweden explained:

> The price regulation of the incumbent regarding access to dark fibre, was replaced by EOI in the end of 2016. The price regulation, though only directed towards the incumbent, brought uncertainty into the market that had a negative effect on fibre investments and FTTP deployment.[98]

[97] See Questionnaire for external experts, FTTH Council Europe answer.
[98] See Questionnaire for external experts, Stokab answer.

### 2.7.5. Wholesale offers

FTTP operators offer wholesale services in all cases where successful deployment has happened, both market driven and public funding driven.

Private operators in competitive markets use wholesale to increase the utilisation of their networks. In Spain, Jazztel and Telefónica as well as Vodafone and Orange entered into co-investment agreements. In addition to this, Orange sells commercial wholesale services to MásMóvil; Telefónica sells commercial wholesale services to Vodafone with better terms than the regulated offer, and regional operator Adamo has wholesale services in its standard portfolio. This is also the case in France, where in addition to co-investment agreements between operators, Numericable (now Altice) sells Bouygues wholesale services over its cable network and Orange sells Bouygues wholesale access to its FTTH network nationwide.

It is usual for state-owned networks to adopt wholesale-only strategies and for PPPs to require them in tenders. Because of this, fibre networks in Sweden, New Zealand, and Australia are separate from retail services, and network operators sell wholesale open access to fibre services. In Sweden, municipal stadsnats adopted this business model, and Telia was required to separate functionally its network. In New Zealand, UFB tenders require successful bidders not to engage in retail marketing, which prompted Telecom New Zealand to separate voluntarily its network operations to its new venture Chorus, which secured many UFB franchises across the country. In Australia, legislation chose a wholesale-only model for the NBN.

### 2.7.6. Consolidation and convergence

Consolidation and convergence look critical for competitive FTTP developments by alternative operators.[99] Consolidation of operators in the same segment (fixed or mobile) allows alternative operators to win the critical mass they need to make a profit on fixed investments. Because economies of scale in fixed networks are local, consolidation can be achieved at the local or national level.

Another factor is the fixed-mobile convergence. At an early stage, it allows mobile operators to leverage their existing customer base of mobile users to enter the fixed broadband. Furthermore, convergent fixed, mobile, and video bundles allow operators to split fibre costs on a larger revenue basis. In addition, convergence allows operators to reap economies of scope from the joint operation of fixed and mobile networks. Looking forward, operators can derive huge cost savings from the joint deployment of FTTP and 5G-ready mobile networks.

Data from the countries in our sample are consistent with this view. Convergence and consolidation have increased in countries where there is competitive FTTP deployment by private investors, and they have remained fairly stable in the others. Four large convergent operators control more than 90% of the market in Spain and France. To the contrary, there are still some large fixed-only or mobile-only operators in New Zealand, Sweden, Australia, and Germany.

[99] This view was explained, for instance, by Christian Hacker, Director Regulatory Affairs of Orange Spain, in his conference in the panel session *Understanding the Spanish success story* at the FTTH Council Europe Conference 2018, Valencia, 13 February 2018.

**Table 4. Fixed Broadband Market Share of Converged Fixed-mobile Operators**

| Country | 2005 | 2016 |
|---|---|---|
| Spain | 72% | 93% |
| New Zealand | 70% | 73% |
| Sweden | 70% | 54% |
| France | 50% | 96% |
| Australia | 59% | 61% |
| Germany | 74% | 66% |

Source: TeleGeography, CNMC, other national regulators

### 2.7.7. Network separation and public funding

The wholesale-only model has proven successful only in companies with public funding. Private operators claim that wholesale revenues are not enough to cover their cost of capital.[100] Public authorities, however, may afford lower returns on the capital they commit to fibre investments.

We have analysed the returns on investment in Sweden in both cases. As a representative of a municipally owned fibre operator, we have taken Stokab, Stockholm's municipal operator and the largest stadsnat in the country. We have also looked at Telia, the largest market-funded fibre operator.

AB Stokab, formed in 1994 and owned by the City of Stockholm, provides a passive optic communications network to the Stockholm region. Based on data extracted from 'Stockholm's Stadshus AB's Annual Report', we calculated the internal rate of return ('IRR') of its investments. By definition, the mentioned rate corresponds to the discount rate that makes the net present value of all cash flows from a particular project equal to zero. Therefore, it can be used as a metric to estimate the profitability of these investments in Stockholm. In Table 5, we present the relevant variables and their evolution along time, used as a reference to estimate the return of Stokab's investment from 2000 to 2016.[101]

**Table 5. Stokab Operating Cash Flow (million SEK)**

| Period | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| Investments | 255 | 422 | 556 | 171 | 52 | 85 | 143 | 177 | 421 |
| EBITDA | 139 | 194 | 206 | -414 | 193 | 197 | 212 | 264 | 317 |
| Op. Cash Flow | -116 | -228 | -350 | -585 | 141 | 112 | 69 | 87 | -104 |

| Period | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|
| Investments | 331 | 361 | 501 | 332 | 172 | 94 | 184 | 214 |
| EBITDA | 343 | 390 | 414 | 451 | 461 | 495 | 483 | 490 |
| Op. Cash Flow | 12 | 29 | -87 | 119 | 289 | 401 | 299 | 276 |

Source: Stockholm's Stadhus AB

[100] This view was explained, for instance, by Christian Hacker, Director Regulatory Affairs of Orange Spain, in his conference in the panel session "*Understanding the Spanish success story*" at the FTTH Council Europe Conference 2018, Valencia, 13 February 2018.

[101] Stokab does not publish full financial information for the years between 1994 and 1999.

Based on the data presented above, Stokab's operations achieved a 2.5% internal rate of return for the mentioned investment.[102] On the other hand, Telia reported in 2016 the pre-tax weighted average cost of capital ('WACC') of its Swedish operations to be 5.4%.[103]

Australia has also found the NBN model unprofitable with service revenue only. The ACCC recently found that:

> A potentially significant factor contributing to these outcomes is that current average revenues per user for NBN services may not be sufficient to meet NBN Co's long term cost recovery requirements.[104]

Those findings are consistent with research on wholesale only networks in other countries. Recent research in the US showed that municipal fibre networks in that country were not financially sustainable.

> An examination of the NPV covering the five-year period from 2010 to 2014 reveals that of the 20 municipal projects that report the financial results of their broadband operations separately, 11 generated negative cash flow. Unless these projects substantially improve their performance, they will not be able to cover the costs of current operations, let alone generate sufficient cash to retire the debt incurred to build the project.
>
> For the nine projects that are cash-flow positive, seven would need more than sixty years to break even. Only two generated sufficient cash to be on track to pay off the debt incurred within the estimated useful life of a broadband network, which is typically projected to be 30 to 40 years. One of the two success stories is an industrial city with few residents that is unlikely to serve as a model for other cities to emulate. Regression models based on the data and the case studies of individual projects underscore the difficulty that municipal fiber projects face in becoming financially viable. [105]

### 2.7.8. Flexibility of administrative processes

Best practices have a more flexible administrative approach to regulation implementation than the worst performers, all other things equal. Deployment of telecommunications networks is a very complex process that involves large-scale engineering and construction, contracting with many partners and suppliers, negotiating interconnection and co-investment agreements with competitors, and complying with national and local telecommunications and construction regulation. Lengthy administrative processes can delay any of those activities and introduce long delays in the overall project.

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[102] This rate does not take into account the impact of interest expenditure and debt leverage.

[103] See 'Telia Annual and Sustainability Report 2016', p. 133.

[104] See Australian Competition and Consumer Commission (ACCC), Communications Sector Market Study - Draft report, October 2017. https://www.accc.gov.au/system/files/Communications%2520Sector%2520Market%2520Study%2520Draft%2520Report.pdf

[105] See Christopher S. Yoo and Timothy Pfenninger, Municipal Fiber in the United States: An Empirical Assessment of Financial Performance, University of Pennsylvania Law School's Center for Technology, Innovation and Competition (CTIC).

The evidence we have found in the sample countries is consistent with the hypothesis that complex administrative processes delay deployment, all other things equal.

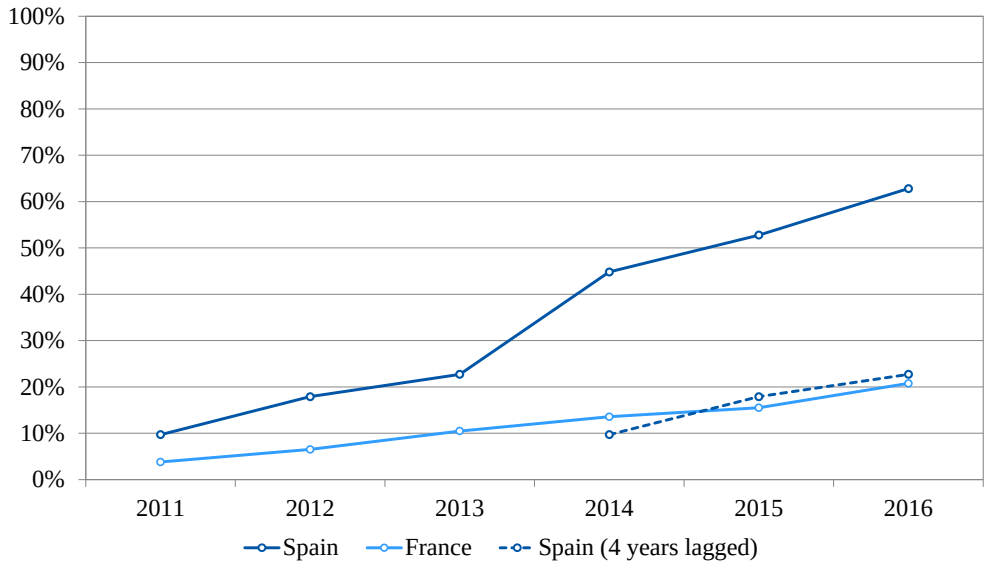
We look first at the cases of France and Spain, which have very similar industry structures, demand patterns, and regulatory design. Table 6 summarizes the administrative approaches in both countries.

**Table 6. Administrative Processes for FTTP Deployment**

| Spain | France |
|---|---|
| • Operators freely decide on network deployment and co-investment agreements.<br>• No investment commitments.<br>• Regulator ex post verifies which areas are not competitive and impose access regulation to SMP operator. | • Regulator ex ante estimates which areas may be competitive and not, and decides after formal public consultation processes that involve complex geographic analyses.<br>• Regulator and operators negotiate access regulation for designated non-competitive areas, including interface and architecture decisions (e.g. GPON vs. P2P).<br>• Operators negotiate co-investment agreements for non-competitive areas and send binding investment commitments to regulator. |

It is clear that the French processes are more complex and cumbersome than Spanish ones. When we compare the evolution of FTTP coverage in both countries, Figure 37 shows that network deployments in France trail those in Spain by roughly four years.

