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Challenges and drivers of NGA rollout and infrastructure competition

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List of abbreviations

CO	Central Office
DAE	Digital Agenda for Europe
DOCSIS	Data Over Cable Service Interface Specification
DSL	Digital Subscriber Line
EC	European Commission
EU	European Union
FTTP	Fibre to the Premises
FTTH	Fibre to the Home
FTTB	Fibre to the Building
GBER	General Block Exemption Regulation
G.fast	fast access to subscriber terminals
GPON	Gigabit Passive Optical Network
HD	High Definition
IPTV	Internet Protocol Television
L2 WAP	Layer 2 Wholesale Access Product
LLU	Local Loop Unbundling
LTE	Long Term Evolution
MS	Member States
NGA	Next Generation Access
PON	Passive Optical Networks
VDSL	Very High Speed Digital Subscriber Line
VOD	Video on Demand

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Executive Summary

Today, a high-capacity communication infrastructure is indispensable for the functioning of an economy and a society. In Europe, there is a broad consensus among all parties (the European Commission (EC), national and regional governments, regulatory agencies, communication providers) that the rollout of next generation access (NGA) networks is a desirable goal. With its 2020 Digital Agenda for Europe, the European Commission has set out targets for NGA coverage and take-up. Moreover, European countries have individually defined rollout strategies and devote efforts towards the swift rollout of new high capacity infrastructures.

Having the common objective of extending NGA coverage, the type and speed of NGA rollout varies considerably across European countries. A number of factors seem to greatly influence the specific deployment of NGA, namely the chosen NGA structure, the technologies deployed and also the pace at which rollout takes place.

This report is motivated by this very variation in NGA rollout: It provides an overview of where MS stand right now in terms of NGA rollout and investigates the main drivers and challenges. The factor analysis is based on a case study approach, drawing on information obtained from NGA stories provided by NRAs. Three important (categories of) driving factors – largely exogenous to NRAs' sector specific regulation – are identified and thoroughly analysed: Infrastructure competition (mostly from DOCSIS 3.0 but also from alternative operators FTTP deployment), demand side factors (i.e. demand for services in need of high bandwidths and a high willingness to pay a premium for NGA-based access) and supply side factors (i.e. factors which influence the costs or the quality of NGA-deployment, including factors which more indirectly influence cost or quality such as public policy). The analysis moreover provides that in many countries especially the type of NGA rollout is considerably shaped by the legacy infrastructure and existing civil infrastructure, hence revealing strong elements of path-dependency.

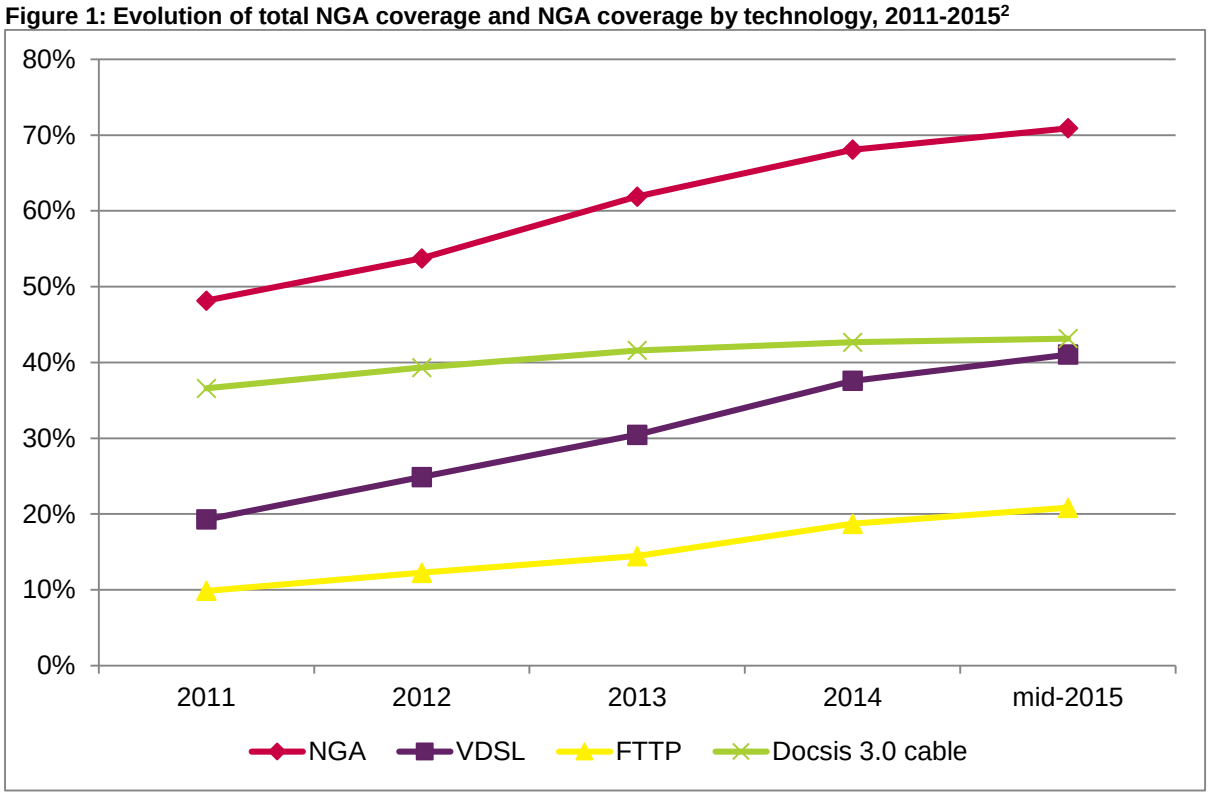
This report, in a second step, looks at the different forms of access regulation adopted in different circumstances and different MS and the possible effects on competition and NGA investments. An important insight from the analysis is that the main factors identified and discussed are factors which are largely or completely exogenous to regulatory interventions by NRAs. Hence, SMP regulation is only one factor among many and its ability to promote NGA rollout or particular types of NGA rollout need not be overstated. Depending on the exogenous factors identified in the factor analysis, regulatory approaches which best meet the principles of promoting sustainable competition and efficient investment as well as safeguarding consumer benefits might look different across MS and indeed even within a MS. Considering four different scenarios, the report shows that SMP regulation focuses on the promotion of competition to incentivise investment taking into account the *given* national (or subnational) conditions and NGA rollout strategies of operators.

1 Introduction

In Europe, there is a broad consensus among all parties (the European Commission (EC), national and regional governments, regulatory agencies, communication providers) that the rollout of next generation access (NGA) networks is a desirable goal. In 2010, the EC defined the so called 'Europe 2020 Strategy'. One of the seven pillars of this strategy is the 'Digital Agenda for Europe' (DAE) which aims at promoting NGA rollout in Europe while defining specific targets: By 2020, every European Union (EU) citizen should have access to at least 30 Mbps, and 50% or more should subscribe to at least 100 Mbps. Europe is now about halfway through the period set out initially for realizing those very targets.

Over the last five years, Member States (MS) have been assigning growing importance to NGA rollout. Overall NGA coverage[1] in the EU increased significantly from 48% end of 2011 to 71% by mid-2015. **Figure 1** shows the development of total NGA coverage as well as of NGA coverage by technology (distinguishing between copper VDSL, cable DOCSIS 3.0 and fibre to the premises (FTTP)) over the years 2011-2015 at the EU level.

Figure 1: Evolution of total NGA coverage and NGA coverage by technology, 2011-2015[2]



[1] Sources: EC (2016) Digital Economy and Society Index 2016 Telecommunications data files and EC (2013, EC (2014), EC (2015) EC studies on broadband coverage. The EC distinguishes three categories of broadband, namely "standard broadband" which includes all fixed and mobile broadband technologies but excludes satellite, "standard fixed broadband" which captures coverage provided by fixed technologies and "NGA broadband" which covers the technologies VDSL over copper, FTTP (comprising both fibre to the home (FTTH) and fibre to the building (FTTB)) and cable DOCSIS 3.0. Technologies which come under this very last category are chosen such that they are able to meet the DAE's 2020 objective of providing 30 Mbps to every household. Coverage is understood to be the percentage of households covered by NGA infrastructure.

[2] Source: ibid.

According to the EC coverage data, rural coverage also increased remarkably within this period, from 9% up to 28%. Yet, it has shown that – although MS have the overarching goals of higher NGA coverage and penetration in common – the current status of NGA rollout differs to a considerable degree across MS.

A number of factors – some of them very specific to single countries – to a great extent seem to impact on the type and speed of NGA rollout. This report provides an overview of where MS stand right now in terms of NGA rollout and investigates the main drivers and challenges based on data obtained from the NRAs (namely on several 'NGA country stories') and partly based on other sources. It explores how far those factors determine the specific deployment of NGA, namely the chosen NGA structure, the technologies deployed and also the pace at which rollout takes place. The report also looks at the different forms of access regulation adopted in different circumstances (and in different MS) and the possible effects on NGA investments and competition.

This analysis might also provide some first insights into some of the issues being addressed in the EC's Framework Review[3], e. g. if rollout of certain NGA technologies should be promoted or the importance of passive or symmetric obligations for the NGA rollout. However, it does not seek to give MS explicit recommendations for further actions in the course up to the DAE 2020 goals.

This report is structured as follows: Section 2 analyses the main drivers of NGA rollout. Three broad categories are identified: (i) Infrastructure competition; (ii) demand side factors and (iii) supply side factors. Section 3 discusses the main regulatory approaches applied in different situations, why NRAs might have opted for one regulatory approach or the other and in how far and in which way regulation impacts on NGA investment. Section 4 concludes. The **Annex 1** includes a summary of selected economic literature related to the topics of regulation, competition and NGA rollout. The **Annex 2** contains the NGA country stories.

[3] Cp. the EC's roadmap concerning the evaluation and reform of the regulatory framework for electronic communications networks and services as of mid-2015, available here: http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_cnect_007_evaluation__elec_communication_networks_en.pdf.

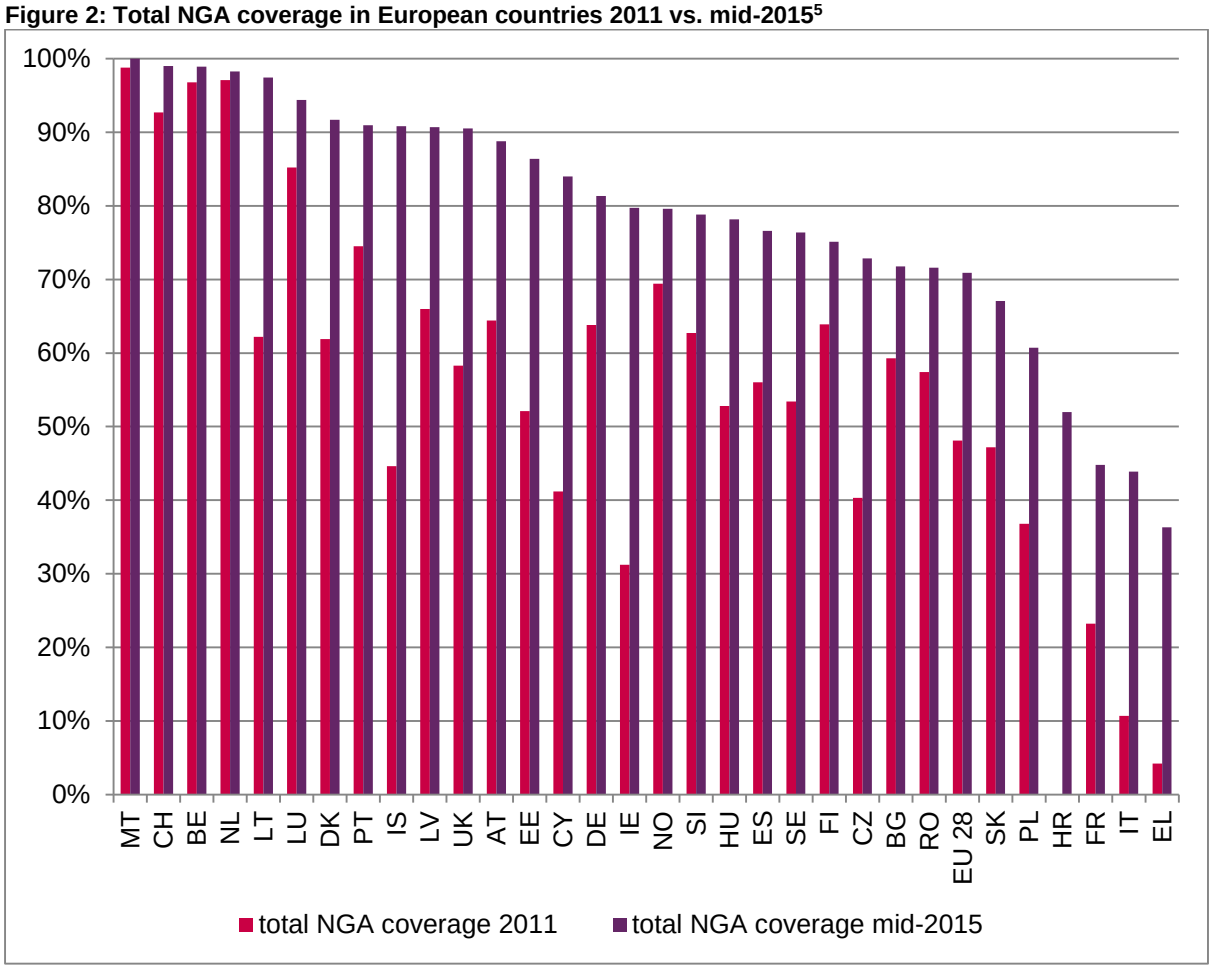
2 Analysis of the drivers of NGA rollout

In this section we discuss several factors which influence NGA investments and may explain differences in status and type of NGA rollout. This section focuses on factors which are mostly exogenous to NRAs and sector specific ex ante regulation.

As a point of departure, we first show the status and progress of NGA rollout based on EC data[4] covering the 28 EU MS as well as NO, IS, and CH.

Figure 2 illustrates that total NGA coverage per country in 2011 and in mid-2015 has significantly increased in almost all European countries (except for those which already had very high coverage in 2011, i.e. more than 90% of coverage) over the last years. Still, there are large differences in total NGA coverage across countries.

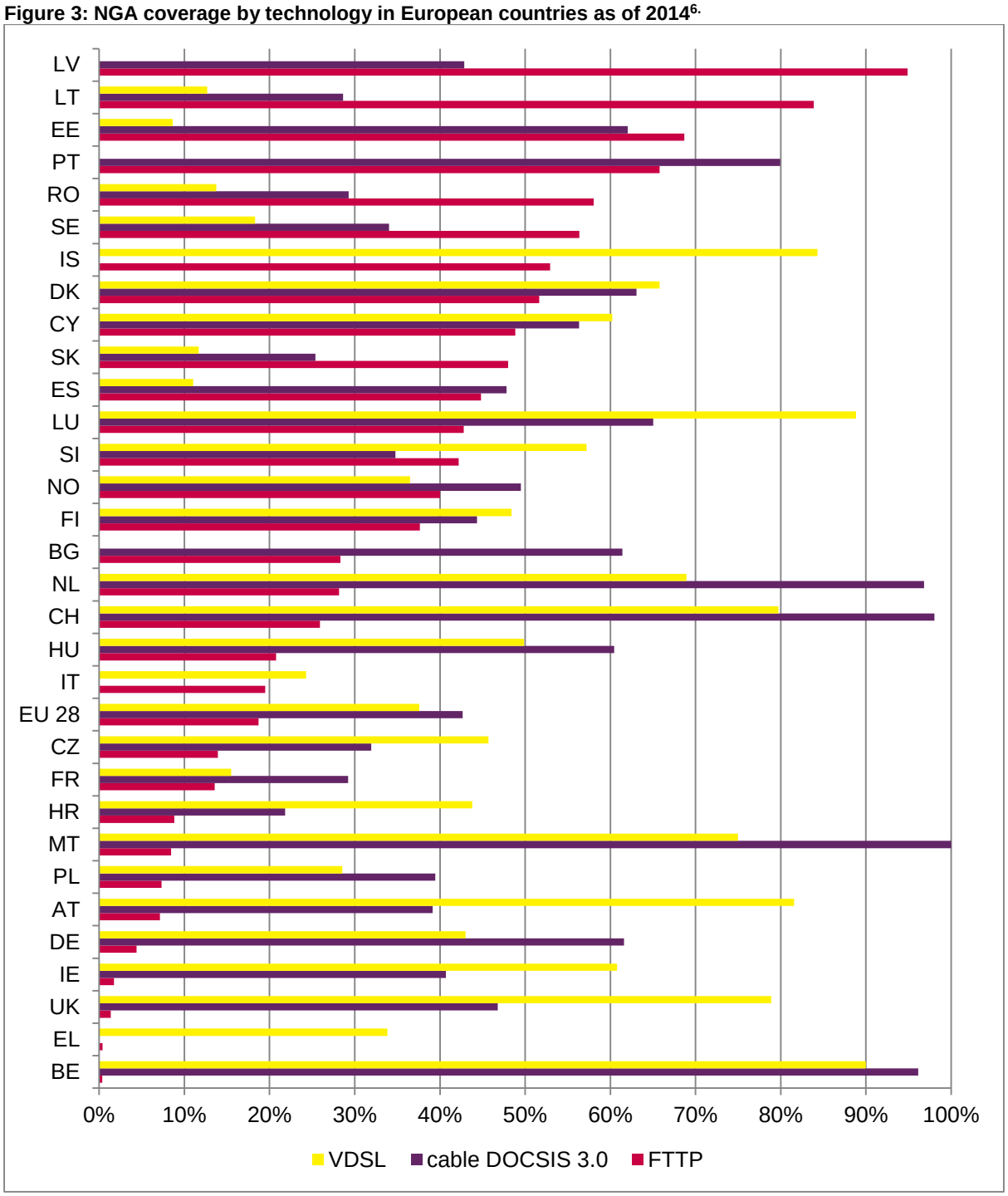
Figure 2: Total NGA coverage in European countries 2011 vs. mid-2015[5]



[4] Source: See fn. 1
[5] Source: See fn. 1.

In **Figure 3**, NGA coverage in 2014 is depicted by country and by technology, differentiating again between cable DOCSIS 3.0, FTTP and VDSL. The relative importance of each technology varies widely across countries. While differences in DOCSIS 3.0 coverage usually can be explained by the historical presence of cable networks, it is not so clear, a priori, what drives the huge differences between FTTP coverage and VDSL coverage across countries.

Figure 3: NGA coverage by technology in European countries as of 2014[6].



[6] Source: EC (2015).

The numbers presented in the preceding figures raise the following question; *why* does NGA rollout take such a variety of forms? In the discussion that follows, we aim to find answers to that question. We analyse the main drivers of NGA rollout based on the NGA stories and, where appropriate, other data available to NRAs. Three main categories of drivers are identified:

(i) Infrastructure competition (presence and impact of alternative (NGA) infrastructures, in particular cable DOCSIS 3.0 and alternative operators' FTTP deployment);
(ii) Demand side factors (such as demand for high bandwidth services which may in turn lead to a higher willingness to pay for high bandwidth access); and
(iii) Supply side factors (such as those which influence costs or quality of NGA rollout)

In particular, when looking at supply-side factors we investigate their effect on the type of NGA rollout, i.e. FTTP vs. FTTC/VDSL.

2.1 Infrastructure competition

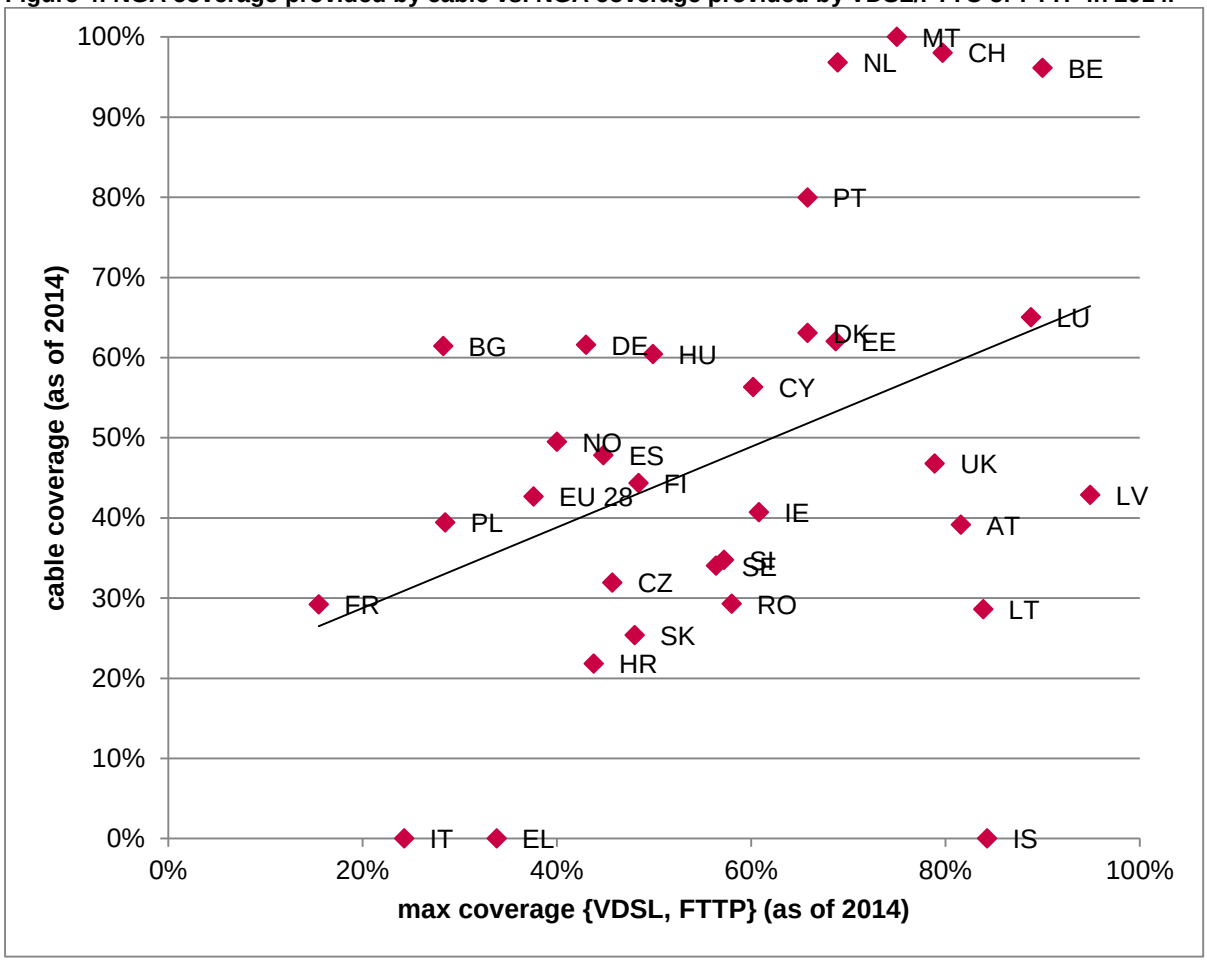
A number of studies show that a main factor driving NGA deployment is infrastructure competition.[7] In this section, the focus is on infrastructure competition that is "exogenous" in the sense that it is not or only to a very limited extent induced by (current) regulation. For the type of infrastructure competition that is induced by regulation, reference is made to section 3 which deals with the relationship between NGA rollout and regulation. In this report, infrastructure competition from cable and from independent FTTP operators is considered being at least not directly related to the regulatory regime.[8]

While **cable infrastructure** was initially rolled out (in a lot of MS by the state[9]) for the purpose of delivering a cable TV signal, it has only been discovered later that when upgraded to bi-directional transmission of signals, this network could be used for broadband internet access. Meanwhile, great parts of the existing cable network were upgraded by enabling the use of DOCSIS 3.0 standard (so called hybrid fibre coaxial network). The cost incurred for repurposing the original Cable TV network to simultaneously carry high speed broadband traffic by this upgrade to high speed DOCSIS technology is relatively lower compared to the cost incurred for an upgrade of the existing copper network to attain a comparable level of bandwidths. Another cost advantage of the upgrade of coax to fibre compared to the upgrade of the copper network to fibre is that it can be done more gradually: the combined fibre-coax system nowadays still provides higher bandwidths than usual fibre-copper combinations. While upgrades have been made to existing coax cables, there has only been minimal increase in extending the footprint of cable coverage in recent years.

[7] See **Annex 1** for a Literature Review.
[8] This is true for most MS. However, in countries where ducts are largely present and cost based access is granted on the basis of SMP regulation, infrastructure competition from FTTP and cable is frequently based on that regulated access (e. g. in PT), cp. section 3.
[9] There might be exceptions. For example, in ES and PT cable networks have been rolled out only relatively recently (early 1990s) by the incumbent and also some alternative cable operators (using duct access as well, cp. footnote 8).

The cable footprint varies a lot across Europe, ranging from no cable presence in EL, IS and IT to over 95% coverage of households covered in BE, CH, MT and NL. With the exception of that latter group of countries showing almost ubiquitous cable footprint, cable coverage in other MS is generally limited to dense urban areas and, to a lesser extent, to some suburban or semi-urban areas. There is very little non-urban presence in most countries. The strategic focus of incumbents in many MS on NGA rollout in areas where cable is already present has shown that incumbents deploy their NGA networks (VDSL, FTTP) in direct response to competition from the rollout of DOCSIS enabled broadband on cable networks. Moreover, it can be observed that in a number of countries with very high cable coverage, operators prefer rollout of FTTC/VDSL to rollout of FTTP. This does not least result from the fact that telco operators need to upgrade quickly in order to keep pace with the offers of cable operators of high bandwidth products. **Figure 4** depicts a positive correlation across Europe between cable coverage and the maximum coverage provided by either VDSL/FTTC or FTTP.

Figure 4: NGA coverage provided by cable vs. NGA coverage provided by VDSL/FTTC or FTTP in 2014.[10]



In a number of countries, **independent FTTP network** providers also play a role in the degree of **infrastructure competition** the incumbent faces. It has been observed that FTTP rollout is driven considerably by smaller local players which through their infrastructure deployment trigger investment by the incumbent as well (DE, SE) or foster infrastructure

[10] Source: EC (2015), 'max coverage' refers to the maximum out of the coverage provided by VDSL and FTTP.

sharing agreements (e. g. CH). In many countries, those players are closely linked to the local utilities and are addressed in section 2.3.4 on investment by municipalities). Alternative network providers' FTTP infrastructure deployment has been – similar to the cable footprint – concentrated in dense urban areas where the unit cost of passing homes is much less than in non-urban areas. However, infrastructure competition can also lead to rollout in less dense areas, as it has been shown in SE and NL. In some countries, for example in NL (alternative operator Reggefiber subsequently acquired by the incumbent operator KPN), in ES (Jazztel,[11] one of the largest LLU operator, has deployed an FTTH network with a coverage of approximately 4 million building units), in PT (Vodafone and Optimus, now NOS, after merger with a cable operator) and in FR (Iliad and SFR), independent FTTP providers played a significant role in the deployment of FTTP. In most cases, FTTP coverage does currently not exceed cable coverage.

Competition from mobile is in so far different from the two types of infrastructure competition just addressed that mobile broadband is usually not competing directly against fixed broadband deployment. Despite advances in technology that has enabled faster access speeds, spectrum remains a scarce resource and consequently mobile broadband is often offered with usage limits. This, coupled with issues of in-building coverage as well as slower speeds when compared to higher capacity fixed networks (FTTC Vectoring, FTTP), has meant that in most MS, users consider mobile broadband a complement, not a substitute for fixed broadband access. The exception is AT, with many mobile-only households, where mobile broadband is often used as a substitute for fixed broadband. In particular with the rollout of LTE, mobile operators are able to offer bandwidths which frequently are above those which can be achieved on the copper network. This sets additional incentives (cable networks also cover about 50% of the households) for the incumbent operator to invest in NGA infrastructure. Yet, competition from mobile has also led to a relatively low price level for entry products. This, together with a relatively low willingness to pay for higher bandwidths make in particular FTTP investments by the incumbent and alternative operators more difficult (cp. also section on retail prices 2.3.3).