**Figure 37. Evolution of FTTP Coverage in France and Spain**




Source: European Commission

Cumbersome administrative processes can also hinder FTTP development. For instance, Germany's FTTP White Spots subsidies scheme was not fully implemented because of difficult administrative conditions in accessing the funds.[106] The federal government had allocated four billion euro to be spent in two years between 2015 and 2017 in the deployment

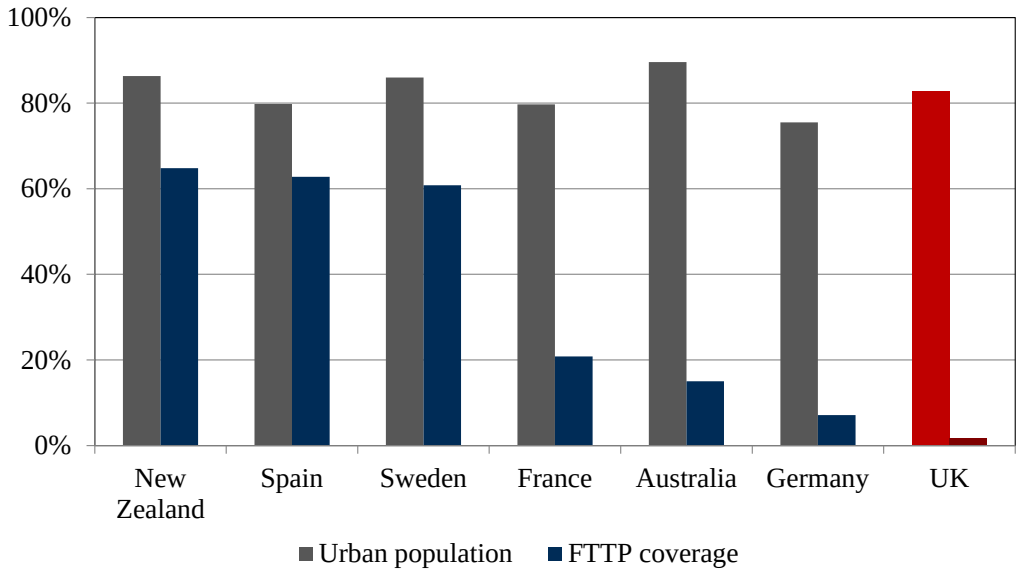
[106] Panel debate 'Germany after the general election – getting real about Gigabit?' at the FTTH Council Europe Conference 2018, Valencia, 13 February 2018.

of NGN in areas without coverage. Funds were to cover a maximum of 50% of investment and to be allocated to municipal authorities. Municipal authorities had to fund the rest of the subsidy and ensure that the network was built, either by entering into a PPP or by building the network themselves. However, as both the federal and the municipal governments had to abide by public contracting administrative processes, making decisions consumed a lot of time. Tendering the funds took six months. Municipal authorities needed another six months for planning and contracting. That left only one year to deploy fibre that qualified for the subsidy. As a result, a significant amount of the funds remained unspent.

## 3. RURAL ULTRAFAST BROADBAND

As the best FTTP countries in our sample are completing fibre coverage in urban areas, their next challenge is ultrafast broadband extension to rural areas.

**Figure 38. FTTP Coverage (% households) and Urban Population (% total population) - 2016**

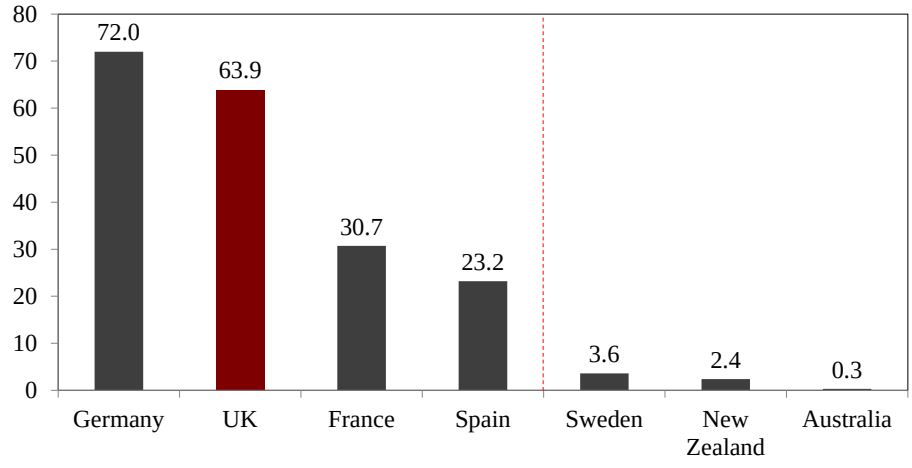



Source: World Bank, European Commission, NBN, Australian Bureau of Statistics, MBIE, NZ statistics

High deployment costs, low return on investments due to low population density, and the lack of high quality passive infrastructure in these areas are factors that introduce complexity in network deployment.

Rural broadband issues, however, are very different in Western European countries than in the other countries in our sample. Figure 38 shows that population densities in Spain, Germany, or France are much higher than in New Zealand, Sweden, or Australia and close to that of the UK.

**Figure 39. Rural Population Density 2016 (pop/km²)**




Source: World Bank

## 3.1. Overview and Policy Models

Policy makers in all countries share a similar view how to address broadband network deployment in rural areas. They recognize the role of wireless technologies in rural development and the lack of a profitable business case for private investors.

Therefore, they acknowledge that rural broadband policies require public funding. This funding is usually implemented in two ways:

- imposing coverage obligations at specific speeds in the spectrum licences auctions for 4G and 5G (implicit cross-subsidy); [107] and
- granting public funding to operators who commit to build a fibre network in a specific area.

Coverage obligations in spectrum auctions can take two approaches: imposing the same coverage obligations to all spectrum blocks for sale or putting coverage obligations on only one of the blocks being auctioned, which is sold at a lower price than the unconstrained blocks.

Public subsidies are awarded based on three of the policy models we identified:

(3) **Nominated regional networks with public funding**. Subsidies are tendered to private operators subject to specific targets in designated areas. This is the case of Spain, New Zealand, Sweden, and some German municipalities.[108] Agreements with private operators can include direct subsidies, Public-Private Partnerships where state authorities take a share of capital, and free access to existing infrastructure or streamlined building permits

(4) **State-owned regional networks that compete with other networks**. This is the case of France and some German towns, where municipalities deploy wholesale-only networks but other operators are free to deploy theirs to compete with them.

(5) **State-owned monopoly national network**. This is the case of Australia, where the NBN operates as a monopoly also in rural areas.

## 3.2. Country Case Studies

### 3.2.1. Spain

Spanish mobile operators make their long-term evolution ('LTE') networks available to most rural users. In May 2017, Vodafone covered 96.5% of the population with its LTE network, whereas Telefónica covered 96.0%.[109]

Private companies in competitive markets also target rural areas. MásMóvil and Adamo are focusing their FTTP network building on unserved areas to lessen competitive pressures.[110]

[107] In purely economic terms, coverage obligations imposed on spectrum licences sold in an auction are an implicit public subsidy because operators will bid a price for this licence lower than the price they would otherwise have paid. The difference between both prices is equivalent to a public subsidy.

[108] German municipalities that receive funds from the federal government can choose to enter a partnership with a private operator or deploy a municipally-owned wholesale-only network.

[109] See Telegeography, GlobalComms Database – Spain

- 65% of MásMóvil's new deployment is in cities with less than 20,000 inhabitants, where FTTP coverage in 2016 was only of 35.8% (compared to more than 90% for cities over 50,000 population).
- Adamo is prioritizing FTTP network development in greenfield areas, often in towns with less than 300 households. Adamo has also signed an agreement with the provincial government of Cantabria and a local electricity company to cover 100% of the towns in the Cantabria province with FTTP. The project will bring FTTP coverage to more than 150,000 households. It foresees the use of electricity rights of way and passive infrastructure in exchange for helping the electric utility to modernize its own network.

In 2013, Spanish authorities launched the PEBA programme,[111] which provides financial support to projects deploying NGA infrastructure in unserved areas. It was co-financed by the European Regional Development Fund, and it has played an important role in fibre extension beyond urban areas.

This program seeks the maximization of the results in terms of number of underserved households covered, without undermining competition. It is based on the following:[112]

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

The approach followed by the Ministry allows operators to choose the specific areas in which to extend broadband coverage, funding those projects requiring less aid. The aim is to locate the projects in the areas closest to profitability, maximizing the use of public funding in terms of population covered. The aid granted from 2013 to 2016 was around USD 144 million,

[110] Presentations by Adamo and MásMóvil in the panel session *Understanding the Spanish success story* at the FTTH Council Europe Conference 2018, Valencia, 13 February 2018.

[111] PEBA, 'Programa de Extensión de la Banda Ancha de Nueva Generación (Extension Programme for Next-Generation Broadband)'.

[112] PEBA project description taken from OECD, Bridging the Rural Digital Divide, OECD Digital Economy Papers No. 265, February 2018.

funding 305 projects, and providing NGA coverage mostly through FTTH to 3 million households and businesses, amounting to public investment per household of around USD 70. There were 74 operators participating with a slight underrepresentation of the major players: Telefonica, Orange and Vodafone have jointly 95 % of the broadband market share, whereas they only received 66 % of the aid.

### 3.2.2. Sweden

The aim of the Completely Connected Sweden Plan is to connect the entire population in Sweden, regardless of whether in urban or rural areas, with village fibre playing a pivotal role. Fibre networks are being deployed over the whole country, including sparsely populated rural areas where about 15% of the population live. The share of fibre connected households outside urban areas has increased from less than 5% in 2010 to more than 22% in 2016. Continued investments mean that the availability of fibre in rural areas will rise as the share of homes passed was more than 25% by the end of 2016.[113]

Rural fibre deployment is being supported by the Rural Development Programme in 2014 to subsidize high-speed Internet expansion into areas not considered commercially viable. This 2014–2020 plan is funded in part by the Swedish government (SEK 1.93 billion) and the European Agricultural Fund for Regional Development or EAFRD (SEK 1.32 billion). Eligible investments include ducts built to route fibre.

Separately, another fund to improve broadband in the northern provinces was approved in 2015. EAFRD funds up to 50% of the total investment of companies that build interurban networks in the eligible provinces.[114]

### 3.2.3. New Zealand

The Rural Broadband Initiative ('RBI') programme in New Zealand operates separately from, but has a similar structure to, the UFB programme. Although the UFB programme has a specified technology (FTTP), the RBI programme is deliberately technology neutral. RBI infrastructure funded by the government is required to be open access.

The initial target for RBI was that 80% of rural households and businesses would have access to broadband with a peak speed of 5 Mbps or better and the remaining 20% able to achieve 1 Mbps.[115] Awarded in 2011, the first-phase RBI contracts involved a government investment of $300 million. Chorus and Vodafone won the tender, thus it involved a mixture of FTTN and fixed wireless. Chorus upgraded 1,242 cabinets and extended its fibre network by approximately 3,100 kilometres.[116] Vodafone on the other hand constructed 154 new fibre-

[113] See OECD, Bridging the Rural Digital Divide, OECD Digital Economy Papers No. 265, February 2018.

[114] See Telegeography, GlobalComms Database – Sweden

[115] See Centre for Public Impact, 'New Zealand's Rural Broadband Initiative (RBI)', 27 May 2016, https://www.centreforpublicimpact.org/case-study/rural-broadband-initiative-in-new-zealand/.

[116] Andrew Sadauska, 'ACCC approves Optus HFC NBN deal', *itnews*, 28 August 2015, http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/fast-broadband/documents-image-library/rural-broadband-initiative/rural-broadband-initiative-phase-1-august-2016.pdf.

connected cell phone towers and upgraded 380 existing cell towers to enable fixed wireless broadband.[117]

The second phase of RBI involved a further investment of $150 million by the government. However, on 30 August 2017, the government allocated an additional $270 million. Crown Infrastructure Partners and Crown Fibre Holdings are managing the contracts for phase 2.[118] The three major New Zealand mobile telecommunications carriers, Spark, Vodafone NZ, and 2degrees, have submitted a joint proposal on the extension of RBI2 and mobile blackspots program, offering an infrastructure capital contribution of $75 million. In addition, the three operators plan to invest hundreds of millions of dollars on operating expenses throughout the life of the projects and contributing mobile broadband spectrum.[119]

### 3.2.4. France

French authorities relaxed in 2009 the regulations on 3G mobile network sharing in order to increase mobile and broadband coverage in "white areas" (areas with no mobile coverage). Orange, SFR and Bouygues entered an agreement to share 3G network in rural areas that was later joined by Free. It allowed 2G coverage to reach 99% and 3G 84% of population in 2017.

4G licenses in the 800 MHz band carried the obligation to cover 40% of white areas by January 2017, a target all three operators surpassed (Orange 54%, Bouygues 52% and SFR 50%). French mobile operators have now deployed LTE networks to most of the territory. Orange is the operator with the most developed network: it covered 88% of the population in 2017 and plans to reach 95% coverage by 2018.[120]

Regarding FTTP, up to 110 local and regional government initiatives (RIP) have funded the deployment of fibre networks, although not only in rural areas. In some cases the network is deployed by a private investor that receives public subsidies. In other cases, the municipal or regional government themselves own the network. To avoid breaching state aid rules, municipal owned networks operate in a wholesale only basis and sell services to all retailers. By the end of 2016, RIP covered one million homes in 7,400 towns, of which 835,000 were in less dense rural areas.[121]

### 3.2.5. Germany

Spectrum licenses in the digital dividend 800 MHz band were auctioned in 2010 with strong coverage obligations in rural areas. Operators that won the spectrum licences had to deploy LTE services in 'white spots' (rural areas without broadband access) before they could launch services in urban areas. All operators had complied by mid-2012.[122]

[117] See Ministry of Business, Innovation & Employment, 'Rural Broadband Initiative Phase 1', August 2016.

[118] Ministry of Business, Innovation & Employment, 'Fast broadband', http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/fast-broadband.

[119] See Corinne Reichert, 'Spark, Vodafone NZ, 2degrees offer NZ$75m for RBI2 and blackspots', *ZDNet*, 4 April 2017, http://www.zdnet.com/article/spark-vodafone-nz-2degrees-offer-nz75m-for-rbi2-and-blackspots/.

[120] See Telegeography, GlobalComms Database – France

[121] Ibid.

[122] See Telegeography, GlobalComms Database – Germany

In 2015, the federal government set up a 2.7 bn€ fund to foster the roll out of high-speed broadband to NGA white spots. An additional 1.3 bn€ was added in 2016, increasing the total fund size to 4 bn€. The fund was targeted at local authorities in rural areas, which had the option to either subsidize a private operator to deploy the network or to build the network themselves and then lease the infrastructure to service providers. The fund contributed with 50% of the budget up to 15 million euro per project.[123]

The FTTP subsidies scheme for rural areas was not fully implemented because of difficulty accessing the funds. Because public funds had to be awarded following administrative law procedures, tendering took six months, planning and contracting with operators took another six months, and therefore there was only one year left to deploy fibre that qualified for the subsidy. As a result, a sizable part of the funds remained unspent.[124]

### 3.2.6. Australia

As part of the NBN statement of expectations, NBNco should 'prioritise locations that are poorly served, to the extent commercially and operationally feasible'.[125] This generally means providing service to rural areas in Australia, which are more remote. Over 1.8 million premises have been identified as 'underserved', defined as 'as areas that do not have access to adequate broadband services'.[126] Prior to 2018, a slightly larger proportion of the underserved premises were RFS compared to the non-underserved premises.

To serve the 29% of Australians outside of major cities, fixed line, fixed wireless, and satellite are used to ensure Australians in rural and remote areas have access to the NBN.[127] Sky Muster satellite broadband provides NBN broadband via two satellites launched in 2015 and 2016 aimed at serving rural and remote areas including offshore.[128] Fixed wireless is also used to serve rural and remote areas as it can support multiple premises at a range of up to 14 kilometres without the need for fixed-line connections.[129] By 2020, an estimated 4% of premises will be served by fixed wireless and 3% via satellite.[130]

The NBN is mandated to charge uniform wholesale prices across geographic areas and technology (at least for basic service).[131] This means that differences in costs are funded through an opaque internal cross-subsidy, with lower cost urban fixed-line users subsidising

[123] Ibid.
[124] See FTTH Conference 2018, round table on Germany.
[125] NBN Co Ltd, 'Statement of Expectations', 24 August 2016, https://www.nbnco.com.au/content/dam/nbnco2/documents/soe-shareholder-minister-letter.pdf
[126] NBN Co Ltd, 'Corporate Plan 2018–21', https://www.nbnco.com.au/content/dam/nbnco2/documents/Corporate-Plan-2018-2021.pdf.
[127] See NBN, 'Australia leading the world in commitment to rural broadband', last updated 21 February 2018, https://www.nbnco.com.au/blog/the-nbn-project/australia-leading-the-world-in-commitment-to-rural-broadband.html.
[128] See NBN, 'nbn™ Sky Muster™ satellite service explained', accessed 7 March 2018, https://www.nbnco.com.au/learn-about-the-nbn/network-technology/sky-muster-explained.html.
[129] See NBN, 'nbn™ Fixed Wireless explained', accessed 7 March 2018, https://www.nbnco.com.au/learn-about-the-nbn/network-technology/fixed-wireless-explained.html.
[130] See OECD, Bridging the Rural Digital Divide, OECD Digital Economy Papers No. 265, February 2018.
[131] Emma Knezevic, 'National Broadband Network, Parliament of Australia, accessed 7 March 2018, https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/BriefingBook45p/NBN.

the more expensive rural fixed-line networks and the fixed wireless and satellite technologies also used in more remote areas.[132]

A new broadband tax, proposed under the Regional Broadband Scheme, would charge fixed-line users (NBN and non-NBN) a tax of around $7 AUD a month.[133] This would increase the subsidy to rural users and broaden the funding base to include non-NBN customers. An interesting issue is what will happen if fixed wireless substitution occurs in a material way in urban areas because the levy only applies to fixed networks. If material substitution occurs, this would reduce the number of customers paying the levy under the RBS, which could result in a higher levy and therefore higher prices for fixed broadband. This, in turn, could create a circularity causing further substitution to fixed wireless and so on.

## 3.3. Cross-Country Analysis

Rural NGA deployment has required some sort of public support in all of the surveyed countries.

In a few cases, support has arrived through the removal of barriers to private deployment (e.g. by opening passive infrastructure to operators or relaxing construction regulation requirements). This has prompted some private operators willing to deploy FTTP in rural areas on purely commercial terms (e.g. Adamo in Spain and Gigaclear in the UK).

Public funding is usually required to stimulate coverage of the most difficult portion of the rural population. How those subsidies are allocated can strongly influence their success.

- Cooperation with private operators usually yields better results than government or municipal-run rural operators.
  - A state-owned monopoly is found only in Australia and is underperforming.
  - State-owned operators are not deploying FTTP in rural areas, except in some parts of France.
- The franchise model (legal exclusivity in a given area) is untested in the countries that we analysed. There is free entry and competition by other operators, even if they usually choose not to enter.
- Subsidies may be implemented as direct payments, soft loans, or interest-free risk capital.
- Technology neutral rural subsidy programmes can be useful in identifying the optimal mix of technical solutions ex post, rather than attempting to find it ex ante or to force a single technology.
- Well-specified subsidy schemes or public-private partnerships awarded on competitively neutral terms have yielded the best results. In addition, in the case of EU Member States (France, Germany, Spain and Sweden) they avoid breaching EU state aid rules in EU Member States. The European Commission reviewed 41 public subsidy projects in those four countries between 2009 and 2017, and cleared all of them as compatible with EU state aid guidelines (Table 7).

[132] Australian Government Department of Communications and the Arts, 'The Regional Broadband Scheme', 22 June 2017, https://www.communications.gov.au/documents/regional-broadband-scheme.
[133] Ibid.

**Table 7. European Commission decisions on State aid to broadband (2009-2017)**

| Member State | Date | Decision | Decision Status |
|---|---|---|---|
| France | 07/11/2016 | SA.37183 (2015/NN) - Plan France Très Haut Débit | Accepted |
| | 19/10/2011 | SA.31316 (N 330/2010 ) - Programme national «Très haut débit» - Volet B | Accepted |
| | 30/09/2009 | N 331/2008 - Réseau à très haut débit en Hauts-deSeine | Public co-financing approved, decision does not constitute aid |
| Germany | 11/08/2017 | SA.46805 (2017/N) - Follow up German NGA / Vula product | Accepted |
| | 22/07/2015 | SA.41416 (2015/N) - NGA Scheme BadenWürttemberg | Accepted |
| | 15/06/2015 | SA.38348 (2014/N) - NGA Germany | Accepted |
| | 21/04/2015 | SA.39518 (2015/N) - NGA-Cluster Nordhessen | Accepted |
| | 09/07/2014 | SA.38690 (2014/N) - NGA Bayern Abänderung | Accepted |
| | 13/12/2013 | SA.36601 (2013/N) - NGA Sachsen-Anhalt | Accepted |
| | 12/09/2013 | SA.36703 (2013/N) – Entwicklungskonzept Brandenburg Glasfaser 2020 II | Accepted |
| | 17/01/2013 | SA.35562 (2012/N) – Brandenburg Glasfaser | Accepted |
| | 20/11/2012 | SA.35000 (2012/N) – NGA Bayern | Accepted |
| | 30/08/2012 | SA.34809 (2012/N) – NGA Breitband Markt Reisbach | Accepted |
| | 04/07/2012 | SA.34845 (2012/N)- Breitbandinfrastrukturausbau Thüringen (Änderung) | Accepted |
| | 08/12/2011 | SA.33364 (2011/N) - Breitbandinfrastrukturausbau Thüringen | Accepted |
| | 07/12/2011 | SA.33869 (2011/N) - Breitband Markt Mömbris | Accepted |
| | 02/12/2011 | SA.33859 (2011/N) - Broadband support in the rural areas of Germany Amendment of Broadband scheme N 383/2009 | Accepted |
| | 19/09/2011 | SA.33420 (2011/N) - Breitband Lohr am Main | Accepted |
| | 08/06/2011 | SA.32309 (N 53/2010) - Amendment of the Federal framework programme on duct support | Accepted |
| | 20/05/2011 | SA.32203 (2011/N) - Breitband Egenhofen, Germany | Accepted |
| | 24/01/2011 | N 451/2010 - Creation of Next Generation Access Infrastructure in Landkreis Rotenburg | Accepted |
| | 20/12/2010 | SA.32021 (2010/N) - Broadband in the rural areas of Saxony | Accepted |
| | 26/10/2010 | N 299/2010 - Prolongation of the Bavarian State aid broadband scheme | Accepted |
| | 12/10/2010 | N 391/2010 - Broadband development in Hessen | Accepted |
| | 12/07/2010 | N 53/2010 - Federal framework programme on duct support, Germany | Accepted |
| | 08/02/2010 | N 383/2009 – Amendment of the State aid broadband scheme N 150/2008 Freistaat Sachsen | Accepted |
| | 22/12/2009 | N 368/2009 - Amendment of the State aid broadband scheme N 115/2008 - Rural areas in Germany | Accepted |