2.2 Demand side factors

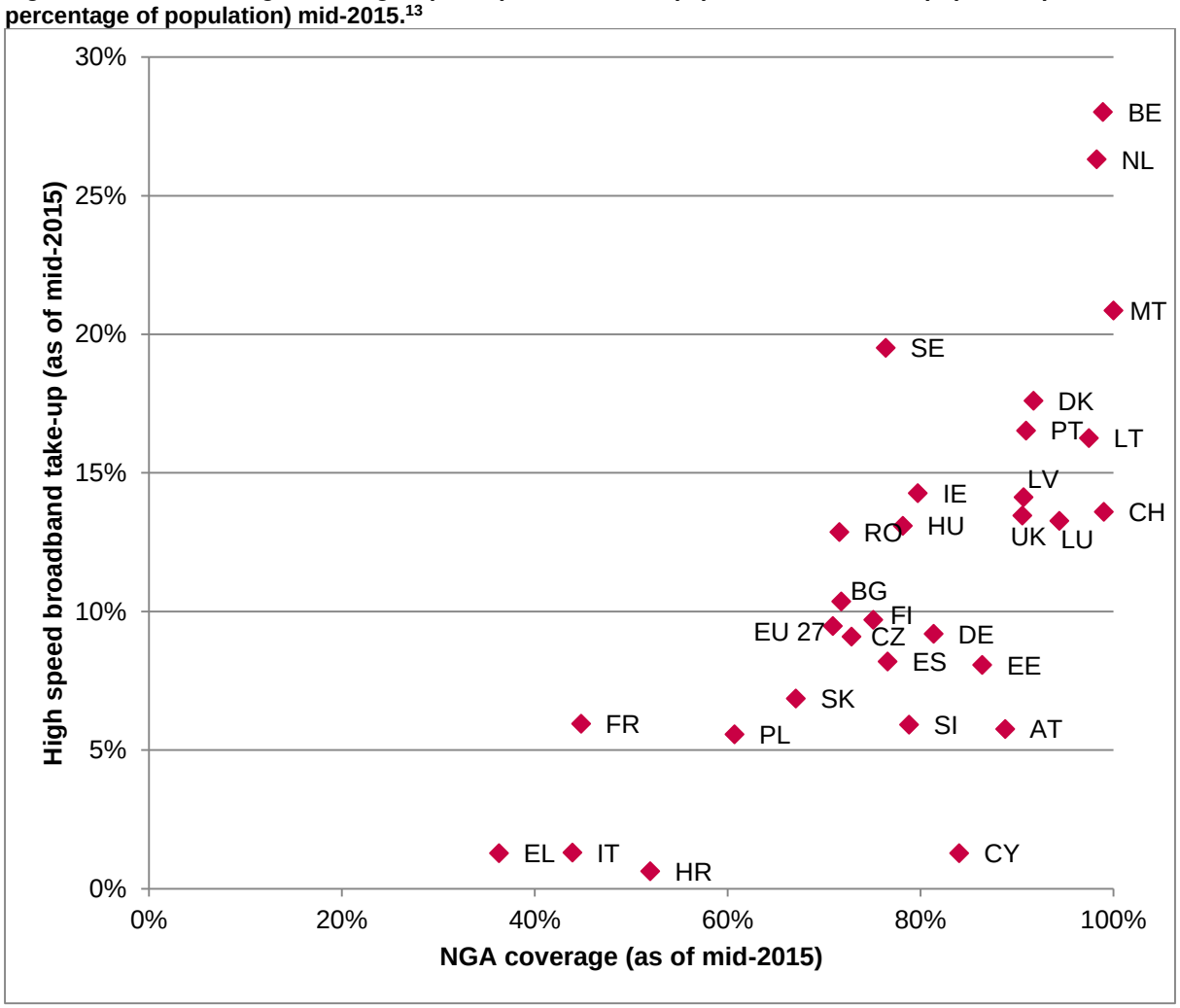
End user demand for high capacity broadband connections and a willingness to pay the associated premium for the higher capacity are important demand side factors (besides infrastructure competition and the supply-side factors mentioned in section 2.3) driving NGA investments (NRAs in CH, DK, EL, FI, PT, RO, SL and SE have specifically pointed out demand as an important factor). Demand side factors cannot be created nor fostered directly by regulation. Although there is unanimity across MS that demand for NGA products – once it is there – is a factor that accelerates rollout, the majority of MS rather report on a *lack of demand and willingness to pay* for very high speed capacity broadband products. This in turn has an effect on the business case of operators when rollout decisions are being evaluated and consequently on both the pace of rollout and on the technology mix of the rollout (e.g. FTTC vs FTTP).

In this context, the lack of willingness to pay does not so much refer to the retail price per se but to the premium that customers are willing to pay for NGA-based products compared to

[11] Jazztel was acquired by Orange after having received clearance by the EC in 2015.

copper-based products (i.e. how much marginal utility is derived from a fibre-based product compared to a copper-based product).[12] **Figure 5** shows that take up (subscriptions as a percentage of population) still considerably lags behind coverage.

Figure 5: NGA coverage and high speed (at least 30 Mbps) broadband take-up (subscriptions as a percentage of population) mid-2015.[13]



While this report in general provides a broader picture of the situation in Europe, this section specifically often refers to a smaller number of MS where the impact of demand on rollout is already clearly visible.

Demand can be divided into two main groups: demand from the private sector, including both end users such as households and private companies, and demand from the public sector, such as schools, hospitals, and public administrations, altogether driving the digitalisation of the society.

[12] The importance of that price premium has been recognized by governments. IT for example, in its new broadband government strategy (2015), initially had the idea to distribute 'vouchers' with which end users would be compensated such that they pay for FTTX services as much as they would pay for ADSL services.

[13] Source: EC (2016), DESI Telecommunications data files 2016. Reference is made to take-up as a percentage of population since no cross-country EU data has been available on take-up as a percentage of households.

With respect to the **demand from households**, a digital way of life or e-culture (such as in SE) that reflects the underlying socio-cultural desire for digital services is a key driver (as can be seen in SE). Increased demand for capacity-intensive services (such as IPTV, HD/4K/Ultra-HD TV, video-on-demand (VOD) video streaming including Netflix, and games), financial and public online services, social media and the simultaneous use of all these services is leading to significantly increased capacity requirements. The demand for multiple play bundles is strong in some countries and drives NGA rollout due to higher bandwidth needs, especially for IPTV (e. g. in PT and RO).

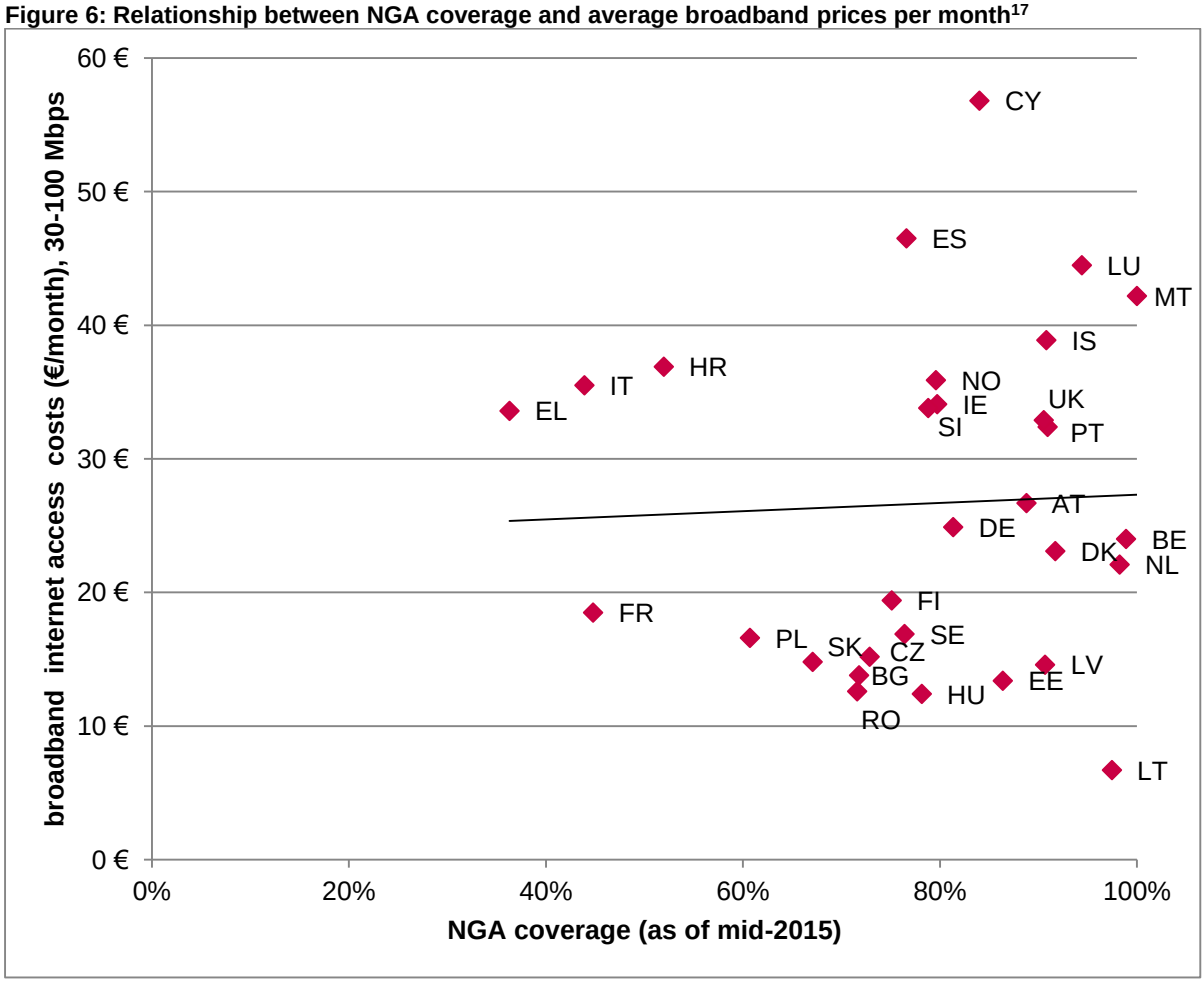
The end users' demand in terms of bandwidths and speed is determined by the end users' perception of needs, both current and in a forward looking perspective. Perception in turn is, often, shaped by comparisons with other end-users' behaviour.[14] The actual need for high speed broadband may often be overestimated by a low capacity user who might be influenced by internet service providers' commercials and society at large to believe that they require higher speeds than they actually do (at present), thereby creating demand. A high capacity user[15] may, however, be limited by the innate technological limitations of broadband over a copper network and may have an actual need for higher quality/speed. A third group of users is aware that their needs are limited at the moment, but they want to futureproof their house when an NGA rollout is being carried out in the neighbourhood (e. g. in SE).

The level of income, employment and educational status are also important drivers for demand and willingness to pay for high speed networks.[16] In countries where end-users have a high willingness to pay a premium for high capacity broadband connections as well as for upfront installation/connection fee, rollout is much more common. In SE, such an upfront payment of around EUR 2,000 for a single-dwelling unit is commonly considered as an investment raising the value of the property, and has led to a general trend of such personal 'digital investment' in houses. The willingness to pay upfront has been instrumental to drive the deployment of fibre to single dwelling units.

Van Dijk (2015) has prepared a study on Broadband Internet Access Cost for the EC. That study investigates how much residential users in the EU pay for fixed broadband access. It finds that there is no clear relationship between speeds and prices, nor between coverage and prices as can be seen from **Figure 6**.

[14] MT and SE.
[15] SE has noted a rising demand for 1 Gbps speeds and expects there to be a noticeable demand for 10 Gbps speeds after 2020.
[16] SE, PT and BG.

Figure 6: Relationship between NGA coverage and average broadband prices per month[17]



Private companies commonly have higher demands for quality, capacity and redundancy than the average household in order to meet their customers demand for products and services. The financial sector and ICT-companies particularly tend to be high capacity users with high demands for redundancy. Also, in SE for example, farms are highly digitalised which contributes to demand for high capacity broadband in rural areas. Similarly, in PT, SMEs are starting to demand 1 Gbps. Demand can stem not only from end-users but also from down-stream suppliers, such as owners of rental multi-dwelling units (MDU), who can add a mark-up to the rent for every apartment equipped with broadband.[18]

[17] Based on EC broadband coverage studies and Van Dijk (2015). The costs for broadband internet access costs (taken from Van Dijk (2015)) are in Euro and corrected using purchasing power parity. The latest study by Van Dijk dates back to February 2015 and explains the methodology used. However, the EC regularly updates the Van Dijk data; the data used here dates back to October 2015 and is taken from the DESI 2016 data (available here: http://digital-agenda-data.eu/). To determine some measure of broadband internet access cost, for every country, Van Dijk identifies the cheapest offer for a certain category of advertised download speed (here: 30 – 100 Mbps). This is done for different types of offers, i.e. standalone internet access, double play offers (internet access and fixed telephony) and triple play offers (internet access, fixed telephony and TV). We used the minimum price out of those three types of offers (which is in most cases equivalent to the price for standalone internet access).

[18] This is the case in SE, where there is an agreement between the Swedish Association of Public Housing Companies and the Swedish Union of Tenants to this effect. The rental market demand has

Political initiatives and the public sector can be a forceful driver for demand for high speed internet. The public sector can be an anchor tenant which makes rollout projects more economically viable. For example, in the UK, the business model of CityFibre, an alternative infrastructure B2B operator, involves securing public sector agencies and large corporate clients as anchor tenants in advance of any network deployment. Its "well planned city" model, under which it dynamically alters its deployment plans in response to high levels of demand from potential customers means that its networks are profitable as soon as they become operational.[19] Moreover, the digitalisation of the public sector positively feeds back to the demand of end-users who use the digitalised public services. Public sector demand may also consist of the need to be able to connect municipal functions and buildings and offer welfare services, i.e. municipal information, e-services in education, health[20] and social care[21] over broadband networks, as a cost efficient way to maintain welfare services outside more densely populated areas. Other interactions between the general public and authorities, such as online tax returns, are a result as well as a driver of e-culture where easy access to information 24/7 is taken for granted.

It should be noted that demand, high take-up and supply are interdependent driving forces. Some factors, e. g. e-culture, create demand and fast expansion. The availability of high-speed connections fosters high capacity habits and elevates the demand.

2.3 Supply side factors

As supply side factors, we consider all factors which influence the costs or the quality of NGA-deployment, including factors which more indirectly impact on cost or quality such as public policy. The extent to which a certain factor determines cost or quality of a particular NGA technology might vary. Furthermore, a factor's expression may not only vary considerably across countries but frequently also within countries. In particular, while some factors favour the deployment of FTTP, other factors may rather favour the deployment of FTTC.

In the following, the most relevant factors given the data and the country case studies available are discussed. Furthermore, we look at some factors which have been used in other studies. Where possible, we identify countries where a certain factor appears to be very pronounced and try to relate it to the outcome observed in terms of NGA rollout. We try to draw conclusions on how these factors generally impact on the extent of NGA rollout and the technology chosen (in particular FTTP versus FTTC).

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most probably had a spill-over effect on demand from tenants in co-operative housing societies and owners of single-dwelling units.

[19] This provides it with the flexibility to extend its network to adjacent areas on an incremental basis and also means that it does not require large upfront capital investment. When acting as anchor tenants, local governments or municipalities ask for providers such as CityFibre to connect governmental offices, community centres, libraries and schools to a ultrafast fibre wide area network (WAN), enabling information to be relayed among staff, students, clients, buyers and suppliers far faster than before.

[20] For example online booking, online medical consultation, web assisted surgery and national patient overview (online health records).

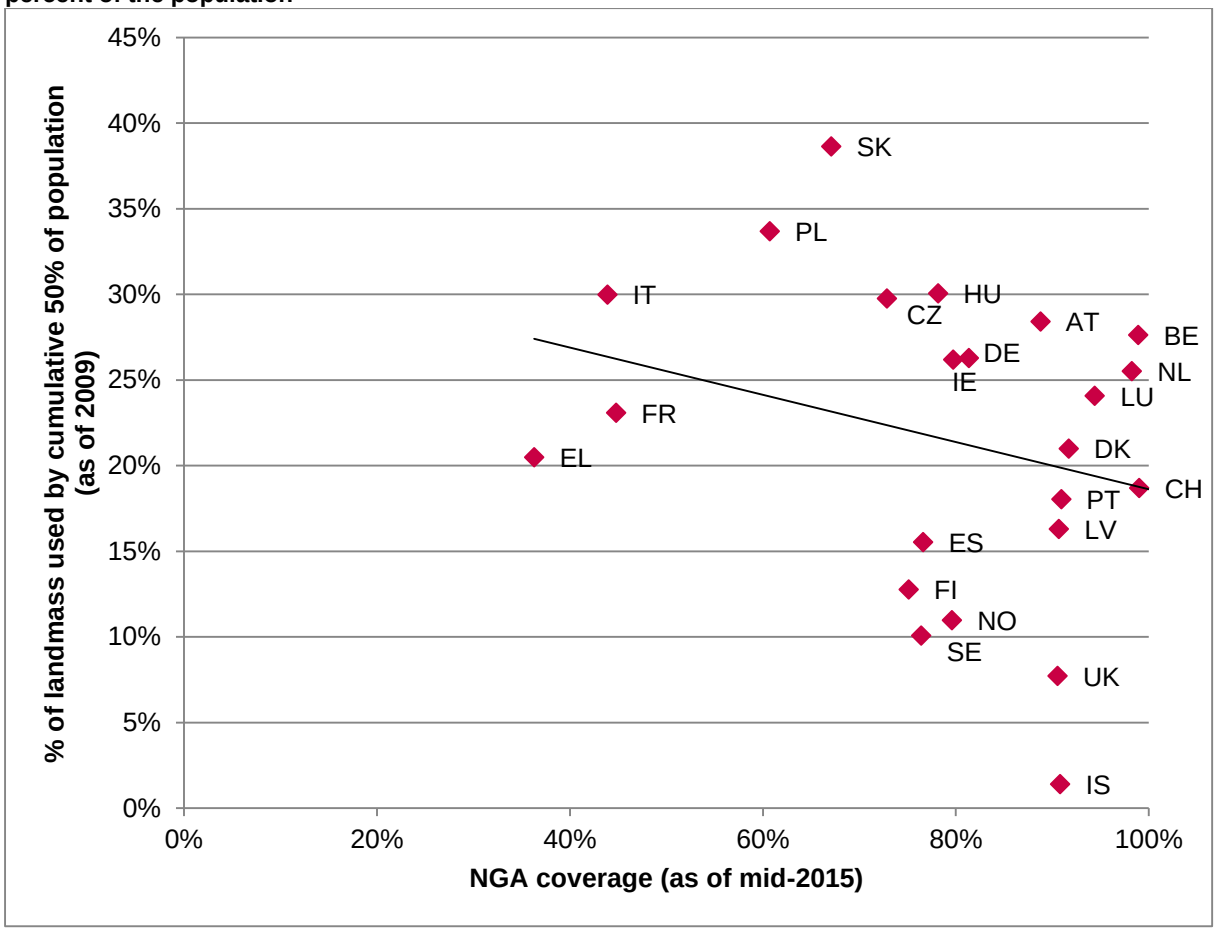
[21] Home care for elderly, disabled and sick persons.

2.3.1 Population density and urbanisation

An important factor driving the cost per household of NGA deployment is population density in a certain area and, often linked to this, the share of MDU. The more households or businesses that can be reached with investment in a certain access technology, the lower are the investment costs per unit reached.

When aiming at giving an estimate for the cost of NGA deployment, the measure for population density should be considered together with a measure for urbanisation. Even when overall density in a country is low, the degree of urbanisation[22] could possibly be very high, making the case for deploying an NGA (at least for most of the population) at comparably low cost. The other way round, population density might be relatively high on the country-level, yet the population being dispersed over a larger number of suburban centres. NGA deployment costs, especially for FTTP, are likely to be substantially higher in that latter case.

Figure 7: Relationship between NGA coverage and the percentage of landmass used by cumulative 50 percent of the population[23]



[22] Yet, one problem when measuring urbanization is to find the demarcation point between rural and urban areas. Depending on the definition of what constitutes an urban area, the measures for urbanization might differ.

[23] Sources: EC broadband coverage study; OECD Broadband portal available here: http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm; data for LV was provided by the Latvian NRA.

Figure 7 depicts the relation between NGA coverage and a combined measure for urbanisation and population density (by measuring the percentage of landmass used by 50 percent of the population) on a *country-basis*. It can be seen that the higher the density (i.e. the lower the percentage of landmass used by 50 percent of the population), the higher the NGA coverage, hence depicting at least a slight positive correlation between density and NGA coverage.

Within a certain country, the relationship between NGA coverage and density often shows up more clearly: NGA- or FTTP-rollout is (first) concentrated in densely populated areas. Differences in population density lead to a change in the differences in cost between deployment of FTTC and deployment of FTTP. Where the population density varies across the territory of one and the same country, FTTP is more likely to be rolled out in densely populated areas whereas FTTC is more likely to be deployed where the population is more dispersed. There are a number of countries reporting on that phenomenon. ES points out that the presence of densely populated areas and MDUs clearly played in favour of NGA rollout since it led to a severe reduction of deployment cost. FR recognizes that operators in densely populated areas with a high percentage of MDU face considerably lower cost by applying an adapted regulatory approach to those areas.[24] FR, PT and SE both observe that investment has focused first on the most densely populated areas (in PT: coastal areas) and only afterwards went to less populated areas as well. FI reports that it is indeed only the large cities (where ducts are available) which see NGA infrastructures being rolled out; residential areas in the surroundings of larger cities do not see considerable rollout. Other examples are NL, CH and RO. Notwithstanding those observations, DK submits that in their case, fibre is not necessarily concentrated in densely populated areas but also to a large extent in rural areas. They consider demand to be the crucial driver for this (cp. Section on demand).

Within highly urbanized areas, the proportion and size of MDUs might provide to some extent an explanation why in some countries FTTP is rolled out while in others FTTC is being used. Countries such as PT that show a relatively high proportion of FTTP report that in the relatively densely populated areas, MDUs are highly present. In contrast, countries with a higher proportion of single dwelling units in urbanized areas face higher cost for rolling out FTTP and might opt in for FTTC.

2.3.2 Network related factors

Many important factors determining the extent of the NGA rollout and the technology chosen relate to the previously existing copper access network.

A factor significantly lowering the costs of NGA-deployment and in particular FTTP deployment is the **availability of high quality ducts** in the access network. Especially in the last segment of the access network, connecting street cabinets/aggregation points[25] and customer premises, high quality ducts are only available in a small number of countries. Such ducts can be used to rollout fibre without any additional civil infrastructure works, which

[24] Cp. section on regulation: FR has fostered a fibre based infrastructure competition up to the buildings in densely populated areas with a high percentage of MDU, where the final parts of the network are mutualized.

[25] In some MS there are no street cabinets (e. g. ES).

saves around 70-80% of deployment costs.[26,27] Therefore, in countries such as FR, ES, PT and LT where ducts are widely available the (future-proof) FTTP rollout is usually preferred to an FTTC-rollout. In some countries, ducts from other infrastructures are used as well – either by the infrastructure owners themselves (often the case for local utilities, e. g. in CH and SE) or through sharing or co-investment agreements between infrastructure owners and telecommunication network operators (e. g. co-investment in CH).

Conversely, where the quality and/or availability of ducts in the access network infrastructure is not high, (e. g. AT, BE, DE, IT, MT, UK) there is considerably less deployment of FTTP using the incumbent's access network and a much greater reliance on copper technologies (FTTC/VDSL). Duct quality/availability can also vary across a country thus leading to different deployment strategies *within* a country: In BG and FI, NGA rollout progresses fastest in the large cities – the areas in the two countries where ducts are available. Yet, the availability of ducts is not a *necessary* condition for FTTP rollout, one example being NL: There, rollout of FTTP technologies takes place in (sub)urban and rural areas even in the absence of such ducts. A main factor facilitating this is the surface conditions which lead to lower civil infrastructure costs compared to other countries.

The **quality of the copper network** can also determine the choice of technology for NGA deployment. In some MS, the copper network is such that it is well suited for the rollout of FTTC. This includes cases such as AT, BE, DK, UK, MT, IT and DE where the network architecture incorporates street cabinets and in which the quality of the copper network between street cabinets and premises is good and the sub-loops are not too long (for VDSL deployment). In such circumstances, incumbent operators (and in some cases also alternative operators) are primarily investing in FTTC since this involves much lower costs per customer compared to FTTP (usually some four to five times less). FTTC deployment can also be realised much quicker as it involves much less civil engineering work. This reduces time to market which is also an important factor in competition for high bandwidths, in particular if there is infrastructure based competition.

However, the quality of the copper network does not always lend itself to an FTTC upgrade path. In a number of MS, the upgrade path to FTTC is not available due to the design and nature of the legacy network architecture. Examples are LT where the quality of the copper cables is relatively poor, HR, where no street cabinets exist, or SE where the local loops or sub-loops are relatively long. In countries like RO and BG, there is only a rudimentary developed (legacy) copper network available, favouring the move to FTTP.

Operators which have chosen FTTC are increasingly asking NRAs for permission to apply technologies such as **VDSL Vectoring** or – on very short access lines – G.fast. These technologies offer higher speeds but they require operator exclusivity.[28] This is relevant for

[26] Communication from the EC on the EU Guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks (2013/C 25/01), footnote 42.

[27] PT's incumbent operator reports figures as low as 100 € per home passed (FTTH-GPON), cp. http://www.totaltele.com/view.aspx?ID=493077.

[28] While multi-operator Vectoring is technically feasible, its implementation is facing practical challenges. Multi-operator Vectoring which enables the operators involved to use DSLAMs of different vendors is currently not available because the interface between the DSLAMs is not yet standardized. Even in case the involved operators use DSLAMs of the same vendor, multi-operator Vectoring needs

the regulatory approaches applied in such situations (see section 3 on NGA rollout and regulation). Countries with regulation on Vectoring include AT, DE, DK, IT and NL. The bandwidths which can be achieved with such technologies are often below those offered with FTTP or cable networks, but are considered sufficient by the operators employing such technologies to meet the demand of most customers in those countries in the short to medium run. However, in the long run, it is likely that it will be necessary to further upgrade such networks to FTTP.

Figure 8: FTTP vs. FTTC/VDSL coverage as of 2014.[29]

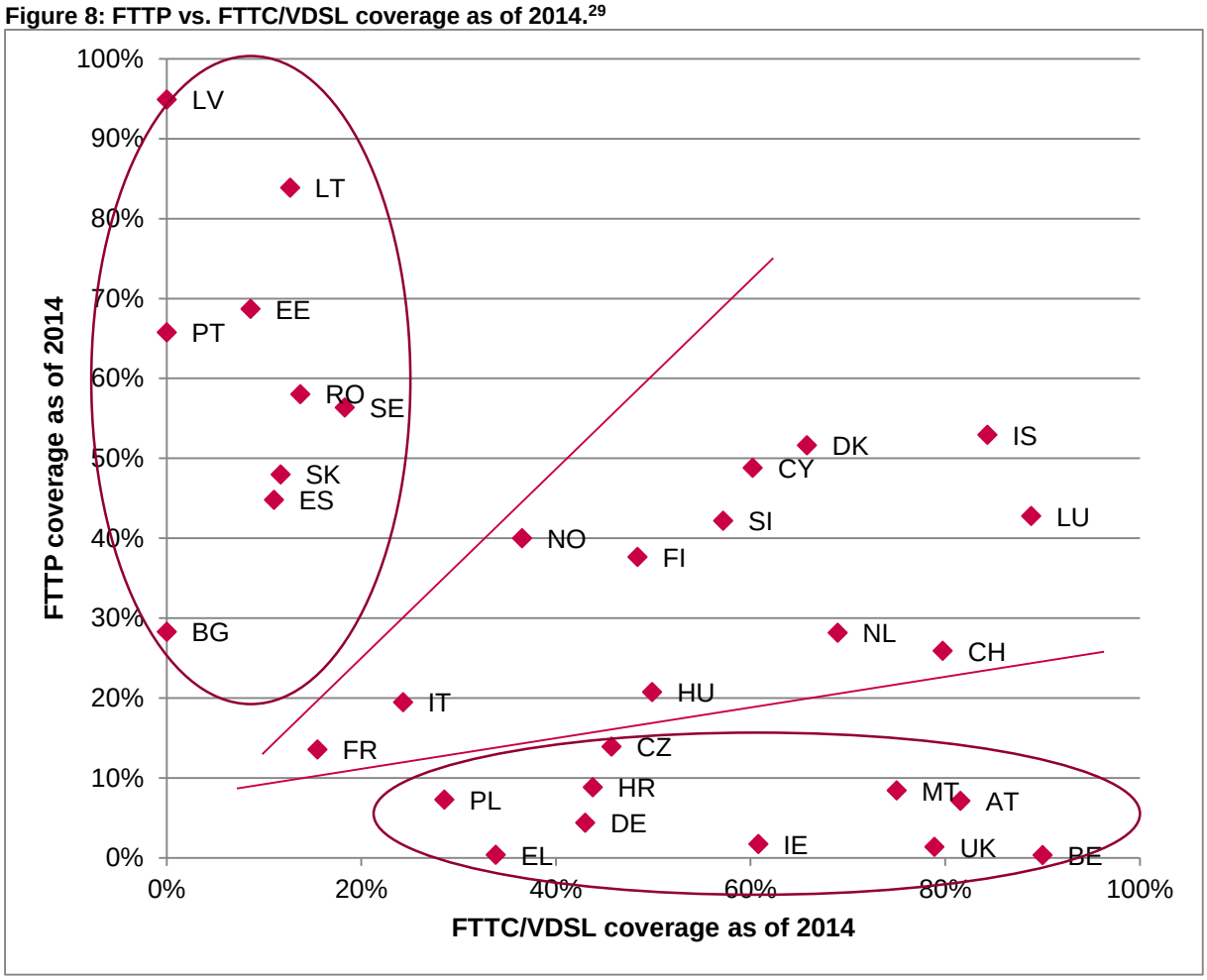


Figure 8 shows the relationship between FTTP (which includes FTTH and FTTB) and FTTC/VDSL-coverage in 31 European countries. Three groups can be identified:

(i) One group with primarily FTTP-investments (upper left). In most of these countries, the costs of rolling out FTTP are comparatively low and/or the copper network is less suited for FTTC/VDSL deployment. Demand (or the lack thereof) seems to play an important role as well.