| Member State | Date | Decision | Decision Status |
|---|---|---|---|
| Germany | 14/08/2009 | N 243/2009 - Extension of broadband coverage in Niedersachsen | Accepted |
| | 19/05/2009 | N 153/2009 - Amendment of the State aid broadband scheme N266/2008 Bayern | Accepted |
| | 23/02/2009 | N 238/2008 - Broadband infrastructure development | Accepted |
| Spain | 05/07/2013 | SA.35834 (2012/N) - Extension of high speed broadband in Spain | Accepted |
| | 24/08/2012 | SA.33099 (2012/N) – High Speed broadband in Rioja | Accepted |
| | 17/12/2010 | N 304/2010 - Programa Avanza Nuevas Infraestructuras de Telecomunicaciones | Accepted |
| | 10/11/2010 | N 424/2010 - Broadband deployment in Galicia | Accepted |
| | 12/08/2010 | N 699/2009 - Desarrollo del programa de infraestructuras de telecomunicaciones en la Región de Murcia | Accepted |
| | 11/08/2010 | N 407/2009 - Optical fibre Catalonia (Xarxa Oberta) | Accepted |
| | 14/12/2009 | N 323/2009 - Broadband in rural areas of Asturias | Accepted |
| Sweden | 24/01/2013 | SA.35913 (2012/N) - Amendment of the State aid to broadband scheme within the framework of the rural development program (modification of N30/2010 and SA.33221) | Accepted |
| | 22/08/2011 | SA.32037 (2010/N) - Broadband development in Västra Götaland, Sweden | Accepted |
| | 25/07/2011 | SA.33221 (2011/N) - Amendment of State aid broadband scheme N30/2010 | Accepted |
| | 25/03/2010 | N 30/2010 - Broadband development within the framework of rural development | Accepted |

Source: European Commission[134]

Another way to bring ultrafast networks to rural areas is the use of wireless technologies. In the past, wireless technologies have been used successfully to bring broadband to rural areas. Some governments, like the German and the Swedish, intend to use 5G technologies also for rural broadband coverage.

Wireless solutions are employed more intensely in countries with lower rural population density, such as Australia, New Zealand and Sweden in our sample. Wireless solutions are part of the ultrafast broadband plans in Australia and Sweden, and they qualify for support by rural broadband funds in New Zealand.

In some cases, authorities added coverage obligations to spectrum licences for mobile operators in low frequency bands. This is a simple way of increasing broadband deployment in rural areas, provided authorities are satisfied with the trade-off between higher coverage and lower auction income to the public coffers.

In other cases, fixed wireless licences were issued for operators to deploy dedicated fixed wireless networks (Table 8).

[134] See European Commission, 'Commission decisions on State aid to broadband'. http://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf

**Table 8. Fixed-Wireless Networks**

| Country | Company Name | Network Status | Access Type | Technology | Frequency (MHz) | Launch Year |
|---|---|---|---|---|---|---|
| Australia | iiNet | Live | WiMAX | 802.16e | 3500 | 2009 |
| | nbn (formerly NBN Co) | Live | TD-LTE | - | 2500 | 2013 |
| | Singtel Optus | Shut Down | WiMAX | - | - | 2007 |
| | TPG Telecom | Planned | TD-LTE | - | 2500 | - |
| France | Iliad (Free) | Trial | WiMAX | 802.16e | 3500 | 2006 |
| | NomoTech Group | Live | WiMAX | 802.16e | 3500 | 2008 |
| | NomoTech Group | In Deployment | TD-LTE | - | 3500 | 2016 |
| Germany | NetCologne | Live | WiLL | CDMA2000 1xEV-DO | - | 2009 |
| | Vodafone Germany | Shut Down | WiMAX | - | - | 2005 |
| New Zealand | CallPlus | Shut Down | WiMAX | 802.16-2004 | 3500 | 2006 |
| | Skinny Mobile | Live | FDD-LTE | - | 700 | 2016 |
| | TeamTalk Group | Live | BFWA | - | - | 2004 |
| Spain | Euskaltel | Live | WiMAX | 802.16-2004 | - | 2005 |
| | Grupo MASMOVIL | Live | TD-LTE | - | 3500 | 2013 |
| | Telefonica | Live | WiMAX | 802.16e | - | 2010 |
| Sweden | Telia Sweden | Live | WiMAX | Pre-WiMAX | 3600 | 2004 |

Source: TeleGeography

# 4. CORPORATE AND MOBILE BACKHAUL FIBRE SERVICES

Large corporations as well as small and medium enterprises often demand services different to those used by individual consumers. Mobile operators are a particular case of corporate client; they require fixed links (backhaul) to connect their base stations with their core networks.

In addition to switched services provided by operators specializing in business services, corporate customers and mobile operators also use pure transmission services, as summarized in Table 9.

**Table 9. Mobile and Corporate Customers' Transmission Services**

| | |
|---|---|
| Leased services | Leased lines |
| | Dark fibre |
| | |
| Self-supply | Radio links |
| | Own fibre over leased ducts |
| | Own fibre over own ducts |

Business customers have no problems in general with access services. They are supplied by competitive networks in many areas and by regulated leased lines or active broadband services in less competitive zones. Fibre connections are usually available on demand even in areas where there is no FTTP deployment, usually at a higher price than in metropolitan areas.

With regard to mobile operators, they were able to source the backhaul connections they needed for 2G and 3G using a mix of copper, fibre, and microwave radio links. Their bandwidth requirements increased significantly with 4G forcing them to increase their use of fibre and microwave.

As mobile backhaul and corporate services require higher speeds than residential and small business customers, operators have usually used different fibre network architectures to serve them. Most residential networks use Gigabit-capable Passive Optical Network ('GPON') architecture, while corporate services and mobile backhaul usually deployed over point-to-point ('P2P') fibre architectures.[135] In many cases, operators deploy a separate P2P fibre because they are not engaging in wisdespread FTTP residential deployments.[136]

However, operators that engage in extensive FTTP deployments can coordinate FTTP and mobile backhaul deployments to minimize overall costs. One case is Portugal Telecom ('PT') which followed two approaches to achieve synergies between the two services:[137]

- Sharing the same passive outside plant[138] for residential, corporate and backhaul services. Outside plant is over dimensioned so that there are enough additional fibre cables to

[135] See e.g. Roland Montagne, 'FTTH: The solution for Mobile Backhaul – A study conducted by IDATE for FTTH Council Europe', Webinar presentation, 6 July 2013. http://www.ftthcouncil.eu/documents/Webinars/2013/Webinar_06June2013.pdf

[136] Ibid. IDATE mentions the case of Deutsche Telekom, Vodafone, Telecom Italia and China Mobile in this document.

[137] Ibid.

connect enterprise buildings, mobile base stations and WiFi hotspots, either with P2P fibre or GPON.

- When GPON is used for mobile backhaul, it uses separate cards with lower splitting rates to supply higher speeds than residential GPON.

In the remainder of this section, we review the status of services suitable for mobile backhaul in the countries in our sample, looking as well at their relationships with FTTP networks.

## 4.1. Spain

Mobile operators are integrated with fixed operators, and they use their own fibre or cable networks for backhaul. In addition, competitive wholesale fibre offers are generally available.

Furthermore, Telefónica has an obligation to lease space in its ducts as an ancillary remedy to its significant market power in the market for wholesale access to the Internet. Telefónica's ducts can be used for mobile backhaul. In case no spare capacity in the ducts is available, Telefónica has an obligation to provide a dark fibre connection. However, regulation does not mandate dark fibre offers.[139]

## 4.2. New Zealand

The UFB programme includes small business services delivered over the point-to-multi point Gigabit capable Passive Optical Network ('GPON') and higher quality point-to-point ('P2P') connections for enterprise and commercial business customers.[140] There are also separate products and price caps for schools.[141]

## 4.3. Sweden

On the fibre backhaul market, beside the incumbent TeliaSonera, there are more than 150 local municipality networks providing fibre backhaul to MNOs. Municipality networks often make economically favourable long-term agreements (>15 years) with MNOs, whereas TeliaSonera strictly applies its general price list and conditions.[142]

## 4.4. France

Because of increased competition, Arcep has lifted the pricing obligations on Orange's copper and fibre services in some competitive areas since early 2015.

Orange has an obligation to lease space in its ducts as an ancillary remedy to its significant market power in the market for wholesale access to the Internet. Orange's duct access wholesale offer can be used for mobile backhaul.[143]

---

[138] Passive outside plant includes passive infrastructure (ducts and poles) and fibre cables.

[139] See Telegeography, GlobalComms Database – Spain; Questionnaire for external experts, Telefónica's answer regarding Spain.

[140] See Crown Fibre Holdings, 'Fact Sheet: Agreement with Chorus', accessed 7 March 2018, https://www.crowninfrastructure.govt.nz/media/13216/fact%20sheet%20-%20agreement%20with%20chorus.pdf.

[141] Ibid.

[142] See EU Implementation Report 2016.

[143] See Telegeography, GlobalComms Database – France.

## 4.5. Germany

DT is the only mobile operator that owns a nationwide fixed network. Vodafone owns a cable network that covers one-third of the country, and Telefónica relies fully on connections leased to third parties. DT has no obligation to lease ducts or dark fibre for backhaul.[144]

## 4.6. Australia

As NBN is a wholesaler, NBN access for retail providers catering to business fibre services is the same as for residential. For businesses, the NBN offers the usual wholesale speed tiers and offers business grade plans with higher speeds suited to multiple users, video conferencing, etc. NBN also has an enhanced Service Level Agreement, which provides a higher level of support. Because the NBN is a wholesaler, these business-focused plans are available through retail providers.

[144] See Telegeography, GlobalComms Database – Germany; Questionnaire for external experts, Telefónica's answer regarding Germany.

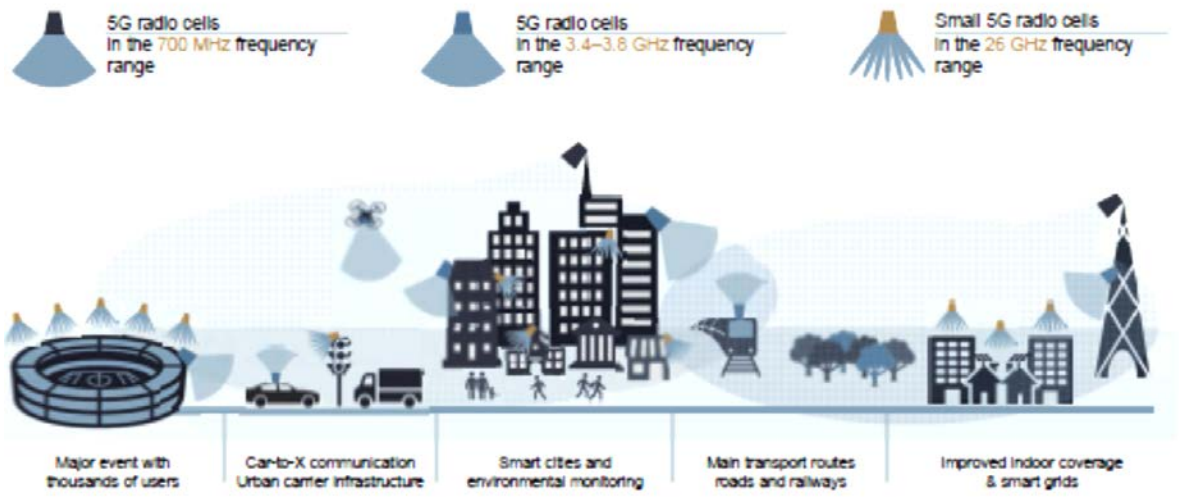
# 5. 5G READINESS

## 5.1. Overview

Mobile operators will need significantly more radio-electric spectrum than they currently have to operate 5G networks. In addition, the very high data rates expected will require channels of 100 MHz or more, much larger than what the operators currently have.