(ii) A second group with primarily FTTC-investments (lower right). In most of these countries the costs of FTTP are comparatively high due to the lack of availability of quality ducts in segments of the access network and the copper network is well

a high level of coordination among them (see AGCOM decision n. 747/13/CONS and BEREC (2014), p. 5).

[29] Source: EC (2015).

suited for FTTC/Vectoring deployment. This group also includes countries with a high prevailing cable coverage (BE, CH, DE, MT). The need to upgrade copper networks relatively fast to higher speeds due to high competitiveness from cable probably has played a role in those countries as well.

(iii) A third group in between with both significant FTTP and FTTC coverage. In such countries, depending on the specific geographic area observed, one of the two scenarios described above might prove relevant.

All in all, network related factors seem to be a very important driver of the type and extent of NGA rollout. Since network related factors are difficult to measure and to collect consistently across countries, they are usually neglected in empirical investigations.[30] Although this is understandable from a practical point of view, it may lead to biased results ascribed to the other factors included in those investigations.

2.3.3 Retail prices

Retail prices influence the revenues which can be made from a certain investment and therefore the investment incentives. Since prices in a market are determined as the outcome of supply and demand, this factor should be looked at not only from a demand-side (cp. section on demand side factors) but also from a supply-side perspective. While demand side factors (e. g. willingness to pay, price elasticity, bundles) are certainly among the most decisive factors when it comes to retail pricing for NGA services, operators have to take into account the **cost of delivery of a specific service, the level of competition and possibly regulatory requirements** (cp. section on regulation for the impact of price control remedies).

For the **cost of delivery** of an NGA-based product, cost of deployment of the network including labour cost for civil infrastructure works is certainly a very decisive factor.[31] Factors accountable for considerable variations in deployment cost across MS due to network related factors are discussed elsewhere (cp. other supply side factors). Another factor which can determine the cost of delivery is to what extent suppliers can rely on demand aggregation. It lowers marketing costs and the threshold for investments for (private and public) suppliers. Private investors being one player trying to realize those economies, local governments and municipalities often facilitate demand aggregation in the first place. In this way, demand can be aggregated on different levels. Local political representatives may call meetings to inform citizens of upcoming NGA rollout and refer to contact points for sign-up. Regional broadband coordinators, charged with the task of facilitating broadband rollout, may be funded by the state or a municipality (such as in SE). An example of aggregation of demand from a local perspective is the rollout of village broadband networks in SE, initiated by non-profit organisations in rural areas. Another private initiative is when an owner of a MDU or a cooperative housing association connects all tenants or apartment owners.

[30] See also **Annex 1** for a Literature Review. Being mostly focused on the relationship between regulation and NGA rollout / investment, the – still relatively rare – recent empirical literature controls for a number of factors possibly impacting on NGA rollout. Yet, path-dependent network related factors are rarely among those since quantifying qualitative factors such as the quality of ducts or of the legacy copper network presents a complex task.

[31] Low labour cost of deploying fibre has been an important factor for example in PT.

The **level of (price) competition** is driven by a number of factors. Depending on the cost structure of a particular NGA infrastructure (cable, FTTP, VDSL and partly mobile infrastructures), the prevailing retail price constitutes more or less of a constraint for the respective operators. While the costs incurred with deployment of FTTP are higher (conditional of course on a number of factors analysed in the preceding section), the cost for an upgrade of cable to DOCSIS 3.0 is relatively low, providing the latter with significantly more downward leeway concerning retail prices. Path-dependency might also play a role in retail pricing: In a number of countries, mobile and cable exerted downward pressure on prices for services offered on the legacy network (e. g. in AT and DE, cp. also section on infrastructure competition from mobile). In such a competitive environment, operators are constrained in their ability to push through a price premium for NGA services even more than when the performance delta between legacy and NGA services is not readily recognized by the costumer.

The above considerations show that the retail price is the result of a number of supply side factors (additional to demand side factors). This might also partly explain why the relationship observed between prices and NGA rollout is far from being clear: The correlation between prices and NGA rollout is rather weak (as shown in the above section on demand). While one would expect that high retail prices correlate with an increased NGA rollout, in a certain market competitive pressure might be very high, driving down prices but still driving rollout, resulting in an inverse relationship between price and rollout. This is the case for example in the Baltic countries (LT, LV, EE): They are among those countries with a high NGA-/FTTP-coverage and at the same time among the countries with the lowest retail prices, probably reflecting comparatively low costs of rollout (beyond PPP) and fierce competition.

2.3.4 Legislative factors

Legislative factors (other than ex ante regulation, cp. section 3) have the potential to increase or decrease NGA rollout costs significantly.

Examples for legislation decreasing the costs of FTTP rollout are **laws mandating access to ducts or in-building wiring**. While a number of countries have imposed access by means of sector-specific regulation some countries opted for legislative instruments to provide for access (examples being ES[32], FR, PT and CH[33]) the technical and economic conditions of this access might still be defined by the NRA (e. g. FR, ES, CH[34]).

Other relevant legislation includes **laws** (but also administrative practices) **on civil infrastructure works** or whether and where it is allowed to use poles for cabling (instead of burying them into the ground)[35] or put cables on the façade of a house (e. g. BE). In this context, the EC Directive on measures to reduce the cost of deploying high-speed electronic

[32] Since 1998, a law ruling on Telecommunications Common Infrastructure (ICT) provided for infrastructure sharing in buildings. CMT/CNMC established symmetric access obligations to in-house fibre through a Decision in 2009. This obligation has been implemented and governed by the NRA until 2014, when competences were redistributed and responsibility was assigned to the Ministry by the General Telecoms Act. Duct access is still within the NRA's competences.
[33] According to the Swiss law, duct access is imposed on dominant telecommunications operators.
[34] On request of access seekers.
[35] E. g. in RO and LV, FTTP rollout via aerial cabling was possible in the early stage of NGA rollout.

communications networks[36] and its imposition into national law in the respective MS will likely play an important role (mentioned explicitly by BG and HR). BG makes clear that current legislation on in-house cabling (in MDUs vertical in-house cabling is owned by *multiple* parties) represents rather an impediment to FTTP rollout. It also puts forward that national legislation foresees underground cabling in areas with more than 10.000 inhabitants, driving up cost for rollout. On the other hand, in its country case study, NL mentions that pilots for rollout of fibre at a lesser depth (only two feet underground) and using brushing techniques, allowed by local governments, reduce costs per connection and therefore are favourable for fibre rollout.

Planning rules have also importance to rollout. In SE, for example, the municipality is in charge of the infrastructure planning and is legally obligated to consider the need for electronic communications. Also, as pointed out in section 2.3.4, the municipality allows or declines excavation permits and enters into land contracts to deploy infrastructure on municipally owned land.[37]

Another field of **legislation** identified deals with **incentivizing broadband take up**. The parliament in DK has agreed upon legislation which enables residential users to get a tax deduction on expenses made for broadband connection[38] (applicable since 1st of January 2016). Similarly, in DE household expenses associated with the installation and maintenance of broadband connections can be deductible for tax-purposes.[39] In IT the government strategy for ultrafast-broadband announced in 2015 specifies that end users that migrate from the legacy to the fibre infrastructure shall be provided with vouchers.

2.3.5 Investment of municipalities / local governmental initiatives

In several countries, NGA rollout – in particular FTTP-rollout – is heavily driven by the investment of local municipalities and community-owned electricity/gas/water utilities.[40] The broadband strategies adopted by those local players often serve as guidance on broadband deployment within the area. These countries include CH, SE and DK and to some extent also DE, FR and IT.[41]

Municipalities and community-owned utilities are involved in broadband deployment in several different ways. As discussed in relation to legislative factors, municipalities play a key role as the **owner of land and issuer of permits**. A municipal player rolling out might thus benefit from an important reduction in the administrative burden. Yet, municipalities

[36] Directive 2014/61/EU of 15 May 2015, available here: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0061&from=EN

[37] Swedish municipal law (when enforced) limits municipal broadband infrastructure investment to the geographic area of the municipality and also contains regulation regarding pricing.

[38] Covers cost for deployment of cables on premise's side as well as of equipment on the outside of premises.

[39] Source: http://www.zukunft-breitband.de/SharedDocs/DE/Artikel/ZukunftBreitband/instrumente-zur-foerderung-von-breitbandzugaengen.html?nn=126332#doc128340bodyText3

[40] The term municipal network should refer to both networks deployed by municipalities and networks deployed by local community-owned utilities. In this report, utilities which are exclusively private are addressed in the section in infrastructure competition as alternative operators.

[41] There are a number of other countries, where local communities/utilities are rolling out fibre to some extent; however, this was not considered a decisive factor for NGA rollout in the case studies of the respective NRAs.

potentially also have the power to at least slow down rollout by other players if they deny or delay (e. g. in PT) excavation permit or refuse to enter into land contracts, thereby restricting possible competition. Many municipalities will permit excavation and will enter into land contracts on reasonable, non-discriminatory and competition neutral terms. However, some municipalities decline, sometimes with reference to an exclusive agreement with an operator or to protect their own municipal fibre infrastructure investment.

Municipal players and utilities also play an important role as **owners of passive infrastructure**. They can frequently use existing passive infrastructure such as ducts or sewers and may therefore face lower cost of deploying an NGA compared to other players.[42] In some countries, sharing agreements between municipal players and the incumbent operator exist (e. g. CH), When rolling out broadband infrastructure, local communities are often motivated by additional aspects when compared to purely private telecommunication operators: Beyond the goal of providing broadband services, they might aim at making the community more attractive and preventing inhabitants from moving to other communities (e.g. avoiding drift to the cities), which might also lead to higher tax revenues for the municipality. Another motivation might be to provide the municipality with NGA speeds to connect municipal houses or provide welfare services, such as e-health, home care and education. Taking those additional aspects into account, municipalities and community owned utilities are often observed to put less of a focus on short-term return on investment, taking a longer term perspective. This is true for some local players; however a number of municipalities act more along the lines of private companies and invest under the same conditions as them, including profit margins and/or short-term returns.

Finally, the rollout of municipal networks is also sometimes supported by **state aid** (cp. also below section 2.3.6 on state aid). One example is SE, where it is common for municipality networks to apply for broadband state aid from the European Regional Fund or European Agricultural Fund for Rural Development, both aid schemes under the General Block Exemption Regulation (GBER) [43]. Municipal broadband deployment outside of the scope of European state aid regulation is commonly conducted through a public tender procedure with the use of public funding from the municipality itself.

Mölleryd (2015) discusses the role of municipal networks for the development of high speed networks. The paper uses a case study approach to exploit conditions promoting municipal rollout and the effect it has on socio-economic development in a number of OECD countries including DK, NL, SE and UK. He finds that municipal networks follow a variety of business models, including B2B wholesale only business model as well as direct provision of services to the consumer: The author considers municipal network deployment (also realised in public private partnerships) as a way forward where infrastructure competition is lacking or return on investment is considered too low by private investors. Those municipal networks are primarily based on FTTP but some do also use other technologies. Mölleryd concludes that municipal networks play an important role in a large number of OECD countries and that

[42] Although other firms can in most countries require access to such passive infrastructure, this may be complicated and time consuming in practice (which should improve with the transposition of the broadband cost reduction directive (Directive 2014/61/EU) in the EU MS).

[43] Cp. EC memo of 21 May 2014 on the new GBER, available here: http://europa.eu/rapid/press-release_MEMO-14-369_en.htm and Regulation (651/2014/EU) of 17 June 2014, section 10, available here http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN.

they often stimulate further investments. This begs the question, of course, why municipal networks are prominent in some countries but hardly exist in others. According to Mölleryd (2015), an important factor is that *"*[…] *public authorities regard them* [municipal networks] *as a way to provide and improve public and social services for their citizens."* (p. 25). The extent to which countries consider municipalities a lever for NGA deployment and economic growth might considerably influence the extent to which public (financial) support is provided (cp. section on state aid).

2.3.6 State aid

While state aid is generally incompatible with the internal market according to article 107 of the Treaty of the Functioning of the European Union, it can be permissible in relation to broadband deployment. Public authorities may fund investment in broadband if it is in line with the EU state aid rules. In 2009, the first broadband state aid guidelines were adopted. A review process was initiated in 2011 and the **new guidelines on broadband state aid** entered into force in January 2013.[44] Under these guidelines, projects aiming to qualify for state aid need prior approval by the EC (unless they were classified as Services of General Economic Interest or did not surpass the de minimis threshold, see also below in this section). A common feature in cases where state aid has been involved in the deployment of high speed networks is that the networks are commonly obliged to provide wholesale access to interested service providers that could market their services to end customers for a certain amount of time (at least 7 years).

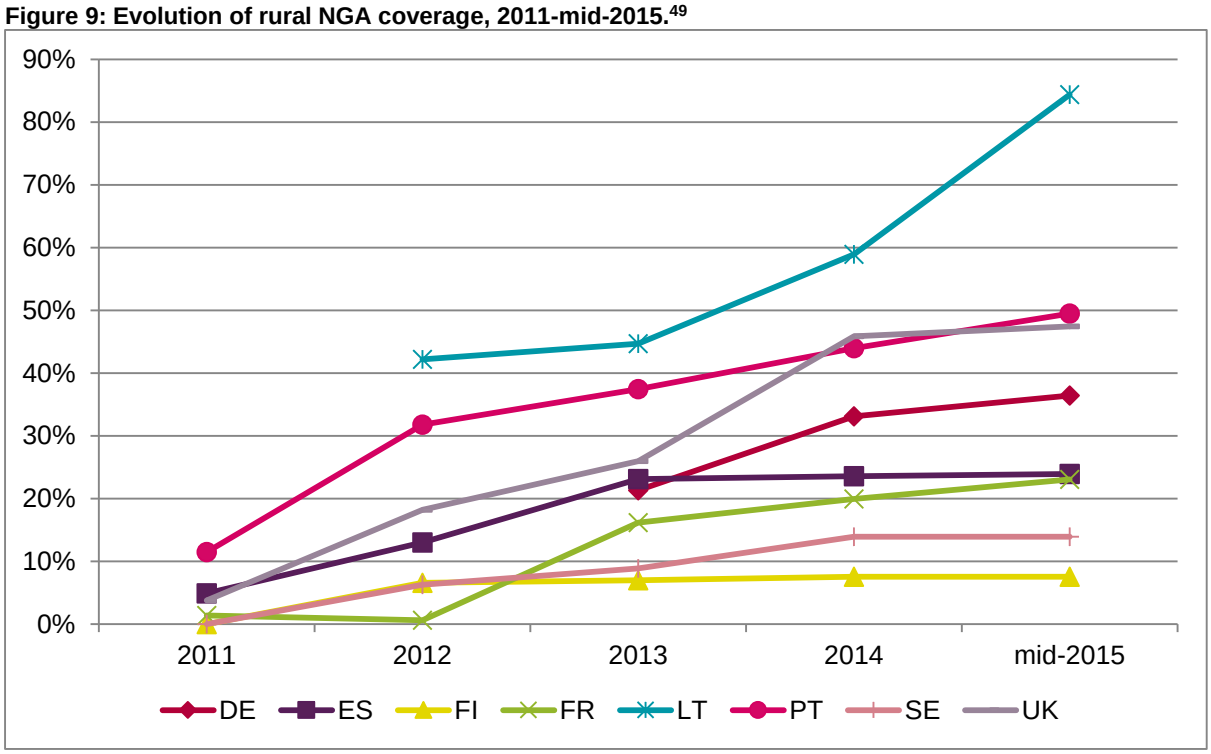
Since 2014, broadband state aid is also permissible under the GBER[45]. This means that specific state aid projects fulfilling a number of criteria do not need to obtain prior approval by the EC. Importantly, projects qualifying for GBER need to be *"located in areas where there is no infrastructure of the same category (either basic broadband or NGA) and where no such infrastructure is likely to be developed on commercial terms within three years from the moment of publication of the planned aid measure"* [46] and aid amount must not exceed 70 million per single project[47]. Under the GBER, network operators shall offer the widest possible active and passive wholesale access to the state funded infrastructure, including physical unbundling in the case of NGA networks for at least seven years.[48]

Given this general state aid framework, numerous projects qualified for state aid in the last years. Examples are ES (PEBA-NGA 2013, 360m € state aid), FR (national government rollout plan 2013, comprising a pledge of 6.5 billion public fund), LT (Development of Rural Area Information Technology Network - RAIN, 2009-2015, 60m € state aid, 5800 km of fiber lines constructed connecting 982 rural settlements to broadband infrastructure), PT (National Broadband Strategy, 106m € state aid, more than 300,000 homes passed end of 2013) and the UK (National Broadband Scheme £780m state aid, having resulted in around 1.6m fibre

[44] Cp. EC press release of 19 December 2012, available here: http://europa.eu/rapid/press-release_IP-12-1424_en.htm.
[45] Cp. fn 43.
[46] Regulation (651/2014/EU) of 17 June 2014, Article 52 (3), available here: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN.
[47] Ibid. Article 4 (y).
[48] Ibid. Article 52 (5).

connections (envisaged: 4,8m by Q3 2017/18)). Other countries such as DE, FI and SE have as well considerably supported rollout by state aid in the past and ongoing.

Figure 9: Evolution of rural NGA coverage, 2011-mid-2015.[49]



For the MS pointed out, the evolution of rural NGA coverage is depicted in **Figure 9**: Especially in PT and UK the increase in coverage is considerable, probably driven to a large extent by state aid.

It is important to note that public financing does not always constitute state aid. Mölleryd (2015) observes that *"if a state, region, or municipality invests, directly or indirectly, for the disposal of an undertaking it is not necessarily regarded as state aid"*[50], given that it could be eligible as an investment that is done under the so called **Market Economy Investor Principle (MEIP)** (e. g. the municipal network in Amsterdam (NL) makes a case for this).[51] Mölleryd (2015) explains that public financing also does not constitute state aid if it is provided for broadband projects that qualify as a **Service of General Economic Interest**

[49] Source: See fn. 1.
[50] Mölleryd (2015), p. 13.
[51] Essentially the MEIP says that the investments are made on terms that a private investor operating under market conditions would have accepted. As public financing usually takes action in areas of market failure, in is not very likely that public financial aid satisfies the MEIP. EC broadband guidelines, no. 17: "In its Amsterdam decision, the Commission has examined the application of the principle of the market economy private investor in the broadband field. As underlined in this decision, the conformity of a public investment with market terms has to be demonstrated thoroughly and comprehensively, either by means of a significant participation of private investors or the existence of a sound business plan showing an adequate return on investment. Where private investors take part in the project, it is a *sine qua non* condition that they would have to assume the commercial risk linked to the investment under the same terms and conditions as the public investor. This also applies to other forms of State supports such as soft loans or guarantees."

(SGEI)[52]. Ultimately, this makes it hard to readily identify in some cases to what extent a state might a have supported NGA rollout.

Observing that private investors are facing particular economic challenges in the deployment of NGA in non-urban areas, a number of countries intend to run large state aid programmes in the coming years. IT[53] has announced a government strategy for ultrafast broadband in 2015 where out of the 12,4bn € needed to implement the strategy, 6bn should be financed via public funds (national, regional and EU funds). DE also envisages greater support of rural NGA rollout (2,7bn € foreseen as of 2015). AT announced plans to support rollout between 2015 and 2020 with an amount of up to 1 bn €.

2.4 Conclusions on the factors driving NGA rollout

In sections 2.1 to 2.3 we have discussed a number of factors which have an impact on the extent of NGA rollout as well as on the type of NGA rollout (in particular FTTP vs. FTTC). **Table 1** lists the main drivers and some country examples.

Table 1: Drivers of NGA rollout and country examples

Drivers of NGA rollout	Country example
Infrastructure competition	
- Cable	BE, CH, CY, ES, MT, NL, PT
- FTTP	CH, LT, LV, PT, RO, SE
Demand side factors	
- High willingness to pay	CH, SE
- E-culture	SE
- Demand aggregation	SE
- Bundles	PT
Supply side factors	
- Population density and urbanisation	BE, ES, LV, NL, PT, SE, UK
- Network related factors	
o Duct availability and quality	CH, ES, FR, LT, PT
o Quality of the legacy copper network	AT, CH, DE, DK, FR, IT, SE
- Retail prices	EE, LT, LV
- Legislative factors	ES, FR, PT, SE
- Investment by municipalities and/or utilities	CH, DK, FR, SE
- State aid	DE, ES, FR, LT, PT, SE, UK

[52] *"Services of general economic interest (SGEI) are economic activities that public authorities identify as being of particular importance to citizens and that would not be supplied (or would be supplied under different conditions) if there were no public intervention."*, cp. *http://ec.europa.eu/competition/state_aid/overview/public_services_en.html.*
The EC submits that *"[t]he compensation provided by MS for the provision of SGEIs is free of aid only if four cumulative conditions (the so-called 'Altmark' conditions established by the Court of Justice case law in the Altmark case) are fulfilled. These conditions are: (i) a clear public service remit, (ii) pre-determined compensation criteria, (iii) the compensation does not exceed the costs incurred in providing the public service and (iv) the beneficiary is chosen in an open tender or in the absence of such a tender, the compensation does not exceed the costs of a well-run company.", see EC memo of 27.09.2009, available here:* http://europa.eu/rapid/press-release_MEMO-09-396_en.htm?locale=en.

[53] State aid granted in IT in the past years mainly went into the backhaul and only recently into the access network.

Summing up, the most important factors mentioned in the case studies are the following:

- Infrastructure based competition, most frequently from upgraded cable networks but also from other FTTP networks, is a main driver for NGA investments where such networks exist.
- Demand side factors (high demand for fibre/bandwidth, willingness to pay, upfront payments, demand for 3-/4-play bundles) drive NGA rollout considerably when sufficiently present.
- Factors reducing the costs of FTTP rollout, in particular the availability of a widespread and high quality duct network.

These factors can therefore be identified as the main drivers of NGA rollout. On the other hand, the absence of these factors can be considered the main impediments.

The analysis also showed that the type of NGA rollout, FTTP or FTTC, is often "path-dependent" in the sense that it depends on the characteristics of the legacy copper access network and available civil infrastructure. In particular, if ducts are available, this favours the investment in FTTP since it significantly reduces deployment costs. If ducts are not available, many (incumbent) operators invest in FTTC with VDSL and Vectoring where the quality of the copper network allows this. If the copper network is, for some reason, not suitable for FTTC, some operators are also going straight to FTTP, but usually at higher costs and at a slower pace compared to cases where ducts are available.

As already mentioned in the section on network related factors, the academic and in particular the empirical literature up until now have only rarely taken into account a number of factors identified in the preceding analysis as being of greater importance to NGA rollout (see also **Annex 1** for a literature review). This is understandable from a practical point of view since these factors are difficult to measure and comparable data for several countries are usually not available. It also means, however, that the results have to be interpreted with caution.

An important insight from the analysis is that the main factors identified and discussed are factors which are largely or completely exogenous to regulatory interventions by NRAs. Importantly, many factors generally associated with public policy such as legislation, municipal support and state aid are not determined by the NRA directly but rather shaped by decisions taken on a political or governmental level. It should be recognised, therefore, that SMP regulation is only one factor among many and its ability to promote NGA rollout or particular types of NGA rollout need not be overstated. SMP regulation focuses on the promotion of competition to incentivise investment taking into account the *given* national (or subnational) conditions and NGA rollout strategies of operators.

3 NGA rollout and regulation

In section 2 it was concluded that the type and extent of NGA rollout depends on many important factors which are largely exogenous to NRAs and sector specific regulation respectively. Depending on these factors, regulatory approaches which best meet the principles of promoting sustainable competition and efficient investment as well as safeguarding consumer benefits might look different across MS and indeed within a MS. This section looks at the different regulatory approaches which have been chosen by NRAs and discusses how they relate to NGA investments in the different MS.

While regulation of the legacy network in most MS had the clear focus on opening up a single incumbent's *existing* network for competition, the tasks of a regulator are different in an NGA environment to promote the ultimate goal of consumer welfare. NRAs need to be more mindful of dynamic considerations: Long term investment decisions for the rollout of *new* high capacity networks need consistent and reliable conditions set out by the regulator, fostering competition that best unleashes the full potential of market-driven infrastructure rollout.

As highlighted in BoR (15) 206[54] ex-ante regulation of wholesale markets in the electronic communication sector has proven to be an efficient tool to create sustainable competition in former monopolistic (end user) markets. Migration to NGA networks has not fundamentally changed the bottleneck characteristics of broadband access networks, since high barriers to entry persist, and in most EU MS ex-ante regulation is still needed. SMP-regulation remains an important tool in many MS.

However, there might be particular new challenges arising with the arrival of NGA networks: Since the NGA footprint may not be uniform within a country, geographically differentiated remedies may have to be considered when applying SMP regulation. Where NGA rollout has taken place, it is not necessarily the (legacy network) incumbent any more owning those networks. In that case, NRAs – in addition to SMP regulation – need to deal with questions such as (symmetric) access regulation and have to set common rules for operators to foster investments and competition.

The remainder of this section is structured as follows: Section 3.1 discusses the possible linkages between regulation, investment and competition. Section 3.2 discusses different scenarios to show how different regulatory approaches were applied under different circumstances in practice and what they achieved in terms of investments and competition.

3.1 Possible relations between regulation, investment and competition

Regulation can influence investment incentives and competition mainly by (i) the access products which are imposed and (ii) the pricing of these access products. That being said, the extent to which the imposed access products and their pricing actually changes the investment incentives also depends on the other drivers of NGA investment that have been analysed above (see section 2).

[54] BEREC Opinion on the Review of the EU Electronic Communications Regulatory Framework, 10 December 2015.

Access products can be applied to NGA infrastructure and/or on legacy (copper network) infrastructure. Furthermore, they can be active (services) or passive (infrastructure) in nature. Examples for such access remedies are given in **Table 2** L2 WAP refers to (OSI) Layer 2 wholesale access products (also known as virtual unbundling local access (VULA) products, in particular if handover is local or enhanced bitstream[55]) which have been imposed by a number of NRAs in the past years.[56]

Table 2: Possible access remedies in the fixed network

	NGA-based	**legacy network**
passive	FTTP unbundling	duct access, local loop unbundling, sub-loop unbundling,
active	NGA-based L2 WAP	copper-based L2/L3 WAP

In general, **access to passive infrastructure** of the legacy network may allow alternative operators to invest in their own NGA infrastructure and therefore this approach promotes alternative infrastructure investments. In particular, access to ducts may allow alternative operators to deploy their own fibre access infrastructure. Copper sub-loop unbundling (possibly backed by access to ducts or dark fibre for backhauling) allows alternative operators to invest in FTTC. The commercial viability of such investments of alternative operators do depend to a large degree on the price of access to ducts or the sub-loop (in absolute terms or compared to the full loop) as well as on an appropriate margin squeeze mechanism that allows them to compete. Also, if alternative operators are able to attain larger economies of scale based on unbundling remedies, (further) NGA rollout is more likely to be economically viable for them.

Passive access to the legacy network may be sufficient to ensure effective competition at the retail level in some cases or areas. In practice, however (see section 3.2), some of these remedies may not be available (e.g. where there are no ducts in the access network) or alternative operators may lack economies of scale so that a rollout – even if based on such passive remedies – is not economically viable. In such cases, **active wholesale products** are often used. These products may not directly promote investments of alternative operators but are rather used to ensure (or maintain) effective service competition on the retail level. These active wholesale products allow market entry and expansion for alternative operators in the first place, providing them with the option to build up sufficient scale to potentially move up the ladder and invest in their own infrastructure in the long term.

The incumbent's as well as alternative operators' investment incentives are determined to a large degree by the **pricing of the** aforementioned **access remedies.**

In the case of **NGA-based active wholesale products**, lower access prices will *ceteris paribus* lead to lower returns on NGA investments for the incumbent operator. This effect is stronger the larger the share of wholesale access lines to total lines and the larger the resulting effect on the retail price level (from intra-modal competition) is. Also alternative operators may reduce their own NGA investments the lower the access to NGA wholesale

[55] L2 WAP are "enhanced" compared to the Layer 3 broadband wholesale access products which also exist in many countries.
[56] See. BoR (15) 133.

access (*ceteris paribus*) is priced ("buy" instead of "make" since opportunity costs of own investment are raised). On the side of the incumbent, the increase in demand for wholesale access by alternative operators in turn raises wholesale revenues, partly compensating for wholesale revenues foregone due to a lower pricing. Just as for the incumbent, a low retail price level for NGA-based products lowers prospects of alternative operators to recover investment in own NGA infrastructure. Therefore, if cost-orientation is imposed, in order not to distort the make-or-buy decision of alternative operator and incentivise investment by all market participants, the rate-of-return must be risk-adequate and the access price needs to be reflective of the efficient costs.

For the pricing of **passive duct access** the story is different given that ducts usually are part of the existing legacy network and no new and risky investment is required by the incumbent. Here, a low access price incentivises NGA-(FTTP) rollout of alternative operators which in turn may incentivise NGA investments by the incumbent operator. Still, the access price needs to be determined such that it allows covering maintenance costs and re-investment in the long run.

The pricing of the **unbundled copper local loop** may also have a significant effect on investment incentives. The effect is less straight forward, however, compared to the pricing effect of NGA wholesale products. While a low copper access price increases the incumbent's incentive to migrate from copper to fibre, it may also decrease the retail price level of copper-based products, expanding the cost-delta between copper- and NGA-based products. At present, where the willingness to pay a premium for NGA bandwidths at the retail level is low, lowering the price for copper-products might further impede migration from copper-based to NGA-based products. Furthermore, a low copper access price may incentivise alternative operators to use copper based services and to not invest in NGA infrastructure.[57]

3.2 Regulatory approaches in practice

In this section we discuss four illustrative scenarios based on (i) duct quality/availability and (ii) economic fundamentals (demand and cost factors). These factors play a large part in determining rollout decisions of both incumbents and alternative operators and of the regulatory decisions taken by NRAs. These scenarios are not designed to capture all the variants of NGA deployment and SMP regulation that have been adopted in the context of NGA rollout across Europe but to map the most important parameters that NRAs appear to take into consideration when making regulatory decisions. In each scenario we discuss how the chosen regulatory approach might impact and stimulate NGA deployment and investment.

Usually, and just as in the past, NRAs aim to promote competition at the deepest level possible of the value chain. While there is consensus among NRAs that (full coverage by) FTTP is the desired goal in the long run, the extent to and the timeframe within which it can

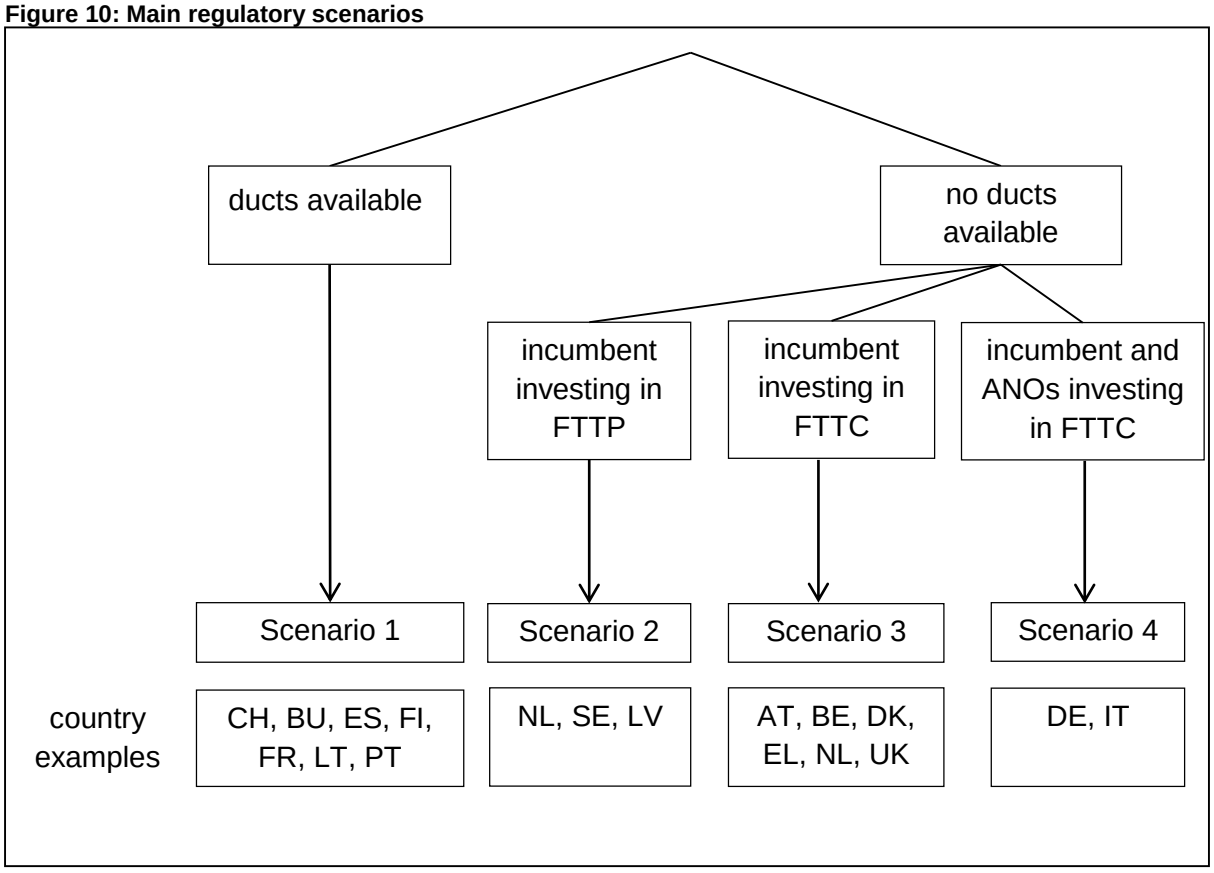
[57] See the **Annex 1** for a literature review, in particular BOURREAU/CAMBINI/DOGAN (2013) who investigated the relationship between access prices for old and for new infrastructure and NGA investments in a theoretical mathematical model. NEUMANN/SCHMITT/SCHWAB/STROZNIK (2016) empirically test the effects identified by the former authors by investigating the impact of the level of the LLU pricing on investment in FTTH infrastructure.

be reached depends to a large extent on factors beyond the influence of NRAs. Therefore, many NRAs apply a comprehensive set of access remedies, including passive and active remedies, in order to give alternative operators the possibility to deploy their own NGA infrastructure based on passive remedies where economically viable and use active wholesale access products in other cases. Depending on other factors, in particular network related factors (see section 2.3.2) and the size and economic strength of alternative operators, particular access remedies will be more or less important.

This is also illustrated in the four scenarios we discuss in this section. The scenarios discussed are shown in **Figure 10**. A first very important differentiation is whether a high quality and widespread duct network, particularly connecting street cabinet and premises, is readily available (scenario 1) or not. Such a duct network lowers the costs of FTTP deployment significantly and may allow several operators to rollout their own fibre networks. If no or only few ducts are available, the situation is quite different: While there still might be cases where cost and demand conditions are such that FTTP can be implemented at relatively low cost (scenario 2), the lack of an ubiquitous duct network will most often lead to a situation where only the incumbent operator – which usually has the largest scale economies – may find it economically viable to invest in FTTC (scenario 3). Absent ducts, cases of FTTP investments by the incumbent and alternative operators are few. There are, however, some cases, where the incumbent as well as entrants invest(ed) in FTTC to a significant extent (scenario 4).

Figure 10 also includes some country examples. It should be recognised, however, that different scenarios can also be relevant in different areas *within* a country.

Figure 10: Main regulatory scenarios



Scenario 1: ducts available

As has been pointed out in section 2.3.2, a widespread and high quality duct network is available in CH, ES, FR, LT and PT. Ducts are also available in larger cities in FI and BG.

Where a duct network of the incumbent operator is available, cost oriented access to these ducts has proven as a very efficient means to allow alternative operators – in addition to the incumbent – to rollout fibre-based networks to the customer.[58] Countries like ES, PT and LT have a relatively high FTTP coverage and at the same time significant rollout of FTTP of alternative operators. In FR, although the coverage is not yet as significant, there is a high share of FTTP rollout from alternative operators.[59]

The availability of a high quality duct network and the prospects of several operators investing in FTTP enabled countries such as CH ES, FR and PT to apply forbearance with regard to NGA-based active access remedies (e.g. FTTH unbundling and active wholesale products). In PT, for example, there are no NGA-based access remedies at all. CH by law foresees no imposition of NGA-based remedies. In ES, the L2 WAP (called NEBA) until recently had been limited to bandwidths up to 30 Mbps. Based on a decision published in February 2016, a fibre-based NEBA without speed-cap now has to be offered nationwide but in 66 municipalities with sufficient NGA competition from competing infrastructures. In FR, there are active remedies on copper networks but "forbearance" for active remedies on fibre networks due to the fact that SMP regulated copper-based bitstream access and symmetric access to the fibre terminating segment together is considered to be sufficient.

In the cases mentioned above, access to ducts lowered the costs of deployment and led to significant FTTP rollout of alternative operators. The rollout from alternative operators – together with competitive pressure from cable network operators – also increased the incentive to rollout FTTP for the incumbent operator. It should also be noted that the alternative operators investing in an own fibre access network were often those which gained considerable economic size based on (LLU) access to the legacy network and had obtained a significant LLU presence (e.g. Free and Numericable-SFR in FR, Vodafone and Optimus in PT or Jazztel in ES). These are examples of how alternative operators used the ladder of investment[60] to move up the ladder to deploy their own access infrastructure.

As has been mentioned already in section 2.3.4, in cases where several operators are rolling out FTTP networks, **access to in-building wiring** is an important measure to lower the costs of deployment. Access to in-building wiring has been mandated in a number of cases (ES, FR and PT) not as an SMP but a symmetric remedy. In those countries, such symmetric remedies are used to create a level playing field that enables every operator to rollout fibre network to the end user. In FR, in addition to the access to the in-building wiring,

[58] Duct access is mandated mostly on an SMP basis. Access to ducts of local utilities in contrast, is – for example in CH – granted through infrastructure sharing agreements.

[59] For at least 62% of the homes passed there is an effective passive access for an alternative operator, who can provide services. Moreover, more than 88% of the homes passed are passed under a co-investment scheme (thus an alternative operator will eventually access to the network he co-invested).

[60] See the Annex 1 for a literature review, in particular CAVE (2006) who introduced the ladder concept in the first place. A number of BEREC papers also refers to the ladder of investment (e. g. BoR (10) 08, BoR (11) 43, BoR (12) 126, BoR (12) 127 and BoR (12) 128).

there is a (national legislative) symmetric obligation to provide access to the 'fibre terminating segment' that effectively translates into an obligation for access to the fibre local loop, in particular in areas which are considered to be less densely populated.[61] Symmetric regulation rules such as those in FR apply to all operators and not just to the incumbent operator. As such, they do not stem from SMP regulation but are rather part of the legislation (e.g. in FR, PT and ES) and/or they are outcomes of agreements between the operators (e.g. in CH and ES).

Scenario 2: No ducts available, incumbent investing in FTTP

In this scenario, no ducts are available in the (last segment of the) access network (or duct availability is quite limited to particular regions/cities) which makes the deployment of fibre access infrastructure much more costly. Still, in some cases, cost and demand conditions are such that FTTP can economically be rolled out. In the countries falling under this scenario, FTTP rollout was initiated by alternative operators, while the incumbent reacted either by rolling out himself or acquiring existing FTTP infrastructure. Only if the infrastructure is owned by the incumbent it is regulated under the SMP framework.

For example in NL, surface conditions are such that construction costs are comparatively low.[62] The alternative operator Reggefibre, has rolled out an FTTP network and was later taken over by the incumbent KPN. Since the rollout of parallel FTTP networks is not considered economically viable, KPN then was obliged to grant access to unbundled fibre access lines. Fibre unbundling is possible (with comparably little technical efforts) since the Dutch FTTP network is built as a point-to-point network (and not a point-to-multipoint/passive optical network (PON)). In order to maintain investment incentives for KPN, the wholesale access price for unbundled fibre access includes a risk premium.

In SE, it was primarily demand related factors which led to FTTP rollout (cp. section 2.2 on demand side factors). The Swedish NRA imposed access to the unbundled fibre at a cost-oriented level (based on LRIC). There, it can be observed that the regulated incumbent and the unregulated alternative FTTP operators are racing to deploy and even rollout parallel FTTP networks in some areas.

The possibility of NRAs to impose access to unbundled fibre can be limited by the fibre architecture deployed. Where a PON structure dominates,[63] unbundling of fibre at an access point similar to the one used for local loop unbundling in the legacy network for technical reasons becomes at least more complex.[64] In some of these cases, active NGA wholesale

[61] In areas which are considered to be less densely populated, this passive access is granted by the building operator under a co-investment scheme at a concentration point that gathers more households (1,000 households). Rules are different in areas which are considered to be densely populated; there, passive access to the building is usually to be provided, also under a co-investment scheme.

[62] Construction costs can also be considerably lowered by making use of aerial cabling. Aerial cables have been used for example in the early years of FTTP rollout in LV. However, in most MS the use of aerial cabling has always been restricted to such extent that it never played a significant role for NGA rollout.

[63] Like e.g. in AT, ES, PT.

[64] Access to a PON architecture is technically possible. In PT, the incumbent voluntary presented a commercial access offer to its new NGPON2 (for new fibre deployments only), starting middle of 2016, see: http://ptwholesale.pt/en/servicos-nacionais/infraestruturas/Pages/Access-PON-PT.aspx.

access products have been imposed in areas where infrastructure based competition is not sufficiently present.

Scenario 3: No ducts available, incumbent investing in FTTC

In this scenario, cost and demand conditions are such that NGA rollout of the incumbent focuses on FTTC, in particular if the quality and architecture of the legacy copper network favours this solution (see section 2.3.2). Scenario 3 discusses a situation in which an FTTC rollout is not economically viable for alternative operators, mainly due to low economies of scale.

As discussed in BoR (15) 133,[65] in such situations several NRAs have imposed active wholesale access products on the incumbent operator, usually L2 WAP with either local or regional point of handover. This includes countries where passive remedies (in particular for reasons of network architecture) play little or no role such as AT, BE, EL and UK. However, countries like NL and ES face a situation where passive remedies do play an important role in some areas but active remedies are also needed (at least in particular areas where passive access is not sufficient).[66]

In this scenario, the importance of L2 WAP is expected to increase with the demand for higher capacity connections, especially as compared to LLU: If alternative operators continue unbundling from the central office (CO), they cannot offer higher bandwidths, hence leaving as the only option to stay competitive in terms of bandwidths a migration to a L2 WAP (at least where own infrastructure investment is economically not viable and hence migration to sub-loop unbundling is not an option).

Furthermore, in case of interferences between DSL lines operated from the street cabinet with unbundled DSL lines from the CO (e.g. no use of spectrum shaping) or in cases where the incumbent applies Vectoring, physical unbundling from the CO may be restricted. Finally, access to L2 WAP with local points of handover have been imposed in cases where the incumbent operator is rolling out FTTP as GPON[67] and the physical unbundling of individual fibre access lines at the CO (or the optical line terminal location) is technically not possible.

In scenario 3, with FTTC rollout of the incumbent operator, the main advantage of active remedies is that the incumbent operator can realise high bandwidths in his network e.g. with VDSL Vectoring or G.fast. While alternative operators can no longer use LLU and need to migrate to active remedies, this enables the incumbent's investments in FTTC and technologies which increase speeds on the (remaining) copper access line.

Prices for such wholesale products have been set either cost oriented (e.g. BE, DK, IT) or, if there is sufficient competition from other infrastructures or from passive remedies, based on

[65] BEREC Report on Common Characteristics of Layer 2 Wholesale Access Products in the European Union, 1 October 2015.
[66] One exception is PT which only imposed duct access and in-house wiring so far, making own network rollout the only option for operators to compete.
[67] GPON with a splitter between the CO and customer premises do not have a single fibre which can be unbundled per household at the CO (except for cases where all splitters are at the CO).

non-discrimination and an economic replicability or margin squeeze test (e.g. AT, DE, ES, UK).[68] In the NL, there is no price control and prices are subject to commercial agreement.

At the same time, active remedies give alternative operators access to high bandwidths which they could not offer based on copper local loop unbundling at the CO. The remedy therefore aims to promote service and price competition for NGA bandwidths. The main disadvantage from the point of view of alternative operators is the lower potential to differentiate retail offers from the incumbent operator compared to physical unbundling (since a service with certain technical characteristics and not a physical medium is bought). If the price of the L2 WAP is differentiated by bandwidth, this may also lower the margins for alternative operators. Depending on such factors, the success of L2 WAP is differing across countries. While active wholesale access products are used to a significant extent in the UK, ES, BE, DK and IT, the use in AT and EL is still very low (in DE and NL, such products have been imposed only recently).

Scenario 4: No ducts available, incumbent and alternative operators investing in FTTC

This scenario differs from scenario 3 in as much as alternative operators have also rolled out (or are rolling out) FTTC (based on sub-loop unbundling and possibly other remedies for backhauling) to a significant extent. This is mainly the case where unbundling operators are sufficiently large and have sufficiently high economies of scale so that such a rollout is economically viable for them. Such a situation can be observed in DE and IT, for example.

The main regulatory challenge in this case is to find a suitable solution for the deployment of VDSL Vectoring.[69] By noise cancellation, VDSL Vectoring can increase the bandwidths on the remaining copper access line significantly but the technology does not currently lend itself to multi-operator deployment.

In DE, where a number of alternative operators have obtained considerable economic size based (mainly) on LLU operations in the legacy network, a regulatory decision was taken in 2013 which, following a first-come-first-serve-principle, allows all market players to invest in infrastructure and in the deployment of VDSL Vectoring at street cabinets. [70] All operators can commit to invest in VDSL Vectoring which is linked to the acceptance of penalties in case of not conforming to the investment commitment. A L2 WAP has to be offered as a substitute for unbundling by the operator applying Vectoring. In March 2016, the incumbent has applied for the regulator's approval of its prices for a L2 WAP. A decision – primarily based on a margin squeeze test – is still pending. L2 WAPs offered by competitors have to meet the main features of the incumbent's L2 WAP but do not face price regulation.

In Italy, the NRA has supervised a technical committee made up of stakeholders and manufacturing companies with the aim of finalizing a document concerning technical

[68] In line with the Recommendation 2013/466/EU of 11.9.2013.
[69] See also BEREC (2014).
[70] While the implementation of Vectoring at the local exchange is not considered technologically feasible, the incumbent in 2015 came forward to the German regulator with the demand to allow for upgrading all surrounding street cabinets in Germany which lie within a radius of 550m around a local exchange with Vectoring technology. Such upgrade would require that access to the unbundled local loop at the local exchanges would be suspended for VDSL. A regulatory decision on this issue is still pending.

specifications for the implementation of a Multi Operator Vectoring (MOV) architecture, in order to allow coordination and interoperability among Vectoring systems. The last approved access market analysis decision (published at the end of 2015) provides that Telecom Italia and all the other operators which intend to use Vectoring-based equipment have to be compliant with the MOV approved technical specifications once they will be published.

Both approaches aim to incentivise FTTC investments from both the incumbent operator as well as from alternative operators.

3.3 Discussion of regulatory approaches

The scenarios discussed above show that NRAs aim to promote investment by both the incumbent and alternative operators as well as competition by means of appropriate access remedies and pricing. According to Art. 8 of the Framework Directive,[71] NRAs shall promote competition as well as efficient investment. Those principles also hold true in an NGA environment. The level of the value chain where intra-modal competition is possible is mainly determined by exogenous factors, however, and differs significantly not only across but often also within MS.

Where ducts are available, access to this infrastructure incentivises alternative operators' as well as incumbent operator's fibre rollout. With the deployment of parallel fibre networks, regulation could be limited or reduced to duct access (PT, some areas in ES) and with co-investment schemes, regulation could be limited to (symmetric) passive access and duct access (FR). Where no ducts are available, rollout costs are significantly higher. This typically leads to a situation where the incumbent owns the most extensive FTTP or FTTC network. In such cases, other access products like fibre unbundling or active wholesale access products are needed to promote competition. Investment incentives are taken into account when the access price is set either based on costs or on some kind of margin squeeze test.

In line with the principle of technological neutrality, NRAs generally do not regulate to favour a particular type of technology. Given the importance of other factors influencing the technology choice, there would be the risk to promote a technology which is not the most efficient (at least in the short to medium run). Still, FTTP has been incentivised in some countries or areas where the rollout of several FTTP infrastructures could be observed or reasonably expected by limiting access remedies to ducts and in-house cabling (ES, PT).

Regarding the influence of regulation of the legacy copper access network on NGA investments, it can be observed that there are some countries where unbundling operators started to invest in FTTP – mainly in cases where widespread ducts and duct access are available (FR, ES, PT). These are examples of how alternative operators used the ladder of investment to move up the ladder and deploy their own access infrastructure. In cases where operators aim to deploy VDSL Vectoring, copper unbundling requires the determination of fair rules for the deployment of VDSL Vectoring.[72]

[71] Directive 2002/21/EC of 7 March 2002.

[72] This is true if there is a large number of operators using the full LLU since those operators, once one single operator gets permission for applying Vectoring, will usually not be able to compete with

In such circumstances, usually active wholesale access products are used to allow the incumbent operator to deploy technologies which require exclusivity such as VDSL Vectoring or G.fast and at the same time maintain effective competition at the retail level (e.g. AT, DK, UK). Where alternative operators have also invested (or are investing) in FTTC (based on sub-loop unbundling), this has been addressed by Vectoring regulations which aim to allow several operators to invest.

4 Conclusions

This document assesses the state of NGA rollout in several European countries and analyses factors promoting or impeding such a rollout, as well as the regulatory approaches adopted and their effects on investments and competition based on market data and several country case studies.

The status of NGA rollout in the different countries as well as the coverage of different access technologies (fibre/FTTP, cable networks/DOCSIS3.0, copper/FTTC-VDSL) varies to a considerable degree. These differences can, to a large extent, be explained by factors which are largely exogenous to NRAs and regulation. A main factor identified is competition from other fixed network infrastructures such as cable networks and alternative FTTP networks. In particular, FTTP rollout has often been initiated or mainly driven by alternative operators. Other important factors are demand side factors such as consumer willingness to pay a premium for high bandwidth, and factors influencing the cost of rollout such as population density, network related factors, or state aid. In particular network related factors such as the availability of ducts or the characteristics of the legacy copper network seem to determine to a large degree the rollout strategy of incumbent operators (FTTC vs FTTP) as well as the regulatory approach taken by the NRA.

While NRAs have to take these exogenous factors into account in their decisions, they nevertheless can shape the investment incentives of the incumbent as well as of alternative operators and the degree of competition by means of imposing (or not imposing) access obligations and the pricing of these access products. Considering four different scenarios it has been shown how regulation has both reflected these exogenous factors and also how it has been specifically designed to promote investments as well as competition.

In times of the transition to NGA networks, NRAs in general – just as in the past – aim at promoting infrastructure based competition at the deepest possible level of the value chain. The level achievable, however, depends on many exogenous factors and varies a lot across MS. While passive remedies (in particular duct access) work well in some cases, other remedies (in particular active wholesale access products) are needed in other conditions.

Therefore, maybe even more than it has been the case in the past, NRAs need to take a close look at the national circumstances. The description of the four regulatory scenarios shows that regulators take account of the specific national features using the regulatory toolbox flexibly to promote competition and investment in NGA rollout.

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that operator in terms of bandwidths anymore. It applies even more in cases where there is alternative operators making use of SLU and being possibly interested in deploying Vectoring themselves.

Annex 1: Literature Review

There is a vast economic literature that discusses access regulation and its impact on competition. The majority of research in that field is dealing with access regulation in the legacy network and how this regulation affects competition on that very network. Only relatively recently has research started to investigate the impact of legacy *and* NGA access regulation in an NGA environment.

The **theoretical literature** in general is focused on the direct relationship between regulation and competition and investment. With the exception of some papers that aim to provide theoretical results for the role of intermodal competition from cable (and partly mobile), the role of factors other than regulation for investment and consumer welfare is not analysed.

The **empirical literature** in turn has to take those other factors into account: The subject of discussion also being the impact of regulation on investment and on consumer welfare measures, empirical papers try to scrutinize the *ceteris paribus* effect of regulatory measures by controlling for the impact of factors largely exogenous to regulation (intermodal infrastructure competition (from cable and mobile), population density, consumer demand etc.).

This literature review will give a fairly short introductory overview of the literature dealing with the impact of legacy regulation on the legacy network. It will then summarize some results from the more recent literature dealing with the impact of legacy and NGA access regulation on NGA competition, presenting results from theory and empirical research separately.

Impact of the legacy access regulation on competition and investment on the legacy network

In the regulation of **legacy (copper) networks**, the ladder of investment by CAVE (2006) had been considered *the* theoretical guideline. According to this concept, giving access to the incumbent's network starting from resale over bitstream and finally unbundling obligations should put competing providers on solid ground to finally build up their own networks and become completely independent of the former incumbent. Taking a look at the concept and its implementation in retrospective, CAVE (2014) makes clear that the end state of the ladder does not necessarily have to be reached. He also notes that in practice separate rungs of the ladder can coexist which in turn enables entrants to decide on the level of infrastructure investment they want to take.

CAMBINI/JIANG (2009)[73] provide an extensive review of relevant literature published in the years after liberalization of the market; their main conclusions are presented here. A part of the literature they review evaluates the ladder concept more generally by looking for example at the theoretical relationship between different layers of wholesale access and investment incentives.[74] Most of the literature however focused on effects of particular

[73] They review 21 theoretical papers and 23 empirical studies published over the period from 1998 to 2009.

[74] E. g. BOURREAU/DOGAN/LESTAGE (2014) find that the layer where access is provided (i.e. resale, bitstream or unbundling) can importantly drive incentives for alternative operators to rollout their own infrastructure. With the model they set up they show that while high level access (e. g.

wholesale access products on investment and consumer welfare (e. g. broadband [75] penetration, take-up) in a legacy network environment. In that context, the overwhelming part of the literature makes **LLU access pricing** the subject of discussion.

Many papers explore the effect of access pricing on incumbent's and entrants' investments. One result often presented is that unbundling reduces incumbent's investment. On the entrant's side it is recognized that for the ladder of investment to occur, an appropriate access pricing policy must be in place. Some early studies look at the relationship between LLU prices and entrant's investment but results are not clear cut and partly lack robustness (due to lack of variation in pricing data). A number of studies shift focus from measuring the impact on *investment* to analyzing the impact on broadband penetration. Results are very mixed, ranging from no impact on broadband penetration to a positive impact (which dissipates over time). Some of the theoretical studies pick up on the regulatory commitment problem which may have a negative impact on incumbent's investment; however, only few more recent empirical papers control for a potential endogeneity bias (investment increasing regulation rather than vice versa). A general result emerging from the early theoretical literature is that intermodal competition generally fosters (or least does not impede) investment and is also a much stronger driver for broadband penetration.

CAMBINI/JIANG (2009) summarize that most of the empirical literatures' findings are that LLU access charges have a negative impact on investment. Yet, just as on the theoretical side, empirical results are widely varying (depending on what data set is used, what proxy is chosen to measure investment and what statistical methods are applied).[76] Inter-platform competition is widely found to have a rather positive effect on investment.[77]

Impact of legacy and NGA access regulation on competition and investment on the NGA network

As pointed out, a more recent stream of the economic literature is dealing with, on the one hand, the impact of regulation of the legacy network on NGA metrics such us invest coverage and take up (i. e. in particular the impact of LLU access pricing on NGA investment

resale) in a first place enables market entry but does not foster rollout, taking into account that altnets might gain experience and market share, even high level access can be beneficial to rollout.