The 2015 World Radiocommunication Conference designated several bands as candidates for 5G. In the EU, the Radio Spectrum Policy Group ('RSPG') and the Radio Spectrum Committee of the EU ('RSC') aim to harmonize the 24.25–27.5 GHz band, in addition to the 3.4–3.8 GHz and the 700 MHz bands already available. Different spectrum bands would be suited to specific applications, depending on their propagation properties and available bandwidth.

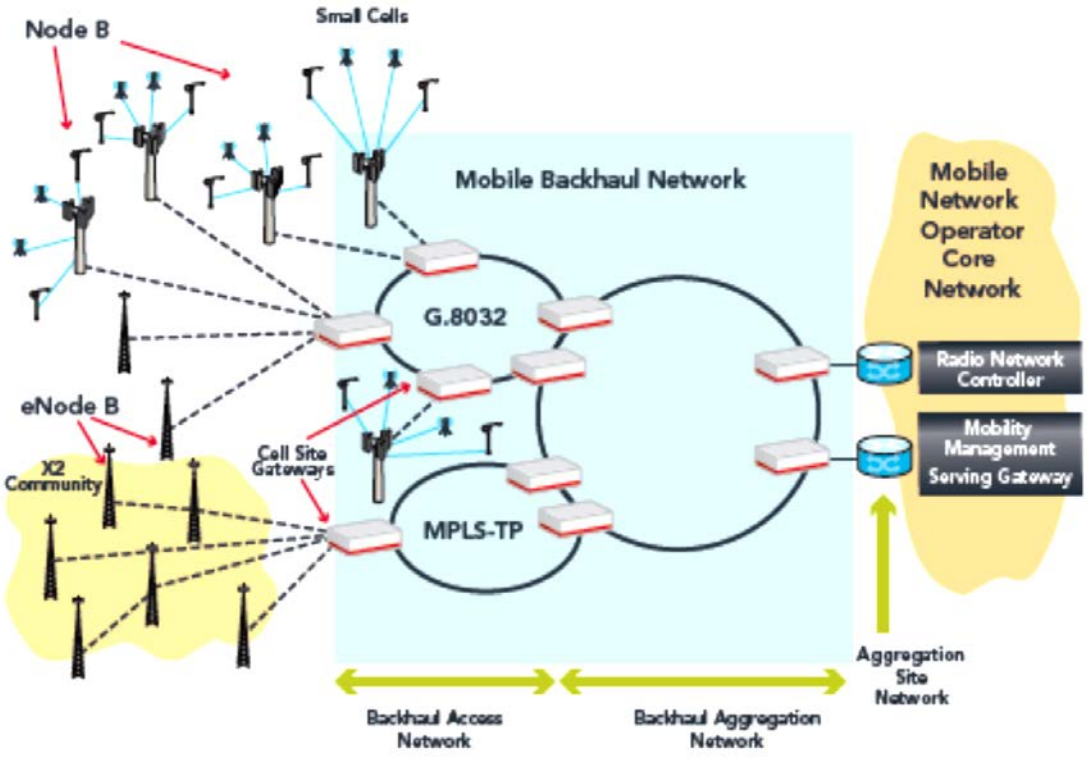
**Figure 40. 5G Frequencies for Different Application Scenarios**




Source: '5G strategy for Germany', based on Ofcom 2017: Update on 5G spectrum in the UK.

5G deployment will also be strongly reliant on the availability of fibre for backhaul. Should mobile operators decide to keep their current backhaul architecture (Figure 41), they will need most of the backhaul links to be supported by fibre because of the very high speeds required. If 4G nodes demanded up to 1 Gbps per base station, 5G will usually require 5 Gbps or more. There are of course developments underway for wireless radio links that may be able to deliver those speeds. However, their future performance and cost is still uncertain, especially because they use very high frequencies in which channel capacity is highly sensitive to rain, clouds, and other atmospheric conditions, whereas fibre has constant performance irrespective of weather.

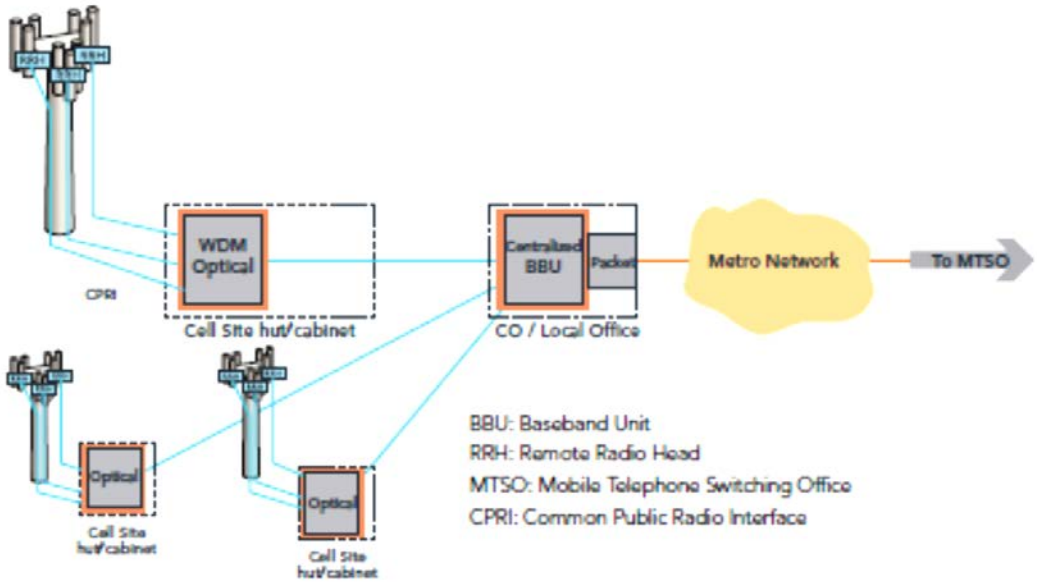
**Figure 41. Conventional Mobile Backhaul Architecture**




Source: Brian Lavallée, Mobile Backhaul Essentials, Ciena Essential Series, 2016.

Even more, there are advanced 5G radio access architectures that require fibre. One of the most promising is 'fronthaul', in which centralised RAN equipment uses a dark fibre connection from the radio interface equipment to the centralized base station (Figure 42). Fronthaul architectures can reap big savings by greatly decreasing the amount of electronic equipment at the antennae and the need for distributed power.

**Figure 42. Fronthaul Reference Architecture**




Source: Brian Lavallée, 'Primer: What is mobile fronthaul?' Ciena, 2016.

The need for fibre in 5G also brings potentially strong synergies in joint FTTP and 5G network deployment. As we discussed in section 4 when we reviewed the case of PT, those synergies can come from the joint planning of duct and pole access, sharing of fibre cables or even an integrated GPON architecture.[145] The savings that can eventually be achieved are hard to quantify at this stage, as they will be dependent on the evolution of prices for technology and the amount of passive network elements that can be reused from previous networks.[146]

## 5.2. Country Case Studies

### 5.2.1. European Union[147]

The European Commission launched on September 2016 its 5G for Europe Action Plan that would guide developments in France, Germany, Spain and Sweden. It aims at bolstering investments in 5G infrastructure and service rollout efforts in the Digital Single Market between now and 2020. This action plan sets out a clear roadmap for public and private 5G investments inside the EU.

[145] Wavelenght Dense Multiplexing over PON ('WDM-PON') techniques are being developed to share the existing GPON passive infrastructure to deliver customers much higher bitrates than GPON. ITU-T standard G.989 (NG-PON2) aims at delivering 40 Gbps per connection, while IEEE is working on the NG-EPON standard to deliver speeds between 25 Gbps and 100 Gbps per connection. See e.g. Cedric F. Lam, 'Fiber to the Home: Getting Beyond 10 Gb/s', Optics and Photonics News, March 2016, https://www.osa-opn.org/home/articles/volume_27/march_2016/features/fiber_to_the_home_getting_beyond_10_gb_s/

[146] Some technology vendors claim that, under very favourable conditions (greenfield development, suburban areas, high service penetration) joint planning and deployment of FTTP and 5G in suburban areas can save up to a maximum of 40–50% of investment. Actual figures in more standard cases are likely to be lower. See Xavier Smet, Comsof. Presentation at the FTTH Conference 2018, Valencia, Spain.

[147] This summary taken from Les enjeux de la 5G, Arcep, March 2017, https://www.arcep.fr/uploads/tx_gspublication/rapport-enjeux-5G_mars2017.pdf.

The Commission has proposed the following measures to achieve this plan:

- Align roadmaps and priorities for a coordinated 5G deployment across all EU Member states, targeting early network introduction by 2018, and moving towards commercial large scale introduction by the end of 2020 at the latest.
- Make provisional spectrum bands available for 5G ahead of the 2019 World Radio Communication Conference (WRC-19), to be complemented by additional bands as quickly as possible, and work towards a recommended approach for the authorisation of the specific 5G spectrum bands above 6GHz.
- Promote early deployment in major urban areas and along major transport paths.
- Promote pan-European multi-stakeholder trials as catalysts to turn technological innovation into full business solutions.
- Facilitate the implementation of an industry-led venture fund in support of 5G-based innovation.
- Unite leading actors in working towards the promotion of global standards.

The European Commission has given every EU country a certain number of ambitious, numerical targets. One core objective for 5G is thus to have at least one major city in every European country outfitted with this new generation mobile system by 2020, and coverage of every city, motorway and high-speed railway lines by 2025. This comes in response to announcements from South Korea and Japan which are both promising large-scale 5G demonstrations, respectively, at the Winter Olympics in Pyeongchang in 2018 and the Summer Olympics in Tokyo in 2020.

### 5.2.2. Spain

The Spanish government published its 5G Plan in 2017.[148] It proposes four action lines.

**Figure 43. Action lines of the Spanish 5G National Plan**


Source: Government of Spain, Plan Nacional 5G 2018-2020

[148] See 'Plan Nacional 5G 2018-2020', Ministerio de Energía, Turismo y Agenda Digital, Madrid 2017, http://www.minetad.gob.es/es-ES/GabinetePrensa/NotasPrensa/2017/Documents/Plan_Nacional_5G.PDF.

The contents of each of the four lines of action is developed below:

(1) Spectrum planning.

(a) Define a roadmap for the release to mobile of the 700 MHz band.

(b) Auction the 1.45-1.49 GHz band as soon as possible and rearrange the rest of the 1.5 GHz band for subsequent release.

(c) Since the 3.4 - 3.6 GHz band is already allocated and ready for use, and the 3.6-3.8 GHz is almost ready, focus on rearranging the whole band to optimize its use by mobile operators.

(d) Immediate use of free frequencies in the 26 GHz band for pilot experiences and get the full band ready for auction.

(e) Actively prompt international bodies to make more spectrum available for 5G.

(2) R&D and pilot experiences

(a) The plan sets up the conditions for network pilots and application trials to start in 2018. The Government foresees three levers to enable those pilots:

a. Granting temporary licences in the 3.6 GHz and 26 GHz bands.

b. Tender subsidies to pilot experiences.

c. Foster the creation of 5G ecosystems that put together all relevant players, including through the terms of the calls for tenders.

(b) The Government has identified a (non-comprehensive) list of use cases that may qualify for 5G pilots:

- Industry 4.0
- Intelligent transport
- Connected car
- Smart farming
- Smart grids
- Multimedia applications
- Smart cities
- Tourism
- Robotics

(3) Regulatory aspects. The Government intends to review a number of aspects of current regulation that may enhance or hamper the development of 5G networks and services.

(a) Perform a general review of the regulation of cybersecurity, privacy, service quality and consumer rights.

(b) Foster increased network sharing by mobile operators. Relax restrictions to the sharing of active elements, on a voluntary basis and within the current competition policy framework.

(c) Lighten administrative burdens to network deployment, including the replacing of ex ante licences by ex post control of base station deployment by municipal authorities; mandating coordinated construction of telecommunications passive

infrastructure during the building in newly developed areas; and granting access to other existing passive infrastructures.

(4) National and international coordination

(a) Set up a Technical Office to coordinate all activities of 5G Plan

(b) Ensure EU regulation is suitable for 5G

(c) Coordinate participation of national organizations in international bodies

### 5.2.3. New Zealand

The Ministry of Business, Innovation & Employment (MBIE) will begin a formal consultation on preparations for 5G in 2018.[149]

In the meantime, New Zealand has disclosed its current plans for spectrum release:[150]

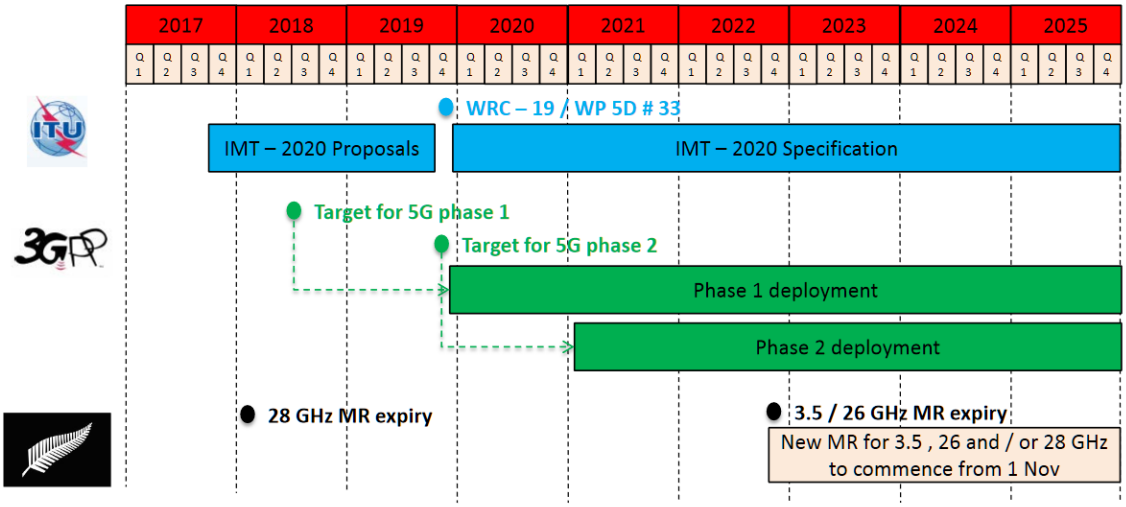
- 700 MHz band is already allocated to operators and can be re-farmed to launch 5G services.
- 1.5 GHz band final status is still under discussion, and several possibilities are considered.
- 3.6 GHz band is partially allocated for fixed wireless with expiration of licenses in October 2022. The plan is not to renew the rights of incumbents at that point so it can be redeployed.
- Regarding the 26/28 GHz bands:
  - Management Rights in 24.549 – 26.4 GHz expire in October 2022. A decision on the future of the band is pending; and
  - Management Rights in 26.4 – 28.35 GHz expire in January 2018. These management Rights are not subject for renewal.

Because some 5G are bands are already allocated beyond 2020, New Zealand may lag on 5G deployment without a reallocation of spectrum.

[149] See Ministry of Business, Innovation & Employment Radio Spectrum Management, '5G Spectrum roadmap', https://www.rsm.govt.nz/projects-auctions/current-projects/5g-spectrum-roadmap.

[150] See: Ministry of Business, Innovation & Employment Radio Spectrum Management, 'RSM 5G Workshop', https://www.rsm.govt.nz/projects-auctions/pdf-and-documents-library/current-projects/spectrum-workshop-slides.pdf

**Figure 44. New Zealand Planned Spectrum Release Schedule**




Source: Ministry of Business, Innovation & Employment Radio Spectrum Management, 'RSM 5G Workshop'.

In addition to frequency plans, Chorus initiated another discussion. It has proposed the idea of a UFB type model for 5G, which was met with criticism by the mobile operators.[151]

### 5.2.4. Sweden

As a pioneer of mobile technologies and networks since the launch of analogue services in the 1980s, Sweden is racing to be one of the first countries in the world to launch 5G services. The Swedish government has considered 5G together with other types of broadband in its 'Completely Connected Sweden by 2025' strategy. In order to get the country ready for a 5G launch in 2020, the government propose the following action lines.

Activities for reaching goals for more broadband for everyone:[152]

- government funding for broadband expansion;
- analysis of effective use of government funds for expansion;
- mission for the future need for frequencies;
- effectuation of an analysis of the surrounding world; and
- analysis of the level of functional access to the Internet.

### 5.2.5. France

France is currently working on the definition of a national 5G strategy.[153] A public consultation is underway since December 2017 to gather all stakeholders' opinions.[154]

[151] See Pattrick Smellie, '5G mobile network should use UFB model says Chorus', *New Zealand Herald*, 7 December 2017, http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11955343.
[152] See 'A Completely Connected Sweden by 2025 − a Broadband Strategy', Government Offices of Sweden, 2016.
[153] See Arcep , Major files -5G website at https://www.arcep.fr/index.php?id=12950&L=1

In preparation of this debate, French regulator Arcep presented its views in a report issued in March 2017 to feed a first public consultation among industry players.[155] They identified a number of challenges surrounding 5G.

- New economic models centred on vertical markets. They specifically mentioned two use cases: automotive and digitization of industry (Industry 4.0).
- Spectrum harmonization. Since the 700 MHz band had already been allocated to mobile operators in 2015, they focused on the other bands selected for 5G in Europe.
  - It discarded in principle the 1.5 GHz band because of the problems associated with moving current users.
  - It is studying how to make compatible current uses of 3.5 GHz band (including defence) and its allocation to 5G mobile services.
  - It is also studying whether to manage simultaneous use of the 26 GHz band by 5G and its current users, or moving current users to another band.
- Continuously smaller cells
  - Taxation
  - Access to high points and not-so-high ones
- Territorial connection and 5G networks backhaul. It highlighted the need for industry to develop technologies that allow for deep fibre connectivity to 5G cells, especially in rural areas. However, they did not advance any specific proposal on this field.
- Net neutrality challenges

### 5.2.6. Germany

The German government released its 5G Strategy in 2017.[156] It proposes an action plan along five action lines.

(1) Step up network rollout

(2) Make available frequencies based on demand

(3) Promote cooperation between telecommunications and user industries

(4) Targeted and coordinated research

(5) Initiate 5G for towns and cities

The federal government intends to support 5G network rollout with the following measures.

- Monitor investments by operators in fibre-optic networks for backhaul, with special attention to the extent that they share their passive infrastructures under the current legal

[154] See Feuille de route sur la 5G : Consultation des acteurs du marché. https://www.entreprises.gouv.fr/numerique/feuille-de-route-sur-la-5g-consultation-des-acteurs-du-marche

[155] See Les enjeux de la 5G, Arcep, March 2017, https://www.arcep.fr/uploads/tx_gspublication/rapport-enjeux-5G_mars2017.pdf.

[156] See '5G Strategy for Germany: A scheme to promote the development of Germany to become a lead market for 5G networks and applications', The Federal Government, July 2017.

situation. Depending on the developments, the government would examine which additional legal or regulatory measures can be used.

- Step up the use of existing passive infrastructure of non-telecom operators for the development of 5G cells, including traffic lights, street lamps, road ducts, street furniture, crash barriers, manhole covers, and electric poles.

Regarding frequency releases, 700 MHz frequency bands were auctioned as a first step in 2015 with attached coverage obligations of at least 50 Mbps download to a minimum of 97% of all households in each Land and 98% nationwide.

Spectrum in the 3.5 GHz band is planned for allocation in 2018. A roadmap for the allocation and usage of frequencies in the 26 GHz band is to be published soon, in time for services to be launched in 2020.

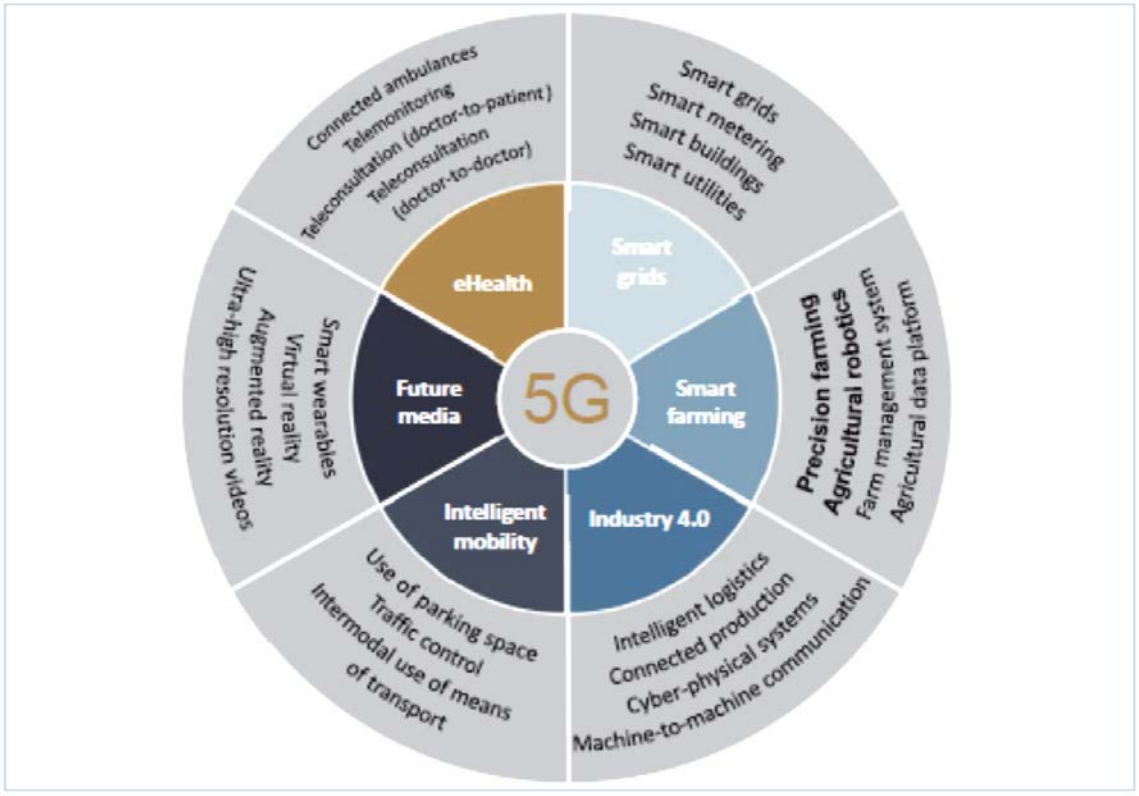
Germany is introducing several potential new approaches other than exclusive national licenses awarded by auction. In a recent public consultation several other approaches were discussed, such as regional licences, combined licensing to several services, shared use of spectrum bands.[157]

The German government is also exploring 5G applications around six use cases.