[75] Broadband in this context refers to first generation broadband (in particular speeds provided by (A)DSL). It does not refer to NGA broadband, providing 30 mbps and more.

[76] To demonstrate the variety of empirical studies dealing with the impact of LLU (pricing) for first generation broadband: LEE/MARCU/LEE (2011) claim that LLU has a positive effect on speed of adoption, admit however that long-term effect on investment might be negative (data 2000 – 2008). GRAJEK/RÖLLER (2011) observe that access regulation has a negative impact on total telecommunications investment (20 EU countries, 1997 – 2006). They do not use specific fixed access network investment. GARRONE/ZACCAGNINO (2015) use OECD data (1975-2007) to investigate the relationship between competition and investment in telecommunication infrastructure. They find that LLU obligations have incentivized incumbents' investment where competition effectively evolved.

[77] BOUKAERT/VAN DIJK/VERBOVEN (2010) investigate the impact of (1) inter-platform competition, (2) intra-platform competition based on unbundling and (3) intra-platform competition based on bitstream on broadband penetration (20 OECD countries, 2003 – 2008). They find that inter-platform competition significantly drives penetration and that unbundling has a small positive effect. They find a rather negative effect of bitstream remedies on penetration. GRUBER/KOUTROUMPIS (2013) also investigate the effect of both intermodal and intramodal competition on nationwide broadband penetration (167 countries, 2000-2010) and find the latter to be more effective for nationwide penetration. They admit however that they included broadband generally and that for NGA specific broadband, the results might look very different.

incentives) and on the other hand, the impact of NGA-specific regulatory measures on the aforementioned metrics.[78] Both empirical and theoretical literature after 2009 specifically focus on the impact on investment in NGA networks in the context where they would *co-exist* with the legacy networks. The amount of empirical literature is still limited since the impact of access pricing is very difficult to test due to lack of sufficiently long time series and variation in pricing data.

Theoretical literature

The more recent theoretical literature – in that respect not very different from the earlier literature – seeks to formalize the **effect of access pricing on investment**, recognizing that the effect on incumbent and entrant can be asymmetric. Important references for a *theoretical* presentation of those effects are BOURREAU/CAMBINI/DOĞAN (2012) and BOURREAU/CAMBINI/DOĞAN (2013). Three main effects are identified:

Frist, the replacement effect for the entrant: It describes that when LLU access becomes costly for alternative operators, the opportunity cost for investment in own NGA infrastructure decline. Secondly, they point out the wholesale revenue effect for the incumbent: Up to a certain level, increasing the LLU price will lead the incumbent to rather delay investment and enjoy the wholesale revenues generated on the legacy network.[79] Thirdly, the importance of the relative retail prices of legacy-based and NGA-based products for NGA investment (and amortization) for both incumbent and entrant are reflected in the business migration effect. That effect describes that a high LLU price leads to a lower retail price delta in between legacy-based and NGA-based products, enabling a high return on NGA investment. The authors acknowledge that there is potentially conflicting goals in setting the access price to the legacy network.

BOURREAU/CAMBINI/DOĞAN (2013) analyse in depth the effect of different regulatory measures on the incumbent's and entrants' incentives to migrate from a copper to a fibre network. Based on their 2012 paper they stress the finding that relative access prices (copper vs fibre access prices) play a role in a setting where legacy and new access networks coexist. The authors point out that cable presence and the fact that NGA rollout might be driven by state-owned companies needs to be taken into account for access pricing. The authors however leave those issues to future research.

Dealing with **geographically differentiated regulatory decisions** is a relatively new topic. Recent theory looks into geographically differentiated access regimes that could vary depending on the degree of inter-platform competition in each area. While the implications of access pricing are not clear cut, findings from literature suggest that uniform access pricing rules may not be the best approach. For one example, BOURREAU/CAMBINI/HOERNING (2015) look into geographically differentiation of legacy access prices[80] and find this to lead to an

[78] E. g. BOURREAU/CAMBINI/HOERNING (2012) Emphasize that during a period of transition legacy and NGA network will coexist and that for those infrastructures a different set of remedies might be applicable. Thereby, NGA investment incentives will be influenced by both legacy and NGA access regulation.

[79] They additionally describe that "if the incumbent invests in a higher quality network, the entrant may invest in reaction, and the incumbent will then lose some wholesale profits"

[80] They compare two access regimes: one where there is a nationwide access obligation but prices differ and another one where there is an access obligation for areas where only one infrastructure is

improved situation in terms of NGA rollout compared to uniform price setting. Yet, the authors acknowledge that sophisticated geographically differentiated approaches are also more difficult to implement in practice.

Empirical literature

Similarly to the earlier literature, the more recent empirical literature focuses on **testing the impact of the LLU access obligation and pricing on investment and consumer welfare** (i.e. penetration, partly also quality parameters such as speeds. This literature importantly includes a wider range of controls. Yet, there is relatively little empirical NGA-specific literature up until now. NGA broadband rollout in Europe has only taken up pace roughly in the last five years. Hence, available NGA (investment) data is limited and empirical research at most covers the first phase of NGA rollout (often datasets are limited to the years up to 2010).

A few papers nevertheless aim to present first findings. NEUMANN/SCHMITT/SCHWAB/STROZNIK (2016) base their empirical analysis on the theoretical effects of the LLU price on NGA investment identified earlier by BOURREAU/CAMBINI/DOĞAN (replacement, wholesale revenue and business migration effects). The authors aim to determine the impact of the level of the LLU pricing on investment in FTTH infrastructure by making use of an unbalanced EU27-panel covering the years 2009 – 2014. The authors take an innovative approach when defining their proxy for FTTH investment as the delta in homes passed by FTTH in between two periods. Finding that the effect of LLU pricing on FTTH investment is complex in structure, their data set reveals a non-linear, inverted u-shape relationship between the two measures. This suggests that up until a certain point of inflection, increasing the LLU price has a positive effect on FTTH investment whereas once having reached that point, a further increase has a rather negative impact.[81]

BRIGLAUER (2015) is another one of the more extensive empirical studies.[82] He investigates what impact sector-specific first generation broadband access regulation and the related service-based access regulation has on NGN investment. The author looks at the impact of infrastructure-based competition from mobile networks and from first generation broadband networks on NGN investment. Compared to most other papers published so far, he uses fairly recent panel data (27 EU countries, 2004-2013) and includes a large number of exogenous factors to control for.

Besides, there is also a small number of papers which – mainly qualitatively, with some empirical extensions – analyse the specific regulatory approaches chosen in the EU. CAVE/SHORTALL (2015) deal with the two generally different regulatory approaches of active and passive access to infrastructure. They conclude that both approaches achieve to

present and no obligation for competitive areas. They find the first regime to lead to more deterministic outcomes. Concerning pricing , they suggest a high access charge for regions with only one infrastructure to cover the higher marginal costs for those – mostly rural – areas and a low access charge for regions with multiple infrastructures to make inefficient duplication of infrastructures in those – mostly densely populated - areas less likely.

[81] The authors admit that determining the exact level of this inflection point depends on a number of model assumptions and specifications.

[82] He builds on his earlier research BRIGLAUER ET AL (2013) where the authors investigate the determinants of NGA investment (panel data: 27 EU countries, 2005-2011).

increase NGA coverage: In 'passive' countries, FTTH coverage increased; in 'active' countries FTTC coverage has been enlarged.[83] ÜNVER (2015) examines regulatory EU policies with a focus on two recent Commission Recommendations[84].

[83] They criticize that for countries where active remedies dominate, the roles of "access seeker" and "access provider" remain assigned asymmetrically, which in turn eliminates symmetric regulation as an option.

[84] 2010/572/EU Recommendation on regulated access to Next Generation Access Networks and 2013/466/EU Recommendation on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment.

Annex 2: NGA country case stories

NGA in Austria

The main NGA-rollout strategy of the incumbent operator is FTTC (with limited FTTB and FTTH) and the use of VDSL Vectoring (G.fast in case of FTTB).

Pressure for NGA-rollout comes on the one hand from cable network operators which cover ~50% of households, most of them with DOCSIS 3.0. On the other hand, competitive pressure comes from mobile broadband, which is very popular in Austria (many households are mobile only) and was/is also offering increasingly high bandwidths based on HSPA+ and now LTE.

Due to the competitive pressure from mobile broadband, the prices for low-end broadband products are quite low. Prices increase with bandwidth, however, the willingness to pay for higher bandwidths is limited. At the same time the cost for FTTB/FTTH are high in particular since no (or very few) ducts are available in the access network and new cables generally have to be put in the ground (and not e.g. on poles).

The low retail prices, the relatively low willingness to pay for higher bandwidths and the high costs lead to a situation in which FTTH-rollout is usually not profitable for the incumbent. The FTTH-rollout of alternative operators (including utilities and communes) has also been very limited so far.

The incumbent therefore focuses on FTTC (with some FTTB in the future) and the use of VDSL Vectoring (G.fast in case of FTTB) which has much lower investment costs per household compared to FTTH, can be implemented much faster, and also allows the offering of higher bandwidths. Unbundling operators usually do not have sufficient economies of scale to invest in FTTC/B/H. They stay at the MDF and try to increase bandwidths by use of VDSL2.

State aid so far only played a limited role but a new programme was started in 2015 with funds of up to 1 bn. until 2020.[85]

Regulation

The current regulation on market 4/2007 and 5/2007 dates back to December 2013.[86] On market 4/2007, the incumbent operator A1 Telekom Austria (A1) holds SMP and has (among others) the following obligations:

- Access to physical unbundling, sub-loop unbundling, access to ducts and dark fibre (as backhaul from street cabinets) and virtual unbundling (VULA)
- Price control: Minimum of cost oriented prices and margin squeeze free prices for physical unbundling and VULA.
- A1 has to announce its rollout plans and has to cooperate with other operators on request.

[85] see http://www.bmvit.gv.at/telekommunikation/breitbandstrategie/foerderungen/index.html
[86] see https://www.rtr.at/de/tk/M1_1_12 and https://www.rtr.at/de/tk/M1_2_12

A1 can deny access to unbundled sub-loops if Vectoring is employed or will be employed within the coming 16 weeks. A1 can also deny access to unbundled full loops in MDFs which are not unbundled if Vectoring is employed or will be employed within the coming 16 weeks. Both requires that A1 offers VULA services and migrates existing lines (if there are any) to VULA.

Market 5/2007 only includes wholesale products for the use of business residential products. A1 holds SMP and has (among others) the following obligations:

- Access to L3 (IP-based) bitstream (including FTTC/B/H connections)
- Price control: retail-minus(margin squeeze free prices)

While the use of physical unbundling and bitstream products decreases, the use of VULA increases, but only at a very low level. VULA is not (yet) accepted by several alternative operators which see high prices and prices increasing with bandwidth as the main impediment.

Markets 3ab/2014 are currently under review.

NGA in Belgium

Before liberalization, coverage of both copper and cable was around 100% with around 90% of penetration (telephony for the incumbent (formerly called Belgacom, now rebranded Proximus), television for the cable operators). Since Belgian consumers typically demand pay TV, triple play offers play a key role in the residential market. Licensing costs for broadcasting rights present a barrier to entry for small players, leaving the market for residential customers to the incumbent and cable and mobile operators only (with some small ISPs on niche markets). There are three large mobile operators in the market: While the largest one (Proximus) is owned by the incumbent, the third biggest mobile operator (BASE) has been acquired by the cable operator Telenet in 2015, making the (the second largest mobile operator) Orange Mobistar the only one which is not integrated with a fixed network.

Coverage of VDSL is 90% and coverage of Eurodocsis cable 95%. There are however some “white areas” where customers do not benefit from NGA services (areas where VDSL2 is not deployed and/or cable does not support bi-directional services). The main challenge in Belgium remains to cover these last households which are not yet covered by neither VDSL, nor Eurodocsis. The possibility to take specific measures to encourage the NGA rollout in those areas will be considered during the forthcoming market review and/or via other stimuli.

BIPT has published a detailed map of the current fixed broadband coverage of 30 Mbps (93.6% of households), 60 Mbps (91.9%) and 100 Mbps (91.1%): http://www.bipt.be/en/consumers/telephone/quality-of-service/coverage-maps-for-fixed-broadband-access.

Infrastructure competition

Infrastructure competition is clearly a key driver to deploy NGA in Belgium and cable is the first mover in this aspect due to the fact that cable networks are cheaper and demand less time to be upgraded. FTTH development is however limited up until now, due to several reasons: (i) the performances of cable upgrades (e.g. Docsis 3.x) makes FTTH unnecessary for cable operators, (ii) the absence of ducts (copper is buried into the ground) and (iii) the incumbent, at present, gives the preference to DSL solutions as he considers that FTTH deployment takes too much time to ensure a reasonable time to market. FTTH is mainly deployed in greenfield areas. It starts to be deployed in brownfield areas where urban renewal projects force operators to uninstall street cabinets and it is expected that other brownfield deployment will take place in the future.

Since the first mover concerning NGA rollout has been the cable operator, the incumbent Belgacom, in the absence of ducts to the end user does not have any other choice but to deploy VDSL technologies in order to attain a reasonable time-to-market. The upgrade of the cable network to the Eurodocsis 3.0 standard has put additional pressure on the incumbent to implement vectoring to stay competitive in terms of bandwidths.

Present ongoing investment plans are driven by the objective of 200 Mbps download speed in the short term (2018-2020):

- For the incumbent, a mix of brownfield FTTH deployment and VDSL enhancement with VDSL 35MHz and moving closer to the user (sometimes using VDSL bonding in place of fibre for backhaul) is planned.
- For cable operators, the strategy is to increase modulation (256QAM), increase bandwidth (600 MHz and more), reduce cable segment length with a long term objective of HPON (Hybrid PON, fibre to the tap) and upgrade to the Eurodocsis 3.1 standard.

Supply side factors

The average length of the sub-loop and the fact that copper is buried into the ground affects the rollout of NGA. To be able to provide services above 100Mbps, DSL incumbents must implement DSLAM's closer to the end-users. Buried copper cables make the deployment of FTTH/FTTB expensive and long to implement and is thus a barrier to invest.As there are no ducts available (except for the ducts for fiber deployment to street cabinets of the incumbent, ducts for optical nodes of cable operators and ducts for business connections, copper is directly buried into the ground and cables are mainly put on façades. In Belgium, coverage is generally very high even in rural areas.

Regional/municipal infrastructure is not available in Belgium. Municipalities were the previous owners of the cable TV networks but they have sold their networks to the present cable operators. In the current economical context, there is a low probability to see public authorities invest in telecom infrastructures.

On the supply side, low end offers now start at 30 Mbps for the incumbent (even if some customers cannot obtain such throughput presently where deployment of VDSL is limited and where the incumbent does not make use of cable wholesale access yet) and at 50 Mbps for cable operators.

Regulation

Since there is no demand for sub-loop unbundling in Belgium, BIPT has decided to cancel this obligation on market 4 (2007) while including a reversibility clause for the case that new technologies would allow for multiple operators on the sub-loop without degradation of performance.

Since the incumbent operator Proximus and cable operators are nationally around parity, it was no more possible to regulate incumbent only. BIPT has decided – in cooperation with media regulators (due to television elements of the markets) – to regulate wholesale cable access. The process of liberalization of the cable market has been started by the end of 2010 and measures came into effect September 2013. Initially, the incumbent was excluded from the benefit of this regulation to avoid de-incentives for NGA investments. The Court of Appeal has cancelled this point of the decision in case the incumbent presents a reasonable demand for wholesale access. The incumbent now requests access to the cable network in areas where he cannot provide 30Mbps access due to economical non-feasibility of VDSL deployment or due to too long sub-loops to provide sufficient throughput. Some areas thus have the cable network as the single NGA infrastructure.

Orange Mobistar has entered the cable wholesale offer in order to be able to make four play offers (including fixed telephony, broadband and television). At the present starting phase, their retail product is offered only to their mobile customers.

NGA in Bulgaria

The NGA deployment in Bulgaria is primarily based on the rollout of FTTH/FTTB fibre access networks, followed by FTTC-based ADSL2+ access, provided by the incumbent operator - the Bulgarian Telecommunications Company (BTC), and cable (DOCSIS 3.0) infrastructures.

BTC has a copper access network with a coverage of more than 80% by population. The FTTC ADSL-based access provided by BTC can support broadband download speeds of up to 20 Mbps. Since 2013, the incumbent operator also started deploying fibre-optic access infrastructure in parallel with the existing copper and has not declared intentions to implement VDSL. At present, BTC has managed to build NGA optical networks with good coverage in 17 of the 27 district towns of Bulgaria where more than 45% of the population of the country is concentrated.

Alternative operators deploy mainly FTTH/FTTB networks with regional PON footing, followed by DOCSIS-based hybrid networks. One of the mobile operators in Bulgaria implements an aggressive policy for acquisition of fixed network companies in Bulgaria. With its last purchase of one of the biggest Internet providers in the country, it has acquired the strongest position on the retail market leaving behind even the incumbent operator.

As of June 2015, high speed NGA broadband coverage is available to almost 72% of the homes in Bulgaria, which is higher than the EU average of 71%. The digital divide problem is severe, as the rural areas are almost not covered by NGA networks. With a rural NGA coverage of 2.7% as of mid-2015, Bulgaria is lagging far behind the EU average of 27.8%.

Infrastructure competition

The competition on the retail internet broadband access market in Bulgaria is entirely based on infrastructure competition. There are no alternative operators using the LLU or broadband wholesale services of BTC to provide retail broadband services. However, infrastructure competition is concentrated in the urban areas and specifically in the biggest 4 cities of the country – Sofia, Plovdiv, Varna and Bourgas, with a trend to spread to the 27 district-centre towns. There are no evident commercial incentives for network infrastructure deployment in the sparsely populated, remote and mountainous areas of the country because of the related high sunk costs.

Important driver for that is the regulated access to the duct network of the incumbent. To deploy their fibre optic networks, alternative operators rely almost entirely on access to BTC ducts. At the end of 2013 BTC provided duct access to 217 operators and Internet access providers.

Demand side factors

By mid-2015 the number of broadband subscribers in Bulgaria reached 1.535 mn, increasing by 6.9% year-over-year. Figure 11 and Figure 12 below show the distribution of fixed broadband subscriptions by technology and speeds.

Figure 11: Distribution of fixed broadband retail connections by technology in Bulgaria.

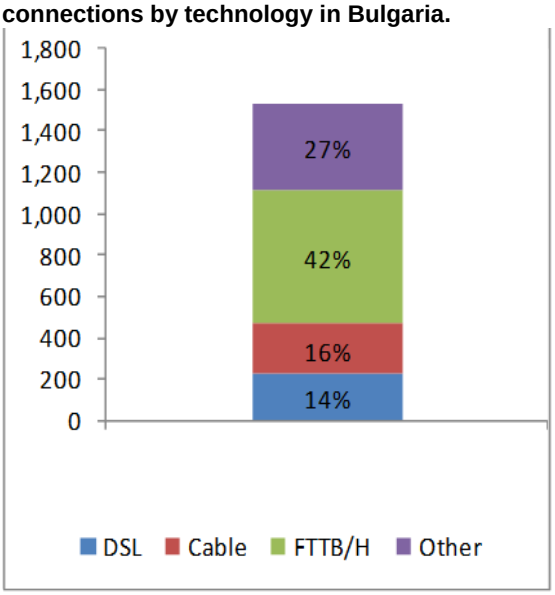
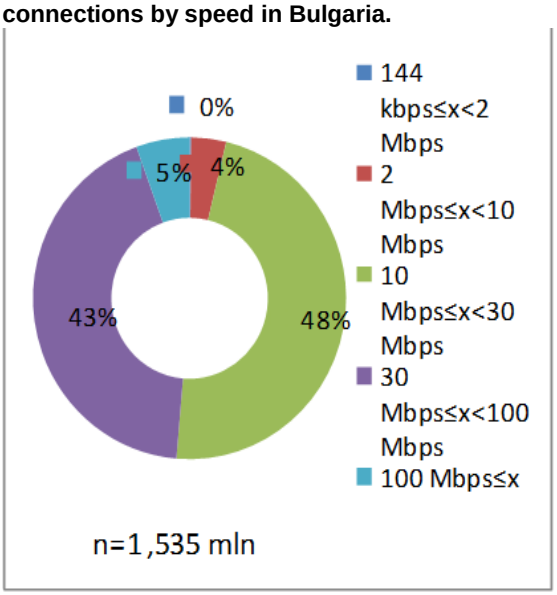


Figure 12: Distribution of fixed broadband retail connections by speed in Bulgaria.



The trends continue for increase of the share of FTTB/FTTH and cable networks subscriptions and of decrease of DSL broadband access. These trends are due to the shift of consumer preferences to higher download speeds enabled by technological developments, where Bulgaria is among the EU leaders, as well as to the fierce competition on the retail market concentrated in urban areas.

The Bulgaria's strength in terms of high-speed take-up (Bulgaria ranks 10th in EU), is challenged by the low fixed broadband take-up of 55% by households and 21.3% by population, nevertheless that the broadband coverage as of mid-2015 is 95% in terms of households. The reasons for this low take-up might be economic or the low level of skills. They shall be assessed and respective measures be taken to stimulated end-user demand.

Supply side factors

Despite the in recent years observed cases of consolidation, the Bulgarian broadband market is characterized by strong fragmentation and participation of a large number of companies, most of which are local providers. Nevertheless, with 76% share of the subscriptions serviced by new entrants, Bulgaria is the leader among the EU MS in terms of the overall market share of the alternative providers of fixed broadband services.

Regulatory approach

The incumbent operator BTC designated as having SMP on market 3a/2014, has an obligation to provide physical access to the copper local loop and virtual access (VULA) in the FTTB/FTTH scenario where physical unbundling is not feasible. The VULA obligation is applicable only upon a reasonable request of an access seeker. If and when an operator makes a reasonable request for VULA, BTC is obliged to submit an amended RUO offer to CRC within nine months. The access obligations include ancillary services such as collocation and backhaul (including dark fibre). In order to ensure conditions for promoting infrastructure competition and deployment of NGA, BTC has an obligation to provide duct access under cost-oriented prices. Further non-discrimination and transparency obligations are imposed to BTC. Bitstream access (Market 3b/2014) is not regulated in Bulgaria.

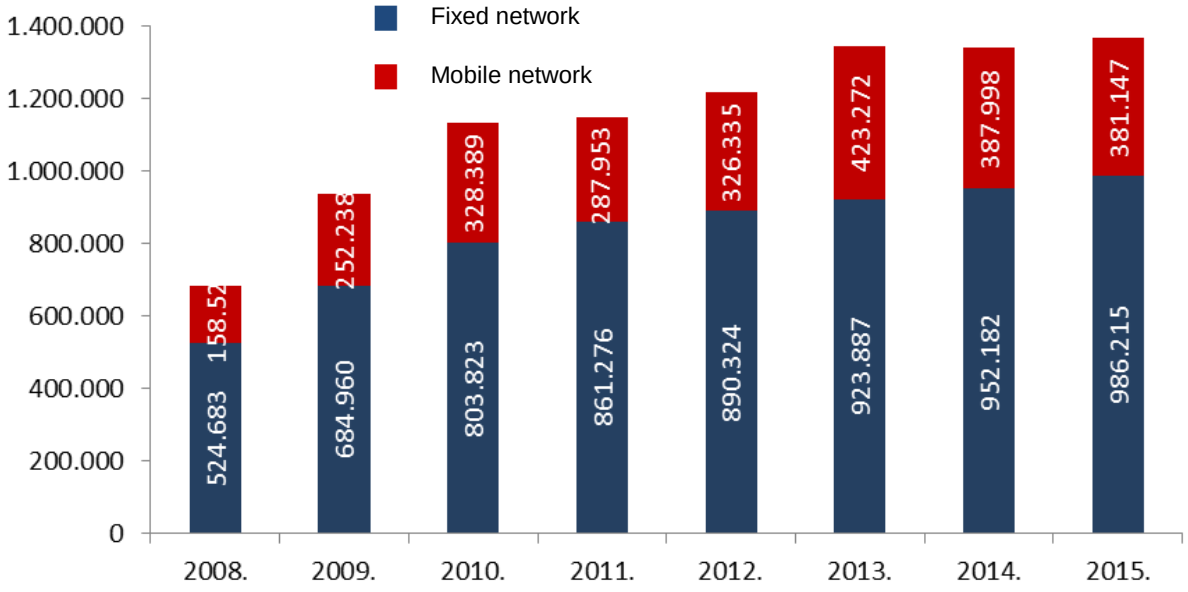
NGA in Croatia

Having recognised the development of broadband services as an exceptionally important factor for the economic development of the Republic of Croatia, the Government of the Republic of Croatia has adopted the national Strategy for Broadband Development in the Republic of Croatia 2012-2015. The main objective of the Strategy was to create preconditions for fast development of infrastructure for broadband Internet access and broadband services as the basis for further development of information society and knowledge society, while ensuring the availability of broadband Internet access services on equal terms on the entire territory of the Republic of Croatia. Target values defined in the Strategy were (by the end of 2015): number of connections will reach 1,000,000 in the fixed network, and 500,000 in the mobile network.

With proposal of new Strategy for Broadband Development in the Republic of Croatia for 2016-2020, the Government of the Republic of Croatia has established that the development of broadband Internet access infrastructure and services, with speeds greater than 30 Mbps, is of interest for the Republic of Croatia and one of the development prerequisites of a modern economy, and therefore this Strategy provides a strong political and operational incentive for the creation of conditions for acceleration of development of high-speed broadband Internet access in the Republic of Croatia and for reaching the level of its availability and usage equal at least to the EU average, by the end of 2020. At the same time the Strategy emphasizes on the need of ensuring the availability of broadband access with speeds in excess of 100 Mbps so that the development of broadband infrastructure follows development services, and applications which are, for trouble-free operation, the necessary broadband speeds more than 100 Mbps, including the symmetry of access speeds.

Current situation (both residential and business customers, download speed < 144 kbps):

Figure 13: Number of broadband Internet connections in the Republic of Croatia



The majority of operators in the Republic of Croatia provide broadband Internet access via xDSL technology, but in order to enable a significant step change in broadband Internet availability and connection speed levels the operators will have to continue investing in the

NGA infrastructure. Additionally, investment in technology increases the quality of service and enables the development and use of new services, which indirectly contributes to user satisfaction.

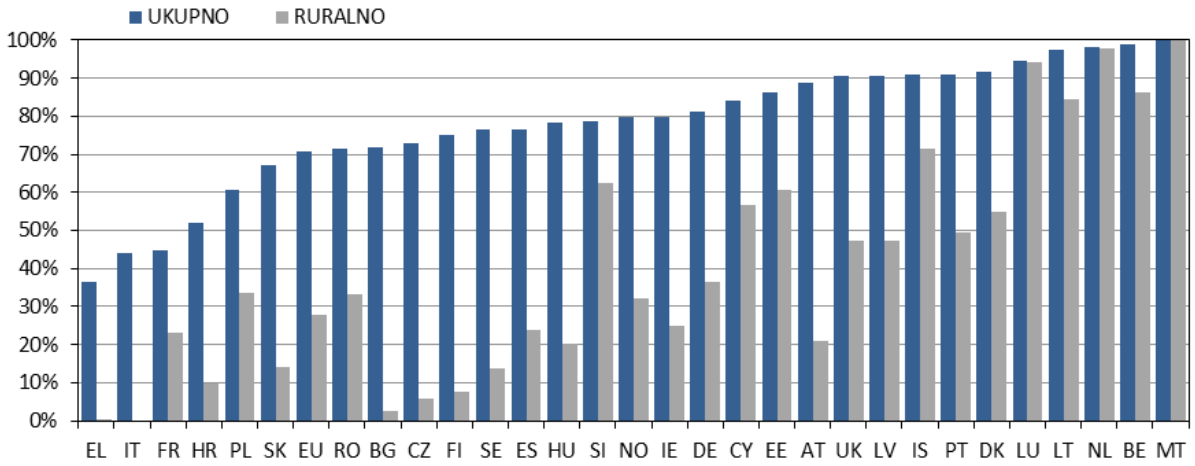
NGA infrastructure development in the Republic of Croatia

The development of infrastructure for broadband Internet access via the NGN technologies currently has the following characteristics:

- Investments in FTTH networks in parts of the largest urban areas by the former (incumbent) operator and several alternative operators;
- Investments in the advanced cable infrastructure (DOCSIS 3.x) are also aimed at the same parts of the largest urban areas.

NGA infrastructure availability in Croatia amounted to 52%, and this mostly in urban areas.

Figure 14: Availability of broadband Internet access via the fixed network in Croatia – NGA (FTTx, VDSL, Docsis 3.0 and other)



In the same period (June 2015), NGA infrastructure availability (VDSL, DOCSIS 3, FTTP) in European Union MS amounted to 70,9% (Figure 6). NGA networks are mostly present in urban areas, while in rural ones NGA availability is only 27.8%, and this mostly through VDSL technology.

At the beginning, the **incumbent operator**, HT deployed PON FTTH infrastructure with splitters very close to the end user for 265.000 households – ca 120.000 households has fibre to the home while rest of the households have fibre infrastructure that is almost finished (in front of building). Since the utilization of fibre infrastructure was very low, HT stopped with the deployment in 2010. In the period from 2010 to 2014, HT haven't done a lot regarding NGA deployment, they built only few street cabinets and reconstruction of copper network was mostly done using FTTN concept (opening a new independent node). In 2014, HT started to deploy VDSL equipment at CO locations. Last information from HT saying that HT has plans to deploy large number of the street cabinets and that they will continue with deployment of FTTH infrastructure (3 projects are in progress). Since HT has planned deployment of the street cabinets they also announced pilot in which Vectoring will be tested.

In case of **alternative operators** most of investments in NGA have been done by the biggest alternative operator VIPnet. VIPnet (Bnet brand) bought almost all cable operators in market and upgraded the network to DOCSIS 3.x. Almost a year ago VIPnet bought Amis, operator that deployed FTTH infrastructure in the capital. Other investments in NGA which should be mentioned are the investment in FTTB infrastructure. First mover was operator Iskon (owned by incumbent HT). In March 2016 Iskon announced some tests with G.fast technology and it is expected that G.fast will play an important role in FTTB concept. Other investments in NGA infrastructure are mostly done by small local operators and they mostly invest in FTTH infrastructure.

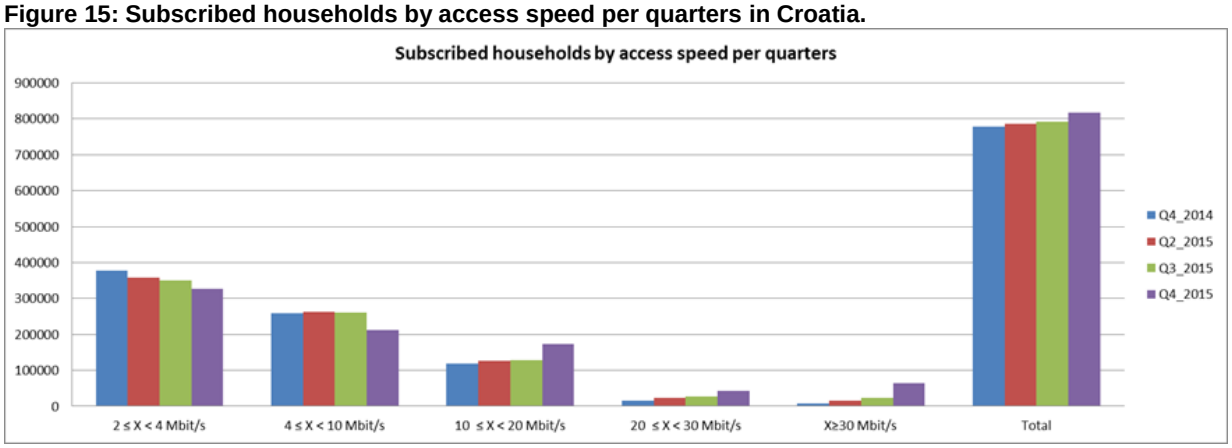
Infrastructure competition in Croatia

In Croatia, it is clear that NGA infrastructure is way more developed in areas where at least one of operators has started with NGA infrastructure deployment. In most cases we are talking about cable infrastructure, which is main driver for the NGA deployment in Croatia. Alternative operator which deploy FTTB of FTTH infrastructure don't play such an important role since the coverage of their infrastructure is too small to put pressure on the incumbent or even on cable operator.

Demand side factors

In Croatia, according to data for December 2015, 53.83% (817,700 thousands) of private households are subscribed to Internet access service with speeds 2 Mbps and more. Although, the number of households which are subscribed to 30 Mbps and more has been growing last few quarters, it is still very low with 7.8% of all subscribed households (see diagrams below). It seems that the price premium that consumers are willing to pay for higher speed remains relatively low, although they are not willing to order higher speed service even in the case when the price is the same like for lower speed. So, it could be concluded that in Croatia, the main driver is not the price only, but also the need for higher speeds, meaning there is the lack of applications and services requiring high speeds.

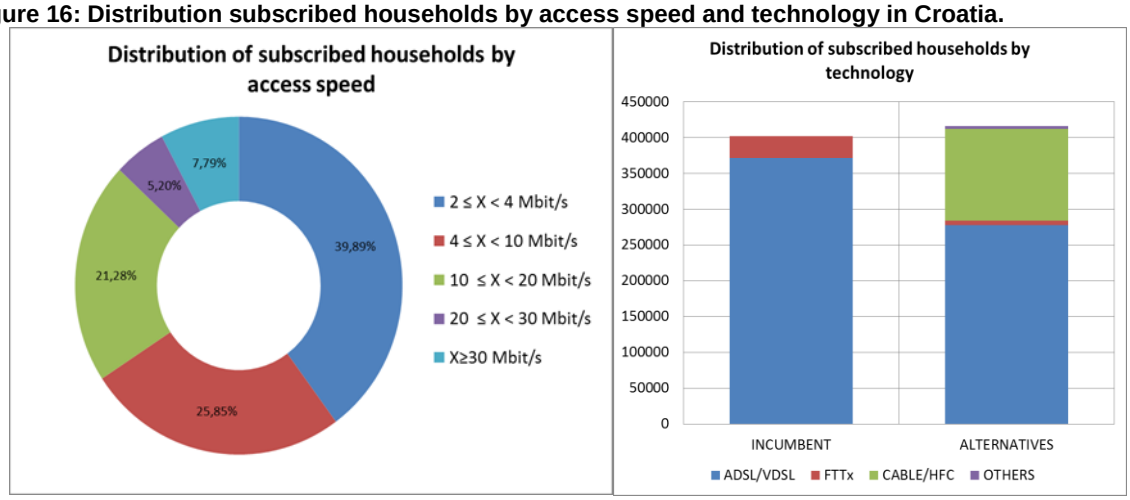
Figure 15: Subscribed households by access speed per quarters in Croatia.



As it is shown on the right diagram below (which is based on December 2015 data), the ADSL and VDSL offers of alternative operators almost exclusively rely on the wholesale access to the incumbent's copper infrastructure (based on LLU and bitstream). As it is already mentioned, in the big cities there is an infrastructure competition between cable/HFC network (123,625 households connected) of alternative operator Vipnet (which has been

upgraded to HFC DOCSIS 3.x. standard allowing download speeds of 100 Mbps and more) and incumbent VDSL network.

Figure 16: Distribution subscribed households by access speed and technology in Croatia.



Supply side factors

Fixed broadband coverage in Croatia is 96.9%, slightly below the EU average. Approx. 52.0% of Croatian households are covered with NGA network, which is still below EU average which is 70.9%. In rural areas NGA networks passed only 9.8% of rural homes, which is considerably below the European average of 27.8%. It is obvious that DAE 2020 target of 100% NGA coverage by 2020 is very challenging to private operators. Therefore, to facilitate NGA rollout in NGA white areas, the government has decided to use structural EU funds. According to "National Framework Programme for the Development of Broadband Infrastructure in Areas Lacking Sufficient Commercial Interest for Investments" which is national state aid scheme for broadband approved by European Commission, broadband projects eligible for state aid will be run at local level (municipality or NUT3 level). Also, it is expected that BB cost Directive implementation will facilitate NGA deployment, especially by using physical infrastructure of other utilities.

Regulatory approach

In Croatia ducts access is symmetrically defined and the same rule is also applied to fibre installations inside buildings, which could be an important factor for facilitating NGA deployment.

3a/2015

The incumbent HT has a nationwide obligation to provide access to:

- the copper local loop
- the local sub-loop
- fibre infrastructure in case of P2P architecture
- FA product in case of P2MP infrastructure.

Prices of all access products are cost oriented and based on BU-LRAIC +.

In case of deployment Vectoring at street cabinets, alternative operators can ask for VULA access and HT is obliged to offer VULA product on the first reasonable request.

Beside HT, alternative operators could also deploy street cabinets in copper network but by now these option haven't been used.

3b/2015

The incumbent HT has a nationwide obligation to provide bitstream service on next levels:

- IP level (L3)
- Ethernet level (L2)
- DSLAM/OLT level.

HT is also obliged to offer at least 4 virtual channels, while 2 of them are reserved for VoIP and IPTV service.

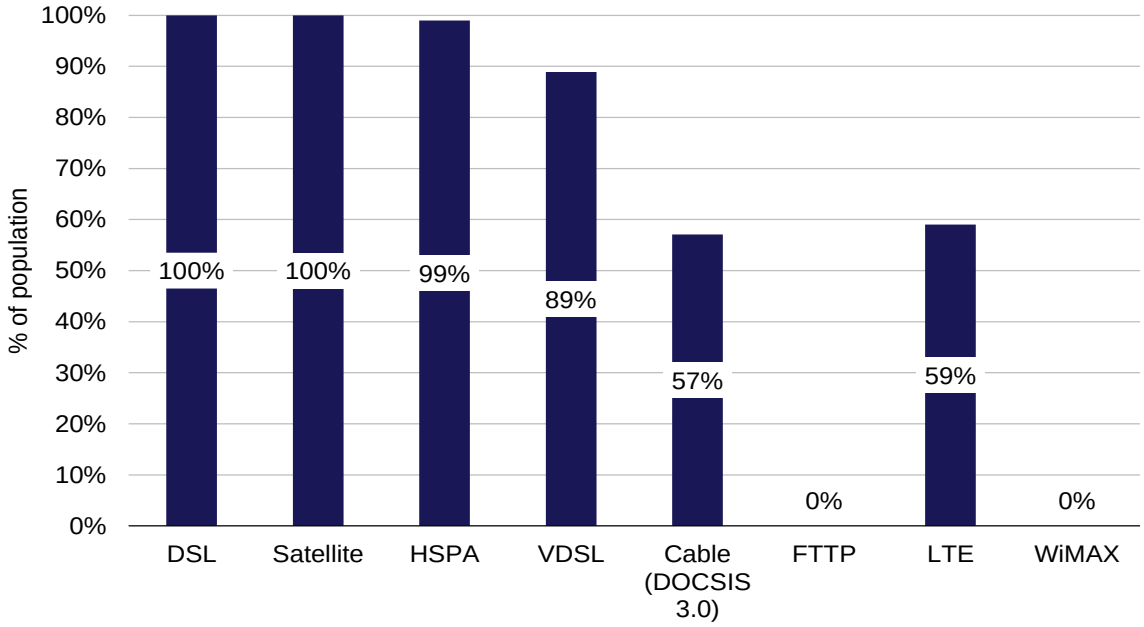
Prices for all bitstream products are cost oriented and based on BU-LRAIC +.

In case of access at IP level alternative operators can choose between access at national or at regional level. Croatian territory is divided in 4 regions so for regional access it is necessary to establish connection at all four regional POPs. In case of Ethernet access only regional access is possibly and in order to have country coverage it is necessary to establish connections at two main Ethernet switches in every region. It is possible to have Ethernet access in one region and IP access in the rest of country. Most of alternative operators are using access at Ethernet level and the bitstream service at Ethernet level is used by all important alternative operators.

NGA in Cyprus

In 2015, fixed broadband and Next Generation Access (NGA) coverage in Cyprus constituted 100% and 80% of population respectively. The coverage breakdown by technology is shown in Figure 1

Figure 17: Coverage by technology in Cyprus, 2015[87]



Cyprus has 100% coverage of basic broadband services, with access to DSL in all areas. Moreover Cyprus is already partially covered by a range of next-generation access technologies:

- VDSL and DOCSIS 3.0 cable are covering 89% and 57% of the population respectively
- Wireless data services are also well positioned, with HSPA at 99% coverage and LTE at 59% coverage.

Cyta the incumbent operator is investing in the next three years in FTTH – GPON architecture in city centres and other economic viable areas and is able to provide vectoring and bonding technique in RDSLAMs in areas where no FTTH will be provided. Cablenet, the cable operator, is expanding its footprint according to its own stated plans.

Infrastructure competition

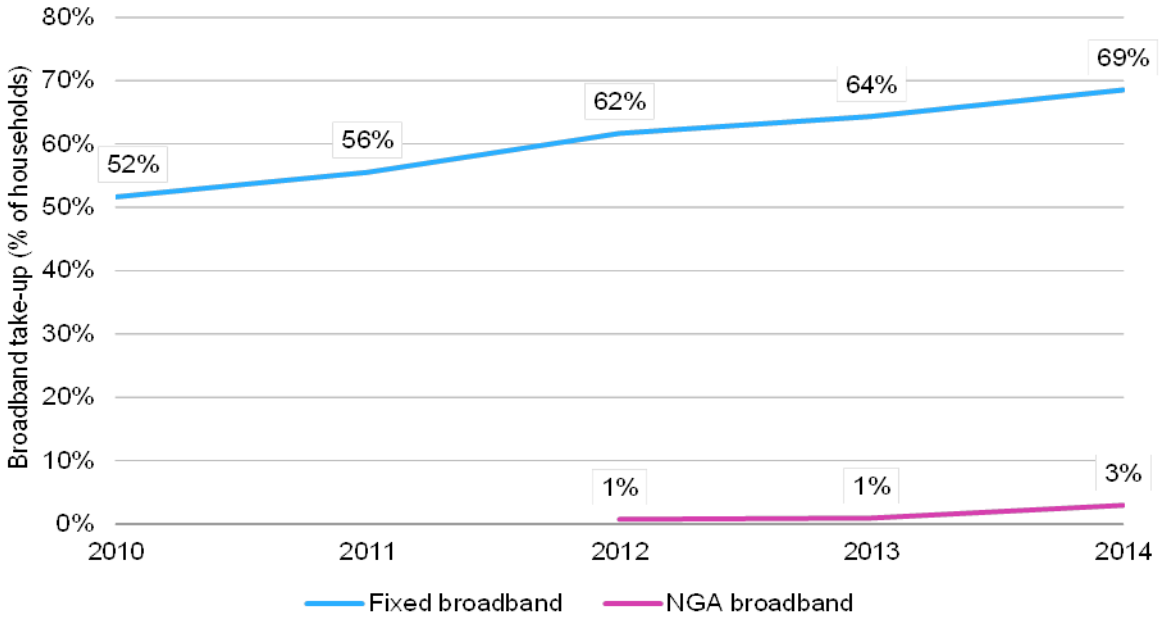
Competition is mainly driven by the deployment of cable infrastructure based on Docsis 3.0. It is expected that further cable footprint expansion would also bring dynamic competition benefits, encouraging the incumbent to roll out NGA infrastructure to compete.

[87] Source: Analysys Mason, EC Digital Agenda, operator data, 2015

Demand side factors

In 2015, take-up of basic fixed broadband and NGA fixed broadband in Cyprus stood at 69% and 3% respectively. Figure 2 shows how take-up of these services has evolved over recent years.

Figure 18: Broadband take-up in Cyprus[88]



The current level of broadband take-up in Cyprus highlights the fact that although NGA coverage is approaching that of basic broadband, the take-up of NGA broadband is still very low.

In 2015 OCECPR commissioned a study by Analysys Mason entitled “National Broadband Acceleration Study”, funded by the European Bank for Reconstruction and Development (EBRD).

The purpose of the study was to propose regulatory and policy-level measures to accelerate development of Cyprus’s broadband market, based on in-depth analysis of the status of its electronic communications sector. The proposed measures aim to attract investment, promote competition, support the Digital Agenda for Europe (DAE), and deliver social and economic benefits for Cyprus.

This study is based on an analysis of the market factors in Cyprus that will drive NGA take-up. In conjunction with demand forecasting work, a detailed scenario analysis was assessed with a range of approaches to NGA infrastructure for Cyprus.

Demand analysis highlights three factors that appear to be influencing demand in Cyprus at present:

- affordability (pricing)
- employment rate

[88] Source: Analysys Mason, EC Digital Agenda, Cystat, 2015

- digital skills (and digital awareness).

The above mentioned study is available at the following weblink: http://www.ocecpr.org.cy/el/content/paroysiasi-ton-apotelesmaton-tis-meletis-gia-tin-epispeysi-tis-anaptyxis-diktyon-epomenis

Supply side factors – Including state aid if applicable

The most probable scenario for deploying NGA infrastructure in Cyprus, based on the study findings, is based on a market-led approach, and is efficient in that it makes widespread use of Cyprus's existing FTTC-VDSL infrastructure, plus some expected deployment of new FTTP and LTE infrastructure in commercially viable areas by operators in the market. This scenario also involves the cable operator expanding its network, providing additional coverage of NGA infrastructure. The scenario requires no public subsidy or intervention. However, the sub-100% coverage of networks able to deliver 100Mbit/s might impede Cyprus's ability to achieve the DAE take-up target by 2020.

Regulation

Markets 3a and 3b are currently under national public consultation.

OCECPR tabled regulatory remedies addressing the incumbent's SMP status in Market 3 that include

i. virtual unbundled local access (VULA) type wholesale access product since incumbent operator is planning to deploy a FTTH-GPON architecture and employ vectoring techniques for its FTTC network.
ii. EoI, Technical Replicability, Economic Replicability
iii. Cost orientation of wholesale prices calculated over an extended time horizon covering the reference analysis period

NGA in the Czech Republic

NGA-rollout of incumbent and alternative operators

The situation in the Czech Republic is very specific. In the middle of 2015 the Czech incumbent made a voluntary (vertical) separation into 2 separate companies: CETIN, which owns the infrastructure, offers wholesale services and is SMP on markets 3a, 3b and 4; and O2, which is only active on the retail market and buys wholesale inputs from CETIN.

CETIN announced its plans about massive investing into the FTTC and VDSL 2 (with Vectoring), and started this process already (it should cover the whole country). CETIN is also planning some investments into FTTP (FTTH PON), it launched some minor pilot project, but it seems not to be a priority.

The biggest cable operator (UPC) is upgrading its infrastructure towards DOCSIS 3.0 and has very dense coverage (as well as the market share) in the locations, where the UPC infrastructure is built – mainly big and medium cities.

There is also a big number of local WiFi operators in the Czech Republic (over thousand operators), they cover over 30% of the retail broadband market. Some of these operators started to build FTTH (both PON and AON) and are very successful with such rollout. But some of them are happy with their WiFi networks and invest (or plan to invest) only into WiFi upgrade (they can easily provide NGA services over WiFi, even with higher speeds than over vectored VDSL).

Infrastructure competition

The incumbent covers the whole country, the biggest cable operator covers only medium and big cities, plus there is always at least one local operator (FTTH or WiFi) present in each location. The retail market is (more or less) equally divided into thirds (similar market shares) between these.

The wholesale inputs exist on the market, but they are not used so much (e.g. no physical unbundling at all).

Demand side factors

In our view, while considering that the competition is with no doubt always beneficial, the demand is the real driver. It is mostly the lack of demand which causes NGA rollout delays in the Czech Republic. End customers in the Czech Republic are very price-sensitive, most of them still prefer “slower” services for lower prices. However, we see a growing demand for bundles and high speed services (e.g. IP-TV).

Supply side factors

There are not so many ducts available in the Czech Republic. The passive remedies (e.g. duct access and dark fiber access) were imposed to the incumbent, but CETIN has only limited number of those. The incumbent also offers a variety of “active” wholesale inputs (due to the regulation, in accordance with the ladder of investment principle), but the alternative operators don’t use them so much.

There is a state aid project in the Czech Republic, but at the beginning stage (some money from the European funds were allocated, but we are still missing some strategical documents, which will fulfil ex-ante conditions and we are in the middle of the NGA infrastructure mapping process). We expect the first state aid projects at the end of 2016.

Regulation

Currently, CETIN has several regulatory obligations imposed under the ex-ante regulation (copper and fibre physical unbundling, virtual unbundling (VULA, in the cases where physical unbundling is not available), dark fibre access, duct access – on market 3a; and bitstream on market 3b).

We expect similar (symmetric) regulation on future state aid projects.

NGA in Denmark

In Denmark, the presence of NGA infrastructure is driven by end users' demand. The investments in NGA networks are primarily made by utility companies and the SMP operator and seen in both fiber-, cable-TV- and copper networks.

In some local areas, fiber networks have already – primarily due to end users' demand - been deployed to such an extent that fiber has replaced the copper network as the primary fixed infrastructure for broadband services. However, there are irregularities in regard to how, why and where fiber network deployment has evolved in Denmark. Fiber deployment has primarily been made by local utility companies. These fiber networks vary from a few hundred households to many thousand households connected. Overall, deployment of fiber is driven by the demand from end users – not necessarily concentrated in densely populated areas but also to a large extent in rural areas. The utility companies' deployment of fiber is not only driven by the expectation of generating a return on the investment. Thus, some companies also feel obliged to ensure that their electricity customers – i.e. the owners – get access to high speed broadband in their respective areas.

The Danish SMP operator, TDC, also owns a local fiber network, primarily present in the Copenhagen-area. This network was originally deployed by a utility company but acquired by TDC years later. It should be noted that deployment of parallel fiber infrastructures to end users is considered to be an unlikely scenario in Denmark.

The Danish SMP operator, TDC, is also an important player with regard to deployment of high capacity networks. This is primarily due to TDC's upgrade of the copper network where street cabinets and transmission equipment thus moved closer to retail customers. DBA has enabled TDC to use Vectoring at street cabinets by allowing them not to offer SLU. TDC as well as AO's have the right to decide where to vectorize.

Cable-TV networks have been upgraded to DOCSIS 3.0. The largest cable-TV network in Denmark is operated by the SMP operator and the second largest is operated by the largest fiber utility company SE/Stofa which is also locally based in the southern part of Jutland . For the time being, end users connected to cable-TV networks are offered 150/60 Mbps and in some areas 300/60 Mbps. Speeds are expected to increase as cable-TV-networks are upgraded to DOCSIS 3.1. TDC has announced that they will start upgrading their network in the beginning of 2016 and expect to have the upgrade finalized before the end of 2017.

SE/Stofa is now Denmark's second largest broadband supplier with a market share of 12 per cent of the retail broadband market. There is, however, still a huge leap to TDC's nationwide market share of 58 per cent. However, in a few postal areas in Southern Jutland, SE/Stofa has a market share above 50 per cent on the retail market.

Regulation

TDC is obliged to provide access to its copper, cable (active data-only access) and fiber infrastructure. TDC also is obliged to provide access to ducts. However, this access has not been used. To DBA's knowledge, multi-dwelling units has not affected the rollout of NGA in Denmark. The Danish government is currently working on an amendment to give operators

access to cheaper funding through mortgage loans and thereby stimulate rollout of high speed broadband.

Furthermore, a majority of the Danish Parliament has agreed that as from 1 January 2016 it will be possible for residential users to get a tax deduction with regard to expenses for the connection of broadband (deployment of cables on your own site as well as installation of antenna equipment for mobile and fixed wireless broadband on the outside of the residential user's premises).

NGA in Finland

NGA-rollout of incumbent and alternative operators and supply side factors

In Finland, the investments in fibre networks (NGA) have been twofold. On the one hand, the large national operators have been deploying fibre in densely populated areas, especially in city centers. However, residential areas even within cities may face difficulties in the availability of high-speed fixed broadband as there usually is no commercial interest to build NGA. Only larger cities have ducts which enable rapid deployment of NGA but otherwise large areas in Finland are dependent on costly ploughing of fibre to the ground or on building the ducts first.

On the other hand, Finland has been accelerating fast broadband accessibility in rural areas with its national broadband scheme which was launched in December 2008 by Government resolution. The aim of the project is to ensure with state aid that fast broadband networks are built in areas where their commercial availability is unlikely. In 2009, regional councils planned regional programmes of projects for building broadband infrastructure. In total, the programmes included some 800 projects and their combined costs were estimated to be nearly EUR 500 million. The projects included plans for expanding the broadband network system by 40 000 km. The availability of state aid has increased interest in rural area fibre projects, which have in many cases been implemented by newly established local on regional operators. By the end of 2015 the rural area broadband scheme has brought fibre coverage for approximately 70 000 households in the most rural areas of the country.

Infrastructure competition and demand side factors

Infrastructure competition is certainly one driver for NGA rollout but consumer demand, for example, also plays a major role. FICORA does not believe that a certain number of NGA infrastructures secure competition in each and every case. The adequacy of competition should always be carefully analysed.

There were a total of 1.73 million fixed network broadband subscriptions in Finland at the end of 2015. As the number of subscriptions has not increased significantly in recent years, the current number of fixed broadband subscriptions can be regarded as fairly stable. At the same time, the number of mobile subscriptions used for data transfers only has increased, with there already being more than two million subscriptions in total. In fact, some Finnish people are using their mobile broadband subscription for data transfers only.

Fixed broadband subscription technologies have become more modern in recent years. At the end of 2015, faster VDSL subscriptions based mainly on optical fibre connections represented 12 per cent of all subscriptions (while at the same time slower DSL subscriptions made up 37 per cent of all subscriptions). Ethernet subscriptions where optical fibre extends at least to the boundary of the premises accounted for 21 per cent of all subscriptions. In addition, modern DOCSIS 3 subscriptions in the cable network made up 19 per cent, and FTTH subscriptions based on optical fibre only accounted for 5 per cent of all fixed broadband subscriptions at the end of the year.

Even though the number of fixed network broadband subscriptions has remained fairly unchanged, changes, even significant ones, are continuously taking place in connection technologies and speeds. The number of subscriptions based wholly or partly on optical fibre

has increased steadily in recent years. The number of high-speed VDSL subscriptions increased by nearly one third in 2015.

One of the most significant changes in fixed broadband technologies during 2015 was the relative growth in FTTH subscriptions. Even though the total number of these subscriptions is still fairly small, their number increased by 20,000 subscriptions during the year. This means an increase of one third compared with the situation in the year before as there were 82,000 FTTH subscriptions at the end of the year.

Even though the number of FTTH subscriptions built with optical fibre that extends all the way to the user is still relatively small, up to 24 per cent of all fixed broadband subscriptions, however, offered speeds of at least 100 Mbps. This situation, together with the number of Ethernet and VDSL subscriptions, shows that optical fibre connections extend to hundreds of thousands of Finnish people, albeit not all the way to the indoor socket.

During 2015, the number of subscriptions of more than 100 Mbps increased by more than 60,000 subscriptions. At the same time, the number of subscriptions of 2–10 Mbps decreased roughly by the same number. However, the total number of subscriptions has remained fairly unchanged, meaning that operators are upgrading their customers' subscriptions to offer higher speeds, while customers are acquiring faster and faster subscriptions. At the end of 2015, of all fixed broadband subscriptions 24 per cent offered speeds of at least 100 Mbps, 32 per cent offered speeds of at least 30 Mbps and 77 per cent offered speeds of at least 10 Mbps.

Regulation

There are multiple ways to meet the demand through different technological means. Since the situation differs from one country to another, the regulatory means should be flexible enough to allow different mechanisms to ensure a sufficient access to NGA regardless of technology.

In comparison to many other EU countries, there are a handful of bigger incumbent operators and numerous smaller operators in Finland, which are regulated through SMP. In addition to these there is a growing amount of smaller local and regional operators whose networks are regulated through state aid regulations. Finland is currently analysing its broadband markets, which include the analyses of markets 3a, 3b and 4 of the Commission recommendation on relevant markets.

NGA in France

In France, LLU has played a significant role in the promotion of infrastructure-based competition and has been a success, reaching 92% of population in France in 2015. Alternative operators therefore own an extended backhaul network, and have a physical access to over 9 000 points of presence across France.

The investment by alternative operators allowed for significant price and service innovation to the benefits of French consumer. A decrease in the existing level of infrastructure competition would be detrimental to both the consumers and the alternative operators since it would jeopardize the return on investment on the significant sunk costs spent on the extensive rollout of their backhaul network. When a NGA approach was defined in France, securing a passive access to the NGA networks under construction was thus of the utmost importance.