- Intelligent mobility
- Industry 4.0
- Smart Farming
- Smart grids
- eHealth
- Future media

[157] See BNetzA, 'Draft consultation document on the order for and choice of proceedings for the award of spectrum in the 2 GHz and 3.6 GHz bands for mobile/fixed communication networks (MFCN) - Reference: BK1-17/001 ',
https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/20180320_consultation_dec_I+II_pdf.pdf?__blob=publicationFile&v=1

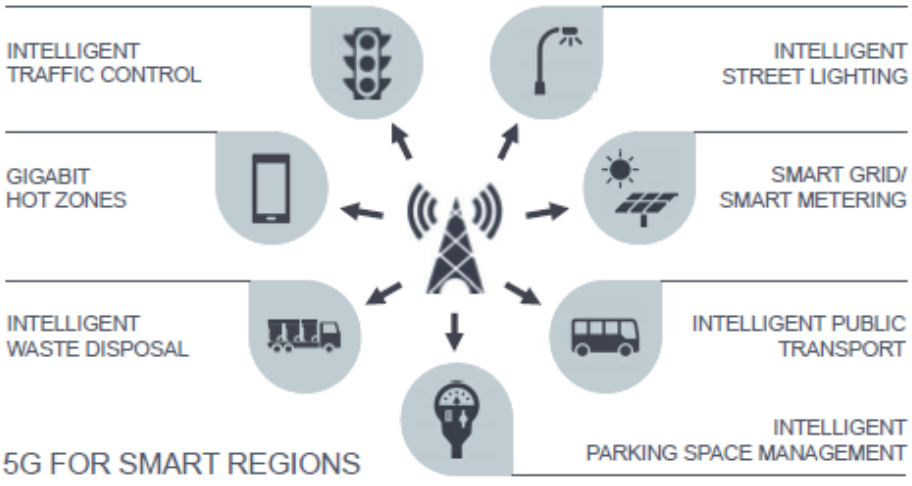
**Figure 45. Application Domains of 5G Networks**




Source: German Federal Government, '5G Strategy for Germany', 2017.

The plan also considers how 5G can help cities and municipalities to more effectively implement and deliver services to citizens. The Smart City Charter of the Smart City Dialogue Platform provides guidance to local stakeholders. The 5G plan also considers several 5G enabled applications for smart cities.

**Figure 46. 5G Application Examples for Municipalities**

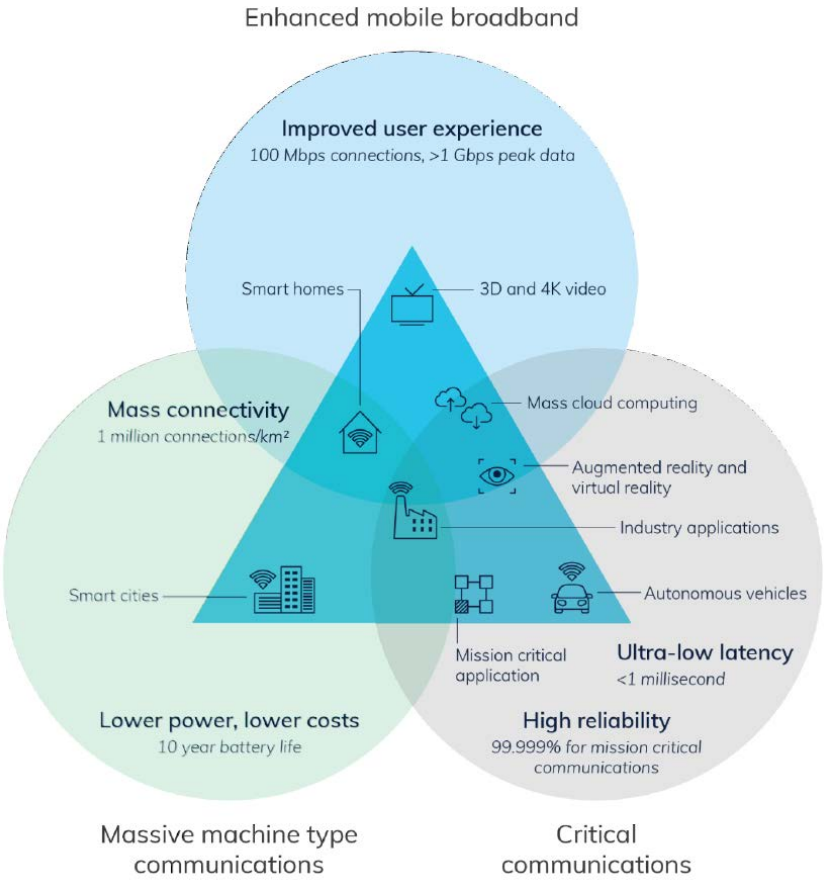



Source: German Federal Government, '5G Strategy for Germany', 2017.

### 5.2.7. Australia

The Australian government released its 5G strategy in October 2017.[158] The review identified three main use cases for 5G, as summarised by the figure below:

**Figure 47. 5G use cases identified by Australian Government**




Source: Department of Communications and the Arts, *5G Enabling the future economy*, October 2017

The immediate actions identified in this strategy were:

- Making spectrum available in a timely manner
- Actively engaging in the international standardisation process
- Streamlining arrangements to allow mobile carriers to deploy infrastructure more quickly, and
- Reviewing existing telecommunications regulatory arrangements to ensure they are fit-for-purpose.

The outcome of the strategy was to establish a 5G working group, which the government announced in December 2017. This working group includes both mobile operators and

[158] See: Government of Austrlia, %G—Enabling the future economy, 12 October 2017, https://www.communications.gov.au/departmental-news/5g-enabling-future-economy

equipment vendors.[159] The aim of the working group is to 'to foster an ongoing 5G dialogue between industry, subject matter experts and Commonwealth Government representatives on how best to realise the benefits of 5G across a range of portfolios and sectors.'[160]

On 8 March 2018, the government announced that 125 MHz of spectrum in the 3.6 GHz band would be auctioned in October 2018.[161]

Both Telstra and Optus have announced plans to launch their 5G networks in 2019.[162]

The ACCC's Communications Sector Market Study December 2017 Draft Report also dedicated significant discussion what 5G means for the NBN, and in particular whether 5G will result in wireless technologies co-existing with fixed broadband or displacing it.[163]

NBNco has the rights to spectrum in the 3.4 GHz and 3.5 GHz bands for its fixed wireless network for $0.03 MHz/pop, a much lower cost than the $0.50/MHz/pop that Telstra paid in late 2017 for 3.4 GHz spectrum. There are some concerns with NBNco having access to this spectrum for a cost much lower than market price, and Vodafone has asked the Department of Communications either to re-auction that spectrum or to charge NBNco closer to market price.[164]

## 5.3. Cross-Country Analysis

National 5G plans in the countries in our sample look at spectrum planning but also at other issues beyond radio frequencies that are expected to be critical to 5G deployment:

- Timely allocation and release of spectrum in 5G bands;
- Test beds of 5G equipment and use cases;
- R&D in applications and equipment related to high priority use cases; and
- Removing barriers to 5G deployment: streamlining building permits processes, reviewing competitive conditions to relax competition law barriers to active network sharing, etc.

### 5.3.1. Spectrum band release

All countries are planning to release 5G frequencies to the operators by 2020 at the latest. The only exception is New Zealand, where discussions are still under way to decide how to rearrange 5G spectrum bands before 2022.

[159] See Corinne Reichert, 'Australian government announces 5G working group members', ZDNet, 20 December 2017, http://www.zdnet.com/article/australian-government-announces-5g-working-group-members/.

[160] Australian Government Department of Communications and the Arts, 'Terms of reference—5G working group', accessed 7 March 2018, https://www.communications.gov.au/file/33186/download?token=43syh6pT

[161] See Mitch Fifield, Government approves auction process for 5G spectrum, 8 March 2018, http://www.minister.communications.gov.au/mitch_fifield/news/government_approves_auction_process_for_5g_spectrum

[162] See Brendon Foye, 'Telstra to launch 5G services in 2019', *CRN*, 5 February 2018, https://www.crn.com.au/news/telstra-to-launch-5g-services-in-2019-484422.

[163] See, section 6.1 of ACCC, *Communications Sector Market Study: Draft Report*, October 2017.

[164] See Ry Crozier, 'NBN Co's 5H spectrum price blown away at auction', *itnews*, 6 February 2018, https://www.itnews.com.au/news/nbn-cos-5g-spectrum-price-blown-away-at-auction-484470.

**Table 10. Planned Dates for Frequency Releases**

| Country | 700 MHz[165] | 1.5 GHz | 3.4 GHz | 3.6 GHz | 3.8 GHz | 26 GHz |
|---|---|---|---|---|---|---|
| Australia[166] | 2018 – 2021 | 2019 – 2020 | Already allocated | 2018 – 2019 | Monitor international decisions | 2019 – 2020 |
| France | Already allocated | No immediate plans | Under study by ARCEP | Under study by ARCEP | Under study by ARCEP | Under study by ARCEP |
| Germany | Already allocated | Not considered | 2018 | 2018 | 2018 | Publish plan as soon as possible, release before 2020 |
| New Zealand | Already allocated | Under discussion | Allocated to other services until 2022 | Allocated to other services until 2022 | Allocated to other services until 2022 | 26.4-28.3 available in 2018<br>24.5-26.4 available in 2022 |
| Spain | Roadmap for allocation in June 2018 | 2018 | Already allocated | Already allocated | About to be available, rearranging underway | Available for immediate use, technical conditions of use still pending |
| Sweden | Public consultation underway | Under study | 2019 | 2019 | 2019 | 26.5 -27.5 in 2019<br>24.5-26.5 available at a later date |

Source: National 5G plans, PTS, TeleGeography

### 5.3.2. Use cases

It is not clear yet which uses or applications will be the main drivers of 5G development, nor which ones will make the most intensive use of them. However, the inspection of 5G plans in the countries in our sample reveal some use cases are considered in most of them: Industry 4.0, automotive, smart cities and smart farming, and eHealth.

[165] For Australia, information refers to the 850/900 MHz band.

[166] See ACMA 'Five year spectrum Outlook 2017–21', October 2017. This plan defines three possible scenarios. Final auction dates for each band are contingent on the scenario finally selected.