Back in 2008, Arcep identified credible intention of several operators to rollout and operate FttH access networks, from both incumbent operators, alternative national operators or local operators backed by local authorities' funding. As this was likely to result in a drastic change in the outlook of the wholesale (physical) network infrastructure access market, with the multiplication of network access providers, new regulatory tools were required to streamline the long-run regulation of a multiplicity of network access providers of local reach.

First, in order to enable each operator to rollout its own fibre network, Arcep has imposed on Orange to give access to the civil engineering on a cost-oriented basis based as a remedy under the market analysis 3a since 2008.

Second, the law on modernising the economy (national law, LME dated 4th August 2008) has allowed Arcep to develop symmetric measures and to mandate passive access for all operators rolling out in-building wiring. On one hand the process of installing fibre in buildings is facilitated for operators and imposed on property developers in Greenfield housing. On the other hand, the party that installs the fibre in the building (i.e. the building operator) is responsible to the property owner for all operations performed on the network on the private property, and must satisfy an obligation to share its infrastructure, allowing other operators to provide ultra-fast broadband services to the residents of the building under non-discriminatory conditions.

The main objectives of the NGA regulatory framework based both on the market analysis and on this national law are to safeguard and improve the competition and innovation as a legacy of the copper local loop and to foster further infrastructure competition where it's desirable and feasible depending upon the areas.

To strike the balance between infrastructure competition and network access, Arcep has defined a list of 106 cities gathering the urban areas with more than 250 000 inhabitants and their periphery, with the condition of a sufficient proportion of buildings with more than 12 dwelling units, as very-high density areas. In those areas infrastructure competition is highly incentivise. The current regulatory framework requires an operator installing the in-building wiring to grant a passive access to other operators at the concentration point. For building which have more than 12 dwelling units the concentration point can be in the premises of the building, otherwise it has to be in a cabinet on the street.

Outside very-high density areas, the regulatory framework stipulates that the concentration point has to gather on average 1 000 lines, resulting in a fibre passive access solution technically similar to unbundling. Thus in those areas, where the rollouts are more expensive, a greater part of the network is shared compared to very-high density areas.

In both areas, the building operators have to publish a reference offer with a co-investment scheme. The terms and conditions governing the price of access must be reasonable - prices are based on the costs and calculated with a risk premium benefitting to the building operators in order to foster investments - and comply with principles of non-discrimination, objectivity, relevance and efficiency. The reference offer also specifies the terms and conditions of subscription and cancellation, prior information, the technical characteristics, the delivery processes and after-sales service, timetables and advance notice and quality of service. Those technical and pricing aspects have been addressed by Arcep either in decisions or in recommendations during the past years.

Finally, one should note that the fibre networks deployments are made under the aegis of a government rollout plan launched in 2013, the “Mission Très Haut Débit”, in particular for the most rural areas. The estimated investment for fiber rollout in the whole country is of 20 billion for both private and public sector. Private funded networks represent an investment of 6 to 7 billion and will cover 57% of the population by 2022. For public funded networks, the plan sets a pledge of 6.5 billion public fund (out of which 3 billion are State’s funds and 3.5 municipalities’ funds) and 6.5 to 7.5 billion private funds. Public funded networks will cover around 43% of the population by 2022.

First, the government plan ensures that the aid amount for subsidized networks (as of today, there is around 84 projects to be launched) enable public authorities to reproduce the wholesale access condition and price of private funded networks. Second, this plan is also in charge to ensure that private operators respect their rollout commitments.

NGA in Germany

In 2013, the government announced the mid-term goal to reach full coverage with 50 mbps until 2018. By end-2015, overall **coverage** by fixed technologies in percentage of households which provide at least 30 mbps (50 mbps) amounts to 79% (70%).[89]

In 2006, the **incumbent operator**, Deutsche Telekom, started to upgrade the local loop from ADSL to VDSL. Where the access network has been upgraded to VDSL, street cabinets and local exchanges have been connected via fiber. In 2010 the incumbent announced plans to connect up to 10 percent of households via FTTH/B. Since take-up of those households which were connected proved to be very low, rollout plans weren't completed (only around 30,000 households can be reached). Another reason for its shift in strategy from FTTH/B to FTTC might have been that upgrade of the copper network had to be timely in order to catch up with bandwidths that could have already been offered at that time on the relatively widespread cable network (cable coverage 63%).

In 2012, the incumbent presented a new strategy which foresaw continuing the upgrade of the access network to VDSL and the implementation of Vectoring at street cabinets (which lay outside a radius of 550m around a local exchange, affecting ~85% of households). Since August 2013, Vectoring at those street cabinets has been given way by the German regulator. The Vectoring regulation generally foresees a first-come first-serve policy for all operators for the deployment of Vectoring at street cabinets[90]. Where Vectoring is deployed, access to the local sub-loop is suspended (instead a L2 bitstream product has to be provided as a substitute).[91] [92]

Alternative operators in Germany currently hold a market share of around 58% in the fixed broadband market. Until recently, there have been two big cable operators operating in different parts of the country, Unitymedia Kabel BW and Kabel Deutschland[93]. In April 2014, Vodafone (formerly only operating on the copper network) acquired Kabel Deutschland, making the merged company the second largest player on the market. Other big players are 1&1 and Telefonica. Besides, there is a number of players which emerged from utilities and focus their operations on specific regions (EWE Gruppe in the region of Oldenburg/Bremen, NetCologne in the Cologne area, M-net in and around Munich). While alternative operators (except for the cable operators) in the last ten years relied mainly on the unbundled local loop (LLU), a slight decline in rented lines has been observed recently. One reason for this

[89] Breitbandatlas TÜV Rheinland, end of 2015, http://www.zukunft-breitband.de/SharedDocs/DE/Publikationen/DG/breitband-verfuegbarkeit-ende-2015.pdf?__blob=publicationFile.

[90] With special provisions to provide for the ownership rights of Deutsche Telekom.

[91] While the implementation of Vectoring at the local exchange is not considered technologically feasible, the incumbent in 2015 came forward to the German regulator with the demand to allow for upgrading all surrounding street cabinets in Germany which lie within a radius of 550m around a local exchange with Vectoring technology. Such upgrade would require that access to the unbundled local loop at the local exchanges would be suspended for VDSL. A regulatory decision on this issue is still pending.

[92] For more information see also BoR (14) 122, available at: http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/4587-berec-report-case-studies-on-regulatory-decisions-regarding-vectoring-in-the-eu

[93] Unitymedia Kabel BW operates in Hessen, Nordrhein-Westfalen und Baden-Württemberg, Kabel Deutschland in the rest of the country.

development is that demand for higher capacity connections has taken up in the last couple of years. Those alternative operators which provide only classical ADSL speeds over LLU have hence lost competitiveness. An upgrade to VDSL in turn usually[94] requires operators to invest into infrastructure up until the street cabinet, renting only the sub-loop. With the arrival of Vectoring, only one operator exclusively can feed in the VDSL-Vectoring signal (while ADSL transmission with LLU remains possible with Vectoring). Hence, alternative operators can either apply for Vectoring and invest into infrastructure up to the street cabinets or they need to migrate to other wholesale access product (most likely L2 bitstream) in order to provide competitive speeds. FTTB/H connections until date have been almost solely deployed by smaller alternative operators (2m homes passed).

Infrastructure competition in Germany

In Germany, infrastructure competition is acknowledged as one of the main drivers for NGA. Most importantly, **cable operators** exert competitive pressure on fixed network operators, especially in densely populated areas. Cable footprint (providing at least 50 mbps) amounts to around 63% overall, being focused on urban areas (81%) and considerably less developed in rural areas (14%). Compared to coverage, take up had been initially relatively low but has been constantly growing over the last couple of years (6.2m use a broadband cable connection in mid-2015). It seems that the fact that high speed connections have been available through cable for a couple of years attracting high speed customers has also played a role for the incumbent's strategic decision for the quicker rollout of VDSL (see NGA story above). While it is almost exclusively **alternative operators which deploy FTTH/B** in Germany, they cannot yet exert the same level of competitive pressure on the market as cable operators, simply because they have not reached a comparable level of coverage yet: Currently, around 2m households are covered by FTTB/H (while the incumbent only holds a negligible number of those) but demand for those very high speed connections seems to remain low. Since mobile and fixed broadband still rather present complements than substitutes, **mobile infrastructure** is not considered an important driver of rollout. Yet, it can be seen that pricing of mobile services plays a certain role in pricing of other telecommunication services as well.

Demand side factors

Next to infrastructure competition, demand (or rather the lack thereof) is acknowledged as an important factor determining the NGA rollout. By mid-2015, 30.1m households in Germany (corresponding to around 75%) subscribed to a fixed broadband[95] connection. The number of households asking for high speed connections providing at least 30 mbps has been growing over the last years but is still relatively low with 7.4m. Up until now it seems that the price premium that consumers are willing to pay for NGA products remains relatively low. As pointed out before, we observe that demand for very high speed FTTB/H connections is even lower (0.4m subscriptions only).The figure below on the left side shows the absolute number of broadband connections by technology (separately for connections marketed by the incumbent and alternative providers), the figure on the right side shows the distribution of those retail connections by speed.

[94] For less than 1% of households in the direct surroundings of MDFs (radius <550m), the VDSL signal could in principal be fed in at the MDF as well and deliver bandwidths of 50 Mbps.
[95] Following the EU-Commission's definition of connections above 144 kbps.

Figure 19: Fixed broadband retail connections by technology in Germany.

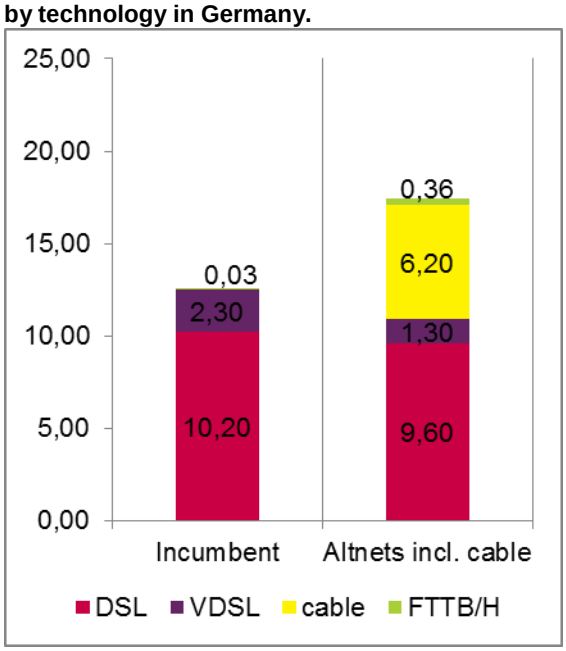
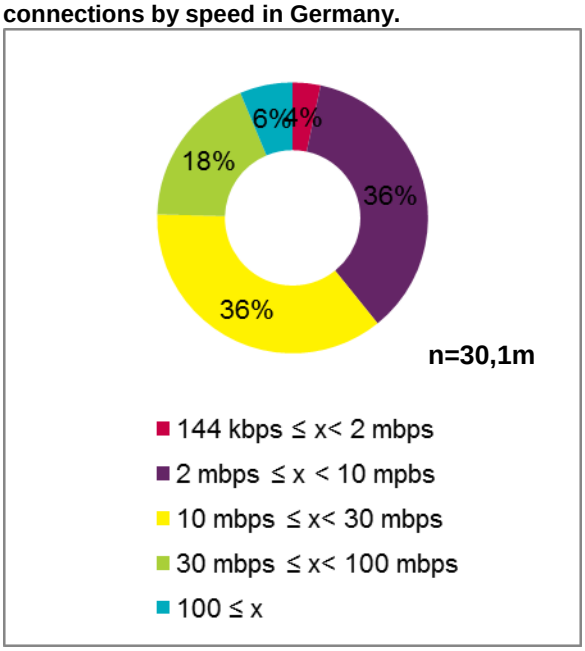


Figure 20: Distribution of fixed broadband retail connections by speed in Germany.



The DSL and VDSL offers of alternative providers in mid-2015 almost exclusively relied on the incumbent's infrastructure (based on local loop access (8.1m) and to a lesser degree also on bitstream (1.0m) and resale (1.8m)).

In the fixed broadband market, **bundles** with other services, especially including fixed telephony (21.6m) are frequently offered. 3 play offers including fixed telephony and TV are also rising in numbers (6.3m).

Supply side factors

Coverage varies considerably depending on **population density**.[96] In cities, fixed technologies' coverage of at least 30 mbps (50 mbps) amounts to 90% (85%) while in rural areas, it amounts to around 42% (26%) only (as of end-2015). It has become clear that bringing high-speed internet to sparsely populated areas in Germany is particular challenging for private investors. To promote NGA rollout in those – mostly rural – areas, the government has decided to grant additional funding (see below 2.7bn for "Bundesförderprogramm"). Moreover, through the implementation of the EU Directive on broadband cost reduction into German Law, exploitation of synergies in infrastructure rollout shall be promoted.

In Germany, deployment of FTTP requires considerably higher investment funds than deployment of FTTC due to the legacy network infrastructure. While in between the local exchange (around 8000) and the street cabinet (~300000), cable ducts are common, in between the street cabinet and the premises underground copper cables were used and ducts do not exist. Since the copper loops are of high quality, they are relatively well suited for the deployment of copper-based technologies such as Vectoring.

[96] 21,9m households are considered urban (at least 500 residents/km²), 13,6 are considered suburban (100-499 residents/km²) and 4,4m live in rural areas (less than 100 residents/km²).

There is a number of independent local players which emerged from **local utilities** (e. g. EWE Gruppe, M-net, NetCologne) and which are still mainly held by the respective **municipalities**. They have in many cases managed to build up own networks which rely only partly on the incumbent's infrastructure. According to the association of local utilities (VKU), those players provided for 5,7m homes passed in 2015.[97]

In Germany, **state aid projects** for broadband rollout are usually realized on a local/municipal level. There is no national broadband rollout plan in the sense that there are state aid funded projects of national scale. To avoid excessive administrative burden for the notification of rather small-scale municipal projects, **general framework guidelines for state aid for NGA rollout** ("Rahmenregelung")[98] were notified to the EC and approved by it in 2015. If a project complies with these framework rules, there is no need for individual notification of the project to the EC. The national framework guidelines themselves are not supported by any funds. Yet, in October 2015, a State programme ("Bundesförderprogramm") comprising around 2,7bn of funds has been adopted to support NGA rollout in white areas within the next three years. This programme is covered by the national framework guidelines making notification of single projects unnecessary. Municipalities can apply for those funds. Next to this national framework guidelines, some Federal States have adopted own guidelines (which have to be notified to the EC) to support NGA rollout in their municipalities (some guidelines are supported by a considerable amount of funds e. g. in Bavaria 1.5bn, in Baden-Württemberg 0,25bn).

Regulatory approach

Generally, SMP regulation is applied. The incumbent Deutsche Telekom Germany has a nationwide obligation to provide access to the **copper local loop and the local subloop** (cost-oriented price control, nationwide). Prices are cost-oriented. Concerning **bitstream access**, there is currently only a **L3 product** (73 access points in the core, IP) offered in the market; a **L2 product** (899 access points in the concentration network, Ethernet) is under development and should be ready to market by mid-2016. With the latest review of the wholesale broadband access market, a nationally differentiated regulatory approach has been taken to L3 bitstream. 20 local exchange areas with sufficiently competitive conditions were identified where L3 bitstream access will no longer be obligatory, given a L2 bitstream product is readily available for access seekers. It is expected that L2 bitstream will become more important as an access product in the upgrade of the access network to VDSL / Vectoring. In cases where the incumbent is entitled to suspend ex post access to the unbundled sub loop in order to use VDSL2/Vectoring, he has to offer **VULA** (bitstream) access at the street cabinet instead. Since 2011, there is mandatory access to the **fiber local loop** (ex post cost monitoring).

[97] http://www.vku.de/grafiken/grafik-der-woche/grafik-der-woche-breitbandausbau.html.

[98] The framework guidelines were adopted in June 2015 and are valid until end of 2021. https://www.bmvi.de/SharedDocs/DE/Anlage/Digitales/breitbandfoerderung-nga-rahmenregelung.pdf?__blob=publicationFile.

NGA in Greece

NGA-rollout of incumbent and alternative operators

In 2012, the **incumbent operator**, OTE, began upgrading the local loop from ADSL to VDSL. Where the access network has been upgraded to VDSL, street cabinets and local exchanges have been connected via fiber. Only recently, OTE announced to EETT its intention to implement a FTTH project for nearly 70 subscribers as a pilot case.

In 2014, the incumbent notified EETT its intention to introduce VDSL Vectoring on its FTTC network in order to offer higher speeds, together with a detailed plan to include the alternative operators in the Vectoring implementation procedure. This issue will be dealt in the context of markets 3a and 3b analysis which is currently ongoing (the public consultation concluded at the end of 2015).

On the other hand, the **alternative operators** have not yet publicly announced any specific plans for NGA deployment. However, during recent discussions with EETT in the context of the 3a and 3b market analysis procedure, some of the alternative operators have expressed their interest in deploying VDSL Vectoring as well as FTTB access network. In the latter case, they are concerned that in areas where the incumbent will have already implemented Vectoring, investments in FTTB may not be profitable. In addition to the above, all ANOs have expressed their concern regarding a possible re-monopolization of the access network due to the introduction of Vectoring. In this context, EETT's Consultation on market 3a shall play a critical role on the development of the access market in Greece.

Infrastructure competition

One of the most important characteristics of the Greek market is the absence of alternative infrastructure in the access network. Specifically, NGA deployment in Greece is solely based on the incumbent's investment on FTTC/VDSL access network since there is neither any cable operator, nor any significant deployment of FTTB/H access networks. ANOs offer retail services to the end-users over OTE's NGA FTTC network by utilizing the relative VULA-type wholesale product. Take up of the wholesale product has been very low until now due to – according to ANOs – the tight margin between the price of the wholesale product and the retail market price. Moreover, until today there has been practically no demand for SLU by the ANOs.

Demand side factors

By the end of 2015, 12.008 subscribers (corresponding to 0.35% of broadband users) used NGA services provided by alternative operators (using wholesale products provided by OTE), whereas 65.469 subscribers (corresponding to 1.91% of broadband users) used NGA services provided by the incumbent.

Supply side factors

Currently, OTE's NGA deployment expands to 395 out of around 2200 Local Exchanges that are equipped to offer broadband services. However, the state of deployment in these LEXs (number of VDSL cabinets implemented) varies from 1 to 100%.

Currently a state aid project is implemented in Greece which relates to network development. The project concerns the development of network infrastructure in rural areas, where no investment interest has been demonstrated by the market players, with the sole aim to provide wholesale broadband services. The project aims to cover 4.86% of the Greek population.

Regulation

Currently, OTE has a number of regulatory obligations due to its nomination as SMP, including local loop and subloop unbundling, provision of a VULA type wholesale product (VPU and VPU light), provision of bitstream products, duct access and alternatively dark fiber provision.

In the recent public consultation of markets 3a and 3b analysis, EETT has proposed to maintain the abovementioned obligations and has also introduced detailed procedure for VDSL Vectoring deployment. After the conclusion of first phase of the consultation, lengthy discussions have been taking place between EETT, OTE and the alternative operators in order to formulate a commonly agreed final procedure.

Moreover, in the consultation discussion some alternative operators submitted a proposal to include naked DSL as an obligation in market 3b and EETT is considering this proposal.

NGA in Ireland

Almost all premises in Ireland now have access to some form of basic broadband services through either copper based broadband, Fixed Wireless Access (FWA) provision or mobile data services. At the beginning of 2015, high speed broadband services were available to over 1.1 million premises in Ireland.

The Irish government's National Broadband Plan (NBP) was published in August 2012. The NBP commitment was to high speed broadband availability across the country during the lifetime of the government (which was formed in March 2011 and dissolved in February 2016) – specifically:

- 70Mbps - 100Mbps to more than half of the population by 2015;
- At least 40Mbps, and in many cases much faster speeds, to at least a further 20% of the population and potentially as much as 35% around smaller towns and villages; and
- A minimum of 30Mbps for every remaining home and business in the country – no matter how rural or remote.

Since 2012, the NBP level of ambition has increased significantly. On 15 July 2015, the government published a draft Intervention Strategy which set out this new level of ambition. The 'Intervention Area' stands at approximately 750,000 premises. Most customers in the 'Intervention Area' currently have access to basic broadband services (e.g. providing download speeds of 2-5Mbps). In other parts of the country, such as in central Dublin, customers enjoy access to broadband speeds of up to 360Mbps (via Virgin Media). Given current and expected trends in internet data use and the development of more advanced applications, end users will need better broadband connections to support their needs. Following a public consultation, the NBP strategy was published on 22 December 2015.

Based on data supplied to ComReg (for ComReg's Quarterly Key Data Report) by operators active in the market, Eir, the **incumbent operator**, held a market share of around 35% in the fixed broadband market at the end of 2015. In March 2013, Eir committed to an investment of €400 million to build Ireland's largest high-speed fibre broadband network, connecting approximately 1.6 million homes and businesses to high speed fibre broadband by the end of 2016. In June 2015, Eir extended its rollout commitment to include an additional 300,000 homes and businesses, which means by the end of 2020, 1.9 million homes and business across Ireland will have access to a high speed broadband network.

Eir is currently deploying three types of broadband technology, Fibre to the Cabinet (FTTC) and eVDSL delivering speeds up to 100Mb/s, and Fibre to the Home (FTTH) delivering speeds up to 1Gb/s (28,000 premises passed by end December 2015). Eir trial-launched the FTTH product in September in 15 communities dotted around the country.

According to its most recent results, a total of 358,000 customers were using Eir's fibre based high speed broadband services at the end of 2015, which represents 44% of Eir's broadband customer base and a 26% penetration of all premises that Eir's network passes throughout the country.

Eir recently announced further details of its deployment of high speed broadband in rural Ireland. In the next twelve months, 100,000 homes and businesses across 200 communities will be passed for access by Eir. Preparation work is already underway in some areas with tree trimming now complete in a number of locations, clearing the way for spans of new fibre cables to be installed alongside the existing roadside telecommunications infrastructure.

As of 31 December 2015, **alternative operators** (Eir's wholesale customers and alternative network operators) in Ireland hold a market share of around 65% in the fixed broadband market. The largest alternative operators (and their market share) are Virgin Media (formerly UPC, 28%), Vodafone (excluding mobile broadband, 18%), and Sky Ireland (10%). Other alternative operators (OAOs) account for approximately 9% of fixed broadband subscriptions.

Retail DSL may either be provided directly to the consumer by Eir using direct access to its network or by alternative operators who use either wholesale Bitstream (enabling resale of another operator's DSL service) or by offering DSL-based broadband using local-loop unbundling (LLU). As of 31 December 2015, 41% of all DSL lines were provided by alternative operators using wholesale Bitstream.

VDSL may be provided directly to the consumer by Eir using direct access to its network. Retail VDSL may also be provided by alternative operators who use either wholesale Bitstream, which enables alternative operators to resell another operator's VDSL service, or by offering VDSL-based broadband using virtual unbundled local access (VULA). As of 31 December 2015, 36% of all VDSL lines were provided by alternative operators using wholesale Bitstream.

Virgin Media Ireland offers download speeds of up to 360Mbps, utilizing DOCSIS 3.0 technology. Its customers are located in five regional clusters, including the capital city of Dublin and other major cities. Its cable network is 90% upgraded to two-way capacity, with 91% of its cable homes served by a network with a bandwidth of at least 750MHz. As of 31 December 2015, 857,000 homes in Ireland are passed for Virgin Media Ireland's broadband services. In January 2016, a 360Mbps service was launched.

In May 2015 Vodafone and ESB (Electricity Supply Board, the state-owned electricity company) unveiled SIRO as the brand of their fibre (FTTH) broadband joint venture company. SIRO is investing €450 million in building Ireland's first 100% fibre-to-the-building broadband network, offering speeds from 200 Mbps to 1000 Mbps to 500,000 premises in fifty regional towns. SIRO in not a retail product; it offers a wholesale open access network, meaning that it will be available to all telecoms operators in Ireland to resell to their customers.

The first ten locations, dubbed Ireland's first Gigabit towns or "fibrehoods", included in SIRO's roll-out are Cavan, Dundalk, Westport, Castlebar, Sligo, Carrigaline, Tralee, Navan, Letterkenny and Wexford. Construction on the network began in September 2014 delivering 1 Gigabit speeds to 300 homes in Cavan. The initial phase of the project, which consists of fifty towns, is expected to be fully rolled-out by the end of 2018 with scope for a second phase that will reach 300 smaller towns.

However, Virgin Media's and SIRO's existing and planned networks are expected to serve the same premises covered by Eir's planned network and will, therefore, not augment the total amount of 1.6m premises served commercially. Nevertheless, as a result of these developments, significant progress has been made towards the target of ubiquitous access to next generation broadband.

Infrastructure competition in Ireland

In 2014, fixed broadband coverage in Ireland remained at the same level of 96% of homes passed recorded in the previous year and slightly below the EU28 average. However, the biggest gains were registered for NGA coverage, which reached 71% of Irish households by the end of the year. However, most investment in NGA infrastructure continued to focus on urban and semi-urban areas, as rural NGA availability increased by a more modest 2 percentage points with just eight percent of rural homes having access to high-speed broadband, a figure far below the EU28 average of 25%. Cable coverage remained at its 2013 level, with 42% of households having access to cable broadband and nearly 41% being able to connect to high-speed DOCSIS 3.0 cable networks. So far, FTTP deployment has been minimal in Ireland with FTTP availability remaining far below the EU average.

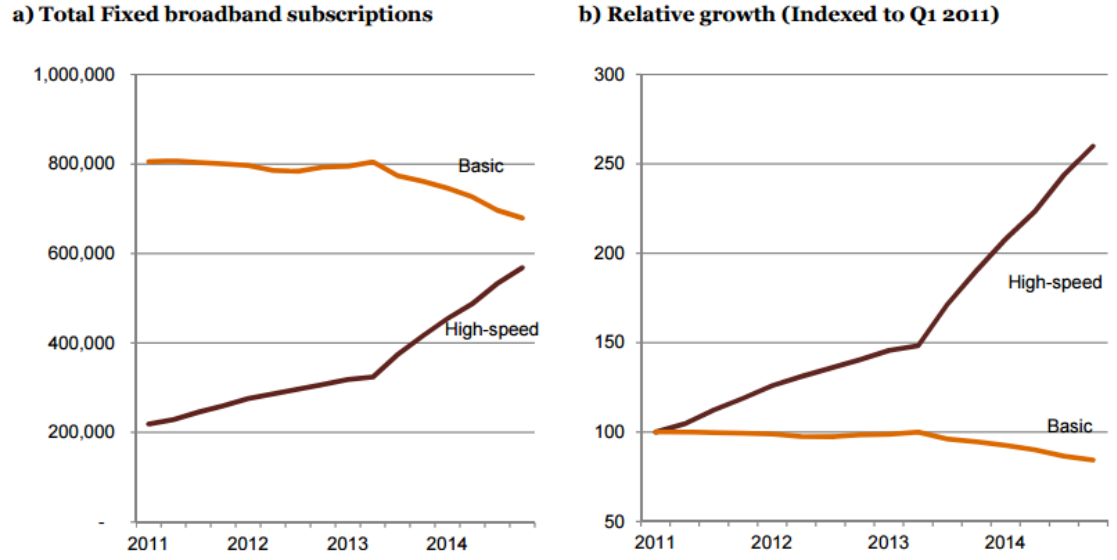
In 2014, Ireland saw a significant progress with regards to LTE coverage. Overall LTE coverage increased by 52 percentage points to reach 87% compared to EU average of 79%. Three Ireland launched its LTE network in 2014, which along with further expansion of existing LTE networks operated by Eircom and Vodafone, helps explain the rapid growth. LTE technology was first introduced in 2013, with Meteor (Eircom's mobile branch) and Vodafone launching their respective networks in September and October 2013. They were followed by Hutchinson's Three Ireland, which launched its network in July 2014 after completing an acquisition of O2 Ireland in May 2014 for EUR 850 million. Rural LTE coverage in Ireland increased considerably, growing by 62 percentage points from only 3% the previous year. This was the second largest increase in rural LTE coverage recorded in the study countries and it resulted in rural LTE coverage in Ireland reaching 65% or rural households, more than twice the EU average of 27%.

Most NGA deployments have so far been focused on urban areas. With very little FTTP coverage, negligible availability of DOCSIS 3.0, the only technology providing high-speed broadband services in rural areas was VDSL. However, it still covered only 7% of rural households, compared to the EU28 average of 15.1% rural households.

Demand-side factors

The total number of broadband subscriptions in Ireland for Q4 2015 was 1,708,787. Using fixed residential broadband subscriptions only, 1,138,688 (i.e. excluding business subscriptions and mobile broadband subscriptions), the estimated fixed broadband household penetration rate (there were 1,703,900 households in Ireland using CSO Q3 2015 estimate) as of Q4 2015 was 66.8%.

Figure 21: High-speed broadband growth in Ireland.



Source: *Compiled from ComReg Quarterly Reports*

Note: *High speed = Cable + vDSL; Basic = DSL + FWA*

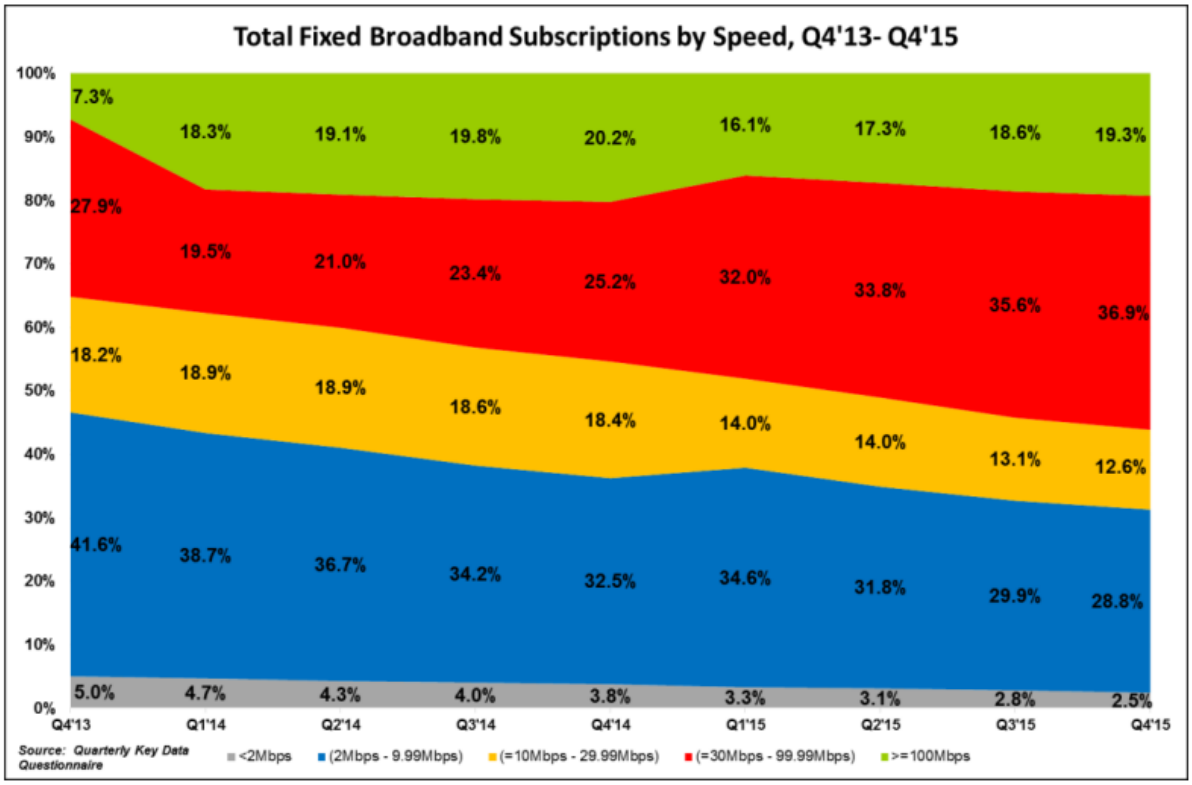
Note: *excludes satellite and fibre as these two categories are very small and would not change the overall trends.*

At the end of 2015, approximately 56% of all broadband subscriptions were >=30Mbps (with 19% >=100Mbps). This equates to approximately 60% (22% >=100Mbps) of residential subscriptions and 28% (2% >=100Mbps) of business subscriptions. The data suggests that most business users subscribe to broadband services with advertised download speeds of between 2Mbps - 10Mbps while most residential users subscribe to broadband services with speeds of between 30Mbps - 100Mbps.

This may be due in part to Virgin Media primarily serving the residential market rather than business market. Many larger business users access their broadband services over dedicated leased lines. Leased lines are not included in these charts. Leased line speeds can range up to speeds in excess of 1 gigabyte per second.

Figure 2 below shows the change in fixed broadband subscriptions by advertised (headline) download speeds between Q4 2013 and Q4 2015. Over the entire period, growth in broadband speeds has been mainly in lines with speeds above 30Mbps. The share of these lines has increased from 35% to 56%.

Figure 22: Fixed broadband subscriptions by speed in Ireland.



Supply-side factors

In the early 2000s both the Government and Irish businesses agreed that significant investment in developing an open access fibre network for Ireland was crucial to further economic development in Ireland's regions. So long as the incumbent controlled the old copper wire network there was no business case for private telecom operators to develop a competitive fibre network outside of Dublin. As a result, competition and innovation for telecoms service was being stifled. This was the original digital divide.

In 2004, in response to this critical infrastructural and market failure, the Government committed €78 million to develop fibre rings around 28 regional centres. Over the past decade, the MANs have become central to Irelands telecommunications network. Over 60 of Ireland's leading service providers now use the MANs to provide their suites of services, including Vodafone, Virgin Media, and Imagine.

The MANs have helped to drive competition in the telecoms infrastructure market, reducing prices for businesses and householders. In Cork, for example, 30 different service providers are utilising the Cork City MAN, creating platform competition and stimulating a quality and competiveness of offerings. MANs are a direct boost to the local economies too. Analysis of data gathered by IDA Ireland (the Irish Industrial Development Authority) shows that MAN enabled towns have increased their share of foreign direct investment from 24% to over 89%, helping to fulfil another major Government policy goal of more balanced regional development.

The benefits of the MANs have also extended to the country's third level institutions, with every regional university and Institute of Technology benefiting from the fibre network. More

recently, the MANs have also been involved in the delivery of 100Mbs broadband to 222 second level schools as part of the Department of Communications' 100Mbs for Schools project.

The developments outlined above are expected to result in almost 70% of homes and businesses in Ireland receiving access to high speed broadband by the end of 2016. However, improvements in service to rural regions have been relatively slow and premises in these areas are unlikely to see a significant improvement in the quality of service they receive. Ireland has a low population density compared to rest of Europe: 67 inhabitants per kmsq compared to the EU average of 120 inhabitants per kmsq. Furthermore, rural Ireland has an extremely low population density of only 26 inhabitants per km.

There is currently a noticeable imbalance in the quality of broadband services being offered in different parts of Ireland. According to the January 2015 Akamai 'State of the Internet' report Ireland has some of the most pronounced differences in broadband coverage between urban and rural areas in Europe. Despite being seventh in the world for average broadband speed, only 35% have a speed of 10Mbps or higher, resulting in the country being 42nd for distribution of high speed services.

The National Broadband Plan similarly identified that the trajectory of investment would lead to a clear urban/rural divide for access to high speed broadband services. It highlighted the importance of minimising this "digital divide", so that segments of the population would not become marginalised and unable to participate fully in a society and economy increasingly reliant on digital and online services.

It is apparent that, in the absence of an intervention, the market is unlikely to deliver services in some parts of Ireland. This is despite evidence that the benefits to Irish society outweigh the costs of delivering the infrastructure needed for high speed broadband. Without the intervention, there is likely to be a market failure in the provision of high speed broadband in parts of the country. As part of its program of work the Department of Communications, Energy and Natural Resources conducted a mapping exercise to identify the likely areas of the country which will require state intervention to address the aforementioned market failure. The resulting "High Speed Broadband Map" identifies every townland in Ireland, clearly indicating where commercial services are already provided or expected to be provided based on plans provided by operators.

The map shows Ireland with two colours[99]. The blue represents those areas that the commercial operators will cover by the end of 2016. Amber represents areas that will be targeted by the National Broadband Plan. The Map demonstrates the scale of the challenge for the Strategy as the 'Amber' Intervention Area makes up 96% of the landmass of Ireland.

Regulatory Approach

M3a/2014

In relation to Next Generation WPNIA (Wholesale Physical Network Infrastructure Access (including shared or fully unbundled access) at a fixed location) the incumbent, Eir, has a

[99] http://www.dcenr.gov.ie/communications/en-ie/Broadband/Pages/National-Broadband-Plan-Map-.aspx#

nationwide obligation to provide unbundled access to the fibre loop for FTTH, and access to civil engineering infrastructure (CEI, dark fibre if CEI is not available). SLU was mandated in ComReg decision 13/11 (January 2013), which considered the impact of NGA and Vectoring. Vectoring was announced by the incumbent in March 2014 – Eir started to deploy Vectoring with the intention to rollout the technology to cover 70% of Irish premises. ComReg decided that Eir is not obliged to offer SLU in areas where it has implemented Vectoring or NGA (including FTTC), or where such implementation is imminent or credibly scheduled (and where there is a commitment to offer VUA or next generation Bitstream access). All operators are allowed to deploy Vectoring at a given street cabinet. The following remedies have also been imposed:

- Transparency
- non-discrimination, based on equivalence of outputs basis (EoO)
- cost orientation (BU-LRAIC plus)
- accounting separation

M3b/2014

The product market is defined as wholesale broadband access provided over an extensive or ubiquitous:

- current generation DSL/copper network; or
- next generation fibre network,

including the self-supply of WBA by Eir, which has a nationwide obligation to provide access to NGA Bitstream and VUA with multicast. The following remedies have also been imposed:

- transparency
- non-discrimination (EoI except for associated facilities – EoO)
- price control based upon margin squeeze tests at retail and wholesale level
- accounting separation

Regulated wholesale access to cable networks is not mandated.

NGA in Italy

Fixed access services in Italy are provided mainly by the copper **incumbent's** network (20.2 million of active lines), but there is an increasing trend of adoption of **alternative** infrastructures, mainly fixed wireless (670'000 active lines) and fibre (1.4 million of active lines) networks.

The retail PSTN access market shows a gradual and constant reduction of the incumbent's (Telecom Italia) market share, although at the end of 2015 Telecom Italia's share in the retail market was still about 58%. As for the retail broadband access market, at the end of 2015 Telecom Italia's market share is declining but still around 47%.

As a results of the market and regulatory status quo, the FTTC coverage is quickly increasing and it reaches almost 12 million households at the end of 2015 (46% of total households). The estimated FTTC coverage at the end of 2017, according to private investment plans, will reach about 20 million lines (84% of the total 24.3 million of households). Even though FTTH coverage has been almost stable in the last few years (around 8% of households), two new investment plans to deploy FTTH/B networks in the major Italian cities have been separately announced by the incumbent (20% of households) and by the newco Enel Open Fibre (31% of households) founded by the major Italian electricity provider. A passive-only operator, which already owns an FTTH network (about 600'000 lines mainly located in the Milan area), is also planning to extend its FTTH coverage in the next years.

Table 3: Investment plans of Italian operators.

	Time Schedule	Euro [bn]	Coverage goal	Network architecture
Telecom Italia	2016-2018	3.6	84%	FTTC/H
Fastweb	2017-2020	2.5	53%	FTTC/H
Vodafone	2014-2016	3.6	29%	FTTC
Enel Open Fibre	NA	2.5	31%	FTTB/H

Infrastructure competition in Italy

The absence of a widespread cable infrastructure in Italy had a negative impact on the deployment of competition and investments in the past, but recently the incumbent and three major alternative operators have invested in FTTC/B/H networks, thus inverting the negative trend.

Legacy copper network in Italy is characterised, in average, by short lengths of the local loop and sub-loop. Moreover, it is worth mentioning that in the past ducts have been installed only in the primary section of the network (from the local exchange to the cabinet), whereas in the secondary segment (from the cabinet up to the end user) copper cables have been directly buried in the ground or installed on poles. Due to the presence of available space to install fibre cables in the ducts in the primary segment and to the short length of the sub-loop (especially in urban areas), FTTC is currently the solution most adopted by operators in Italy.

However, as shown in the previous table, relevant investments in FTTH/B have been planned for the next years by private companies; in addition, a State Aid Strategic Plan by the Government will fill the gap in order to reach the objectives of the Italian Digital Agenda, as reported in the following section.

As for the mobile infrastructure, in Italy mobile broadband is not considered yet a retail substitute to fixed broadband access for various reasons: different technical characteristics in terms of data speed and quality, functional differences and different commercial policies implemented by operators for these two services, including monthly data caps for mobile broadband subscriptions. Notwithstanding, it is observed that mobile services' prices exert a certain constraint on fixed services' prices.

In this context, it is worth noticing that in Italy the mobile broadband penetration is quite high (about 75% in July 2015), in line with the European value, and the LTE coverage (90% mid-2015) is slightly above the European average (86%).

Demand and supply side factors

In order to stimulate the demand for ultra-broadband services, the new government strategy for ultra-broadband announced in 2015 provides that end users that migrate from the legacy to the fibre infrastructure shall be provided with vouchers. One possible idea is that end users will pay for FTTX services as much as they would pay for ADSL services.

According to current operators' investment plans, it is reasonable to expect that in the densely populated areas there will be more infrastructure competition. Therefore, population density can be considered one of the factors that are able to affect private investments for NGA rollout.

In addition to private ones, an investment plan has been proposed by the Italian Government for 6 billion EUR (national, regional and European Community funds), in order to deploy ultra-broadband networks in areas not interested by private operators' plan. In order to meet EU Digital Agenda objectives by 2020, the plan will extend NGA coverage and provide 100 Mbps to 85% of the Italian population (at most), and at least 30 Mbps to the remaining 15% of the population. In the past years, state aid granted in Italy mainly went into the backhaul network, only recently into the access network and cabinets.

Moreover, it is expected that the adoption of the national legislation transposing the broadband cost reduction directive (transposed in March 2016) will stimulate the rollout of broadband networks. The legislation integrates other measures, already adopted, concerning the national database for infrastructures and the in-building equipment.

It is worth mentioning that over the years, some local utilities – active in the provision of other network services in the north of Italy – have played an active role in the deployment of fiber networks.

Regulatory approach

Regulatory measures, ensuring passive access (to ducts and dark fibre in all the sections of the access network, including access to cabinets for co-location) and active access (VULA and bitstream) to the incumbent NGA infrastructures, have encouraged alternative operators'

investments. All access services' prices are cost oriented (except for bitstream services at IP level and long distance bitstream transport services). It has also been provided a risk premium for investment in new infrastructures, dark fiber and equipment; the value of the risk premium is different for FTTC and FTTH infrastructures and is included in the cost of capital.

In addition to SMP regulation, symmetric (non-SMP) regulatory measures ensure access to ducts – where available – and dark fiber in the building entry segment and access to the fiber in the terminating segment of existing networks in order to drive investments also in FTTH networks.

Agcom is supervising a technical committee made up of stakeholders and manufacturing companies with the aim of finalizing a document concerning technical specifications for the implementation of a Multi Operator Vectoring (MOV) architecture, in order to allow coordination and interoperability among Vectoring systems. The last approved access market analysis decision (published at the end of 2015) provides that Telecom Italia and all the other operators which intend to use Vectoring-based equipment have to be compliant with the MOV technical specifications once they will be published.

NGA in Latvia

In 2012, the government announced the mid-term goal to reach the Digital Agenda targets and to promote expansion of existing NGA networks.

NGA rollout of the incumbent operator

In ~2006, the incumbent operator, Lattelecom, started to invest in urban areas mainly in FTTH (GPON) and in some cases - FTTB in response to competition from the rollout of FTTB by alternative operators. The incumbent was mainly relying on its own ducting for the roll-out. On 1 January 2016, the incumbent's FTTH technology share was 76% of all NGA active broadband connections and 52% of all active (NGA and copper) broadband connections.

When areas with higher population density were covered, the incumbent started to upgrade less densely populated areas. Since ~2012, the incumbent gradually has been upgrading its access network to VDSL but not at a large scale. In the end of 2014, the incumbent started the deployment of VDSL2 Vectoring, mainly outside city centers where deployment of FTTH is not considered to be cost efficient.

NGA rollout of the alternative operators

Alternative operators (cable operators and ISP) were first movers, starting to invest in the late 90s/early 2000s in urban areas mainly in FTTB or in some cases – FTTH via installation of overhead cables connecting roofs of apartment buildings or through attics directly from house-to-house. In some cases, alternative operators constructed its own ducts or used the ducts of the incumbent on commercial basis. Later they have been gradually expanding NGA networks also outside dense city centers where they saw the business case to invest. On 1 January 2016, alternative operators' FTTB technology share was 91.7% of all NGA active broadband connections and 50.5% of all active broadband connections. FTTH technology share is smaller – 17.6% of all NGA active broadband connections. There is also DOCSIS 3.0 technology deployed by alternative operators but not at a large scale.

Alternative operators do not tend to rely on LLU or BSA but instead have their own broadband infrastructures. Currently, market share of alternative operators' broadband connections based on their own infrastructures is 45%.

Infrastructure competition in Latvia

Broadband access market in Latvia is FTTH/FTTB based. Infrastructure competition is the main driver for NGA. As mentioned before, the first movers were alternative operators and the incumbent started its investments in response to the strong competitive pressure exerted by alternative operators who at that time were able to offer higher speed services for affordable prices, especially in densely populated areas.

Comparable networks tend to compete with peers. In Latvia, the incumbent, which mainly deploys FTTH, competes with alternative operators who mainly deploy FTTB.

Fixed and mobile broadband are rather complements, except in remote areas where fixed broadband is not available. Mobile broadband is not considered to be as the main driver for

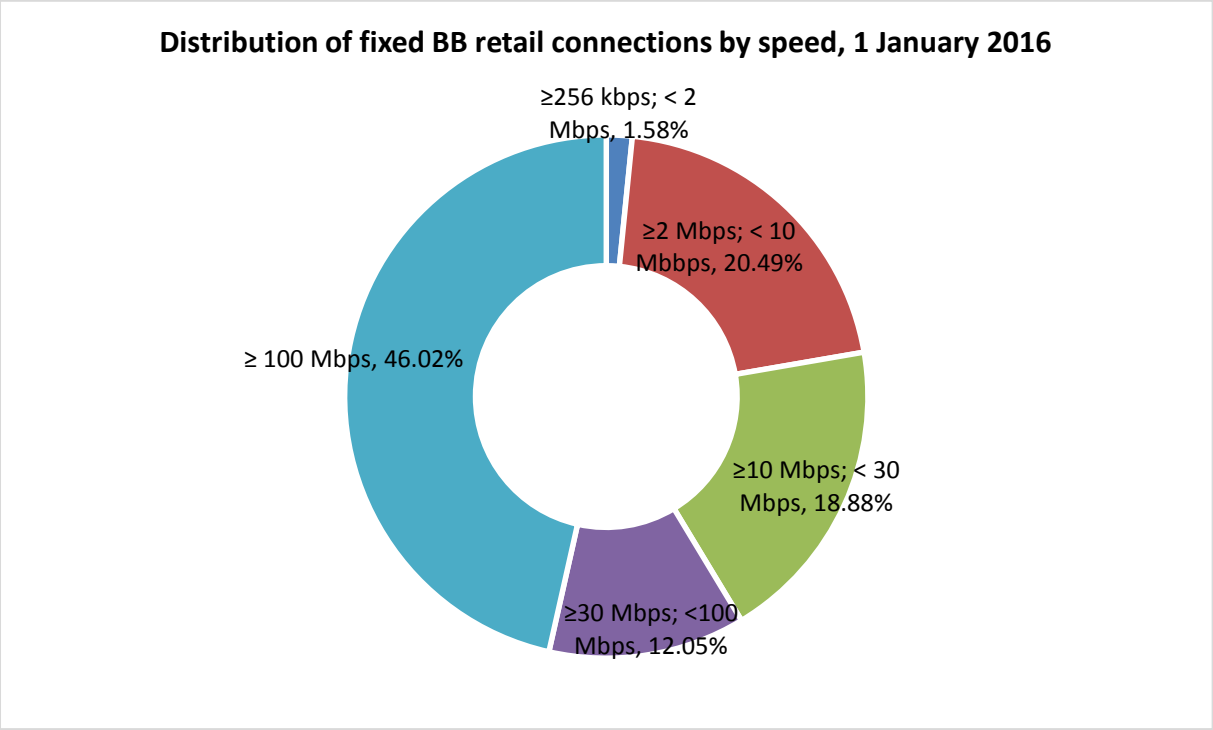
NGA rollout. However, fixed operators take into consideration that mobile operators have been upgrading its networks and currently there are three 4G networks operational. They are able to offer higher speeds than before and currently have also unlimited data tariff plans.

Demand side factors

There is a demand for high speed services in Latvia due to affordable prices. The infrastructure competition among operators has brought down the prices, and the offered speeds and quality have increased significantly. The most common optical internet speeds for mass market offered by the incumbent are up to 30, 60, 100, 250, and 400 Mbps. To give an example, the monthly price for incumbent's 100 Mbps is 17.50 EUR. Alternative operators offer optical internet up to 100, 250, and 1 Gbps. Prices of alternative operators are cheaper and monthly cost of broadband up to 100 Mbps connection is 10-12 EUR. Both the incumbent and alternative operators have promotional periods where the prices are even cheaper. There are many tariff plans (including bundles) and customers have choice to select the most suitable offer.

The figure below shows the distinction of retail connections by speed based on incumbent's and alternative operators' infrastructures.

Figure 23: Distribution of fixed Broadband retail connections by speed in Latvia.



To conclude, the price is an important factor for take-up here in Latvia. However, there is quite large proportion of older population who are not necessarily computer literate and do not require broadband services at all, which triggers the actual take-up.

Supply side factors

Broadband coverage varies depending on population density. At the end of 2015, FTTH/B coverage reached 85% of homes passed in Latvia. FTTP remained the key technology providing fixed broadband in rural areas. 47.2% rural households have access to FTTP

services. According to various surveys, Latvia also ranks very high in terms of measured speeds.

In order to facilitate provision of high-speed broadband in rural areas, the State aid project (Middle-mile) started in 2012 and was supported financially by the EU and the Government. The project foresees construction by an operator - LVRTC of middle mile in remote areas up to municipalities where the access point is. Infrastructure then is offered on the basis of open access for local ISPs. The project enables competition in the last mile, i.e. the local ISPs should rollout optical fibre or use wireless from the access point till subscribers' premises. The project is deemed also for mobile operators (to connect base stations) which is important for the development of LTE.

Regulatory approach

SMP regulation has been applied in Latvia. The incumbent has an obligation to provide cost-oriented copper and fiber access to LLU (including VULA – L2), and BSA (L2 and L3). As alternative operators deploy their own infrastructures, they do not rely on incumbent's wholesale offers, which are used only in exceptional circumstances.

In order to reduce the costs of network deployment, and to facilitate competition among operators, asymmetrical regulation (sharing of duct and poles) has been imposed on the incumbent under SMP framework since 1 July 2014. Sometimes a duct system of the incumbent can limit the number of cables that can be installed and installation of the cables in the ducts of the incumbent might be impossible because of damaged old ducts etc. reasons. Therefore asymmetric regulation is not enough and symmetrical regulation has been mandated which is applicable to all duct owners under Electronic Communications Law since April 2014.

NGA in Liechtenstein

With a total area of only 160 km2 the Principality of Liechtenstein is the fourth smallest country in Europe and the sixth smallest country in the world. With a population of around 37.000 inhabitants, approx. 13.000 households and 4.300 enterprises the telecommunication markets are very limited.

This limitation was one of the main reasons to put a functional separation between the network (layer 1) and service layers in place. All fixed access network infrastructures (twisted copper, hybrid fibre coax HFC network and FTTB/H, ducts, collocation) and the core network infrastructure (dark fibre, ducts) are built, operated and maintained by the state-owned Liechtensteinische Kraftwerke (LKW). LKW is obliged to grant access to its networks by offering ULL, dark fibre, or frequency/channel unbundling, as well as access to collocation rooms and ducts. LKW is further obliged to offer its communication-network exclusively to providers of communication services as a wholesale service and is not allowed to have any enduser-contact respectively retail offers in this regard.

In May 2014 the government of Liechtenstein adopted a strategy for the communications network, which foresees a FTTB rollout all over the country taking into account the requirements of all service providers and making best use of existing infrastructures. For the strategy the expected bandwidth demand until 2020 was assumed with 100 Mbit/s Download and 40 Mbit/s Upload. Until the complete transition to the new technology all existing network infrastructures are used in parallel. Residential areas with high capacity limitations in the twisted copper network (long distances) will be reinforced by upgrading the HFC network (cell splits). So far no decision or timeframe about a switch-off of existing infrastructure (twisted pair, HFC) was reached.

According to the strategy LKW established a network planning group, consisting of all operators, who are actual recipients of access-services. The network planning group defines the expansion sequence of the relevant 18 optical Main Distribution Frames (MDF) in Liechtenstein. The goal is to build out densely populated areas until 2022 (roll-out phase 1) and the rest of the country until 2032 (roll-out phase 2).

Infrastructure competition

As mentioned above in Liechtenstein a vertical separation between network (layer 1) the operation of the network(s) (layer 1) and the supply of services is in place. This separation was not introduced by regulatory means but by decision of the Government of the Principality of Liechtenstein as owner of both undertakings: LKW is the network operator which only offers physical access to its networks (including dark fibre and lambda wavelength physical access , but no wholesale leased lines), while the 75.1 % state-owned Telecom Liechtenstein AG (TLI) – as well as all other alternative operators in Liechtenstein – is supplier of all relevant telecommunication services for end-users. TLI also offers wholesale leased lines but no dark fibre or HFC-wavelength access.

The way for this vertical separation was paved in September 2003 when the Government of Liechtenstein requested TLI and LKW to explore ways to restructure the telecommunication markets of Liechtenstein, which was characterised by a „competitive monopoly situation“ of both state-owned operators: TLI held a monopoly over the classic twisted pair copper

telecommunications network and provided voice, data, internet and broadband services in Liechtenstein. LKW had a monopoly over the coax-TV network and provided cable television ("CATV"), internet, broadband and data services. Every household in Liechtenstein in nine out of eleven districts has a connection to both of the networks of TLI and LKW.

The solution of the Government was the restructuring of the telecommunication markets by bundling all network and infrastructure related issues (planning, building, operation, provision and maintenance of all networks) in the hands of LKW and the offering of services in the hands of TLI and other service providers.

In July 2006 LKW and TLI concluded a consolidation contract which implemented the restructuring of the telecommunications market.

Due to the small size of Liechtenstein and the limitation of its telecommunication markets, all fixed networks are planned, build, operated and maintained by the state owned LKW since 2006.

Demand and supply side factors

In order to stimulate the demand for ultra-broadband services, the new network strategy for FTTB provides that all newly built houses, and existing buildings with 3 or more units (flats or office space), are connected to the FTTB network (Point to Point (P2P) architecture, 2 fibres per unit) in roll-out phase 1. Existing buildings with 3 and more units are connected without charging additional costs. In addition owners of existing buildings with less than 3 units have the possibility to connect their buildings for a flat fee during local roll-out works in roll-out phase 1 (instead of waiting for the second roll-out phase). The internal cabling of the building has to be adapted by the owner at his own cost. The necessary investment for FTTB will be borne by LKW who will provide the FTTB service (ULL-fibres) initially for the same price as ULL-copper, until the next revision of the regulated access prices. Currently first internet services with very high capacity internet access have been introduced to consumers, with a bandwidth of up to 1 Gbit/s.

Regulation

Generally SMP regulation is applied in Liechtenstein in all relevant markets. Focussing on the markets relevant in the given context of NGA LKW is SMPO on the market for physical access to all network infrastructures (access and core networks) and TLI is SMPO on the wholesale market for broadband access.

Regulatory measures towards LKW ensure equal access to all passive infrastructures, including access to the unbundled local loop, shared local loop, dark fibre, ducts, manholes and colocation.

On the wholesale market for broadband access TLI is obliged to offer a bitstream access product on cost oriented prices in a non-discriminatory way. This obligation is also applicable to services rendered on the basis of FTTB or HFC.

The prices for all wholesale access products of LKW are regulated as cost orientated prices on the basis of fully distributed historical costs according to the – also regulatory mandated –

cost accounting system of LKW. The same applies to the wholesale products of TLI, whose cost accounting system is currently under regulatory examination.

The Office for Communications closely monitors the development regarding NGA rollout and takes part in the above mentioned planning committee.

NGA in Lithuania

Fast roll-out of NGA infrastructure in Lithuania is a good example of successful combination of private sector and State efforts in this area. Urban areas of the country are characterised by well-developed NGA infrastructure – this is the result of effective competition in e-communications market that lead to operators' investments