**Table 11. Use cases mentioned in National 5G Plans**

| Country | Use cases |
|---|---|
| Australia | *(no specific cases mentioned)* |
| France | Automotive, Industry 4.0 |
| Germany | Industry 4.0, eHealth. smart farming, smart grids, future media, smart cities |
| New Zealand | *(no specific cases mentioned)* |
| Spain | Industry 4.0, intelligent transport, connected car, smart farming, smart grids, multimedia applications, smart cities, tourism, robotics |
| Sweden | Rural connectivity, including for industries, police, eHealth, and defence; TV services |

Source: National 5G plans

### 5.3.3. Measures to facilitate network deployment

In addition to frequencies and use cases, countries that have already launched 5G plans (Spain, Sweden, Germany and Australia) include measures to facilitate network deployment. The most common are:

- Foster network sharing by mobile operators, including active elements;
- Lighten administrative burdens to network deployment by municipal and telecommunications regulations; and
- Step up the use of passive infrastructure owned by utilities and other non-telecommunications organizations.

# 6. CONCLUSIONS AND RELEVANCE TO THE UK

Consumer demand is driving the deployment of NGA but not necessarily that of FTTP. At least until now, customers look at superfast VDSL services as a substitute for ultrafast FTTP and cable broadband connections. In addition, FTTP and cable are suited to deliver gigabit services.

In countries where FTTP deployment is widespread, it has been driven by a combination of policy decisions and national geographic and market circumstances.

- Spain, Sweden, and New Zealand have gotten very high FTTP coverage with very different policy models.
- France took some time to start FTTP deployments but is now investing heavily.
- Australia set ambitious goals for FTTP deployment but it is now betting on a mix of FTTP and other NGAN technologies (VDSL, cable and wireless).
- Germany has very extensive deployment of good quality VDSL but scant FTTP coverage.

***If the UK Government wishes to foster FTTP deployment, specific policy measures tailored to UK circumstances ought to be designed and implemented.***

## 6.1. Urban FTTP Development

All countries in the sample intend to **foster retail competition** as the best means to serve consumers. However, they have **different approaches to infrastructure competition**: infrastructure competition between vertically integrated operators (Spain, France, and Germany), infrastructure competition between wholesale-only operators (Sweden), ensuring at least one wholesale-only network per area while allowing competition from other networks (New Zealand), and an infrastructure monopoly in the hands of a wholesale-only operator (Australia).

- Consumer outcomes and competitive rivalry are similar in vertically integrated markets and those where the main networks are separated from retail.
- Markets with vertical integration are more advanced in retail and network convergence than wholesale-only ones.
- Retail consolidation has not had a negative impact on infrastructure competition.
- Best practices (Spain, Sweden, and New Zealand) foster competition in the infrastructure market: either *intra-market competition* (Spain and Sweden) or *competition for the market* (New Zealand).

***The UK should base its telecommunications infrastructure policy on infrastructure competition.***

- Where possible, competition between several gigabit networks should be fostered.
- In areas where network competition is not foreseen, policy should foster competition for the market, in tenders open to any suitable operator.

Best practices in urban FTTP deployment have several other points in common.

- Deregulation of fibre services
- Access to passive infrastructure
- Light-touch administrative processes, and ex-post intervention when possible
- Countries where alternative operators are deploying fibre have also seen the launch of fixed-mobile convergent bundles and a reduction in the number of alternative retail operators

***If the UK wishes to foster FTTP deployment, its policy should consider relaxing ex-ante fibre regulation and administrative burdens and broadening the scope of competition policy.***

Actions the UK needs to consider.

- Relaxing fibre services regulation to the minimum extent necessary to protect consumers
- Ensuring proper access to all suitable passive infrastructures, beginning with Openreach's
- Avoiding the imposition of heavy administrative burdens on the industry and lightening the existing ones where possible
- Applying competition rules to prospective mergers considering the convergent market as a whole, rather than narrow service markets

**Passive infrastructure is a critical element in FTTP deployment**. It amounts to more than one-half of total network assets and most of the time expended in network deployment projects. Therefore, operators can attain large savings in capital expenditures and time where they can reuse existing passive infrastructure. Those savings often make the difference between profitable and unprofitable FTTP projects.

Two parts of the network display very different technical and economic properties: the feeder network (up to the street cabinet or equivalent) and the final drop (up to the building and in-building cabling). Feeder networks are similar in most countries. However, the final drop makes the biggest difference between technologies and between countries.

- VDSL and cable can reuse the existing final drop from legacy networks, whereas FTTP requires a new final drop to be installed between the cabinet and the premise.
- There are large differences between countries in the infrastructure already in place (street cabinets, ducts to buildings, in-building ducts) and in the regulation of access to buildings and in-building cabling, including rights-of-way, landlord obligations, construction permits, and standards regulation.

Best practices mandate access to ducts in the feeder network and allow their use for mobile backhaul in addition to residential and business fibre connections. Duct access obligations also prompt the incumbents to properly map their duct plant.

Best practices in the final drop include granting operators the right-of-way over private land in regulated terms, allowing cheaper cabling techniques, mandating landlords to condition buildings and/or to allow building connection to telecom networks, symmetric access to in-building cabling between telecommunications operators, mandating the coordination of

infrastructure construction by operators, and simplifying and speeding up construction permit processes.

***If the UK wishes to foster FTTP deployment, it should revisit all of its policies affecting passive infrastructure construction and sharing, especially in the final drop from street cabinets to customer premises.***

In the feeder network, access to ducts and poles should be properly implemented, including proper mapping and cleaning up[167] of duct and pole plant. Any restrictions on the use of ducts for mobile backhaul should be reviewed and eventually lifted.

Policies affecting the final drop require a comprehensive review, taking into account the British legal system and the current situation of infrastructure in the UK. The UK should rethink some policies and consider measures such as:

- Granting telecommunications operators the right-of-way over private land, in terms that protects the value of the land for the owners
- Granting access to any existing passive infrastructure that can be used to access buildings with fibre cables
- Mandating new buildings or the remodelling of existing ones to incorporate ducts suitable for deploying fibre cables to every flat
- Mandating all fibre operators symmetric access to each other's in-building cabling, when technically feasible and not disincentivising commercial investment by operators
- Reviewing municipal and any other regulations in order to ensure that the cheapest cabling techniques are allowed
- Reviewing municipal and any other regulations in order to ensure that administrative process are as simple and fast as possible
- Mandating landlords to allow connections to a building if at least one tenant requests service from a fibre operator

**Wholesale-only FTTP networks** in the analysed countries are very heterogeneous and in many cases of regional scope and/or state-owned.

- There are municipal FTTP networks in parts of competitive markets: most urban areas in Sweden and some rural areas in France.
- The Australian NBN is a state-owned monopoly.
- Telia is partly state-owned, and its wholesale-only unit Skanova has only partial FTTP coverage, because it still relies strongly on VDSL.
- Local Fibre Companies in New Zealand are privately owned companies that operate under a government mandate in 33 designated urban areas.

***It should be analysed whether any of those experiences can provide references relevant to the UK market.***

[167] Clean-up includes the removal of cables no longer in use, the redesign of cabling routes, the removal of sand or other debris inside ducts and chambers, and other actions to get legacy plant in shape.

## 6.2. Rural Ultrafast Broadband

Rural ultrafast broadband deployments have received public support in all countries. As a rule, public support has aimed at fostering private deployment in areas deemed not to be profitable in purely commercial terms. Common traits in most countries include the following.

- Public subsidies are offered to private operators in tenders that foster competition for the market in a given geographic area.
  - The franchise model (legal exclusivity in a given area) is untested in the countries that we analysed. There is free entry and competition by other operators, even if they choose not to enter.
  - A state-owned monopoly is found only in Australia and is underperforming.
  - State-owned operators are not deploying FTTP in rural areas, except in some parts of France.
  - Subsidies are granted in unserved areas and usually in a competitively neutral way to avoid breach of state aid rules.
  - Subsidies may be implemented as direct payments, soft loans, or venture capital.
- In addition to financial support, operators sometimes receive other help that contributes to lower their costs, such as privileged access to existing passive infrastructure or streamlined permits.

Wireless networks play an important role in rural NGA deployment.

- Rural coverage obligations were attached to 4G spectrum licences and are likely to be attached to 5G licences.
- Satellite and fixed wireless access solutions have been included in some rural broadband plans.
- Technologically neutral tenders have sometimes resulted in wireless solutions being chosen.

***Rural NGA policies in the UK should consider a combination of public subsidies and other support, wireless and wireline technologies, and private investment.***

The UK should consider different options.

- Granting public subsidies and other support to private investors that commit to deploy NGA in unserved rural areas.
- Launching technologically neutral tenders for rural subsidies.
- Making explicit the willingness to trade-off some spectrum auction revenue for increased ultrafast mobile coverage.
- Devising ways to decrease operators' deployment costs by reducing legal hurdles and granting access to existing passive infrastructure.

## 6.3. Corporate and Backhaul Fibre Services

Business customers and mobile operators demand different services to residential customers. Corporate networks often require fibre links. Mobile backhaul is more reliant on fibre with each generation (quite reliant for 4G and critically reliant for 5G).

Larger business customers generally have few problems with access services. They lease competitive services in many areas with network competition and regulated leased lines or active broadband services in less competitive zones. Fibre connections are usually available on-demand even in areas where there is no FTTP deployment, usually at a higher price than in metropolitan areas.

Mobile operators that do not own a fixed network have to build their own fibre links or rely on fibre backhaul supplied by third parties. Some countries have implemented policies to ease mobile operators' access to fibre backhaul.

- Wholesale-only network operators sell fibre for backhaul as one of their services.
- Mobile operators have the right to lease ducts to deploy mobile backhaul in Spain and France. In Spain, they have the right to lease dark fibre when there is no free space in ducts.

***The UK should ensure that mobile operators have access to fibre links for backhaul under reasonable terms.***

The UK should consider how mobile operators access fibre backhaul.

- The use of duct access services for mobile backhaul should be allowed.
- If an operator must provide dark fibre or gigabit connections for corporations, the mandate should also include backhaul connections.
- For as long as Openreach is a part of the BT Group and is vertically integrated into mobile, the inclusion of mobile backhaul as part of its services on an Equivalence of Input basis should be considered.
- In areas where competitive operators do not supply fibre backhaul, it should be added to the set of services to be provided by regulated operators or those that receive public subsidies for NGA deployment.
- Reviewing and eventually relaxing or lifting the regulation of the incumbent/PPP operators if competitive fibre offers develop for backhaul in a given geographic area.

## 6.4. 5G Readiness

The analysed countries are launching 5G national plans to make their digital sector ready for 5G. All 5G plans analysed take a comprehensive perspective. That is, they look at spectrum planning and at other issues beyond radio expected to be critical to 5G deployment:

- Timely allocation and release of spectrum in 5G bands;
- Test beds of 5G equipment and services; and R&D in applications and equipment related to high priority use cases; and

- Removal of barriers to 5G deployment: streamlining building permit processes, reviewing competitive conditions to relax competition law barriers to active network sharing, etc.

In Sweden, there is not a separate 5G plan. All types of ultrafast technologies are considered together in the Completely Connected Sweden plan.

***The UK should consider a comprehensive action plan for 5G that combines spectrum release with other measures intended to foster the development of a vibrant 5G ecosystem.***

The UK 5G action plan should envisage the following.

- Timely release of spectrum bands allocated to 5G services
- Coordinate test beds of equipment and use cases with the relevant industry players
- Include 5G equipment and applications in public R&D programmes
- Ensure 5G actions to self-reinforce other actions in infrastructure policy, such as rural broadband deployments, maximizing synergies between 5G and FTTP network deployment, or competition policy applied to fixed-to-mobile consolidation
- Devising ways to decrease operators' deployment costs by reducing legal hurdles and granting access to existing passive infrastructure

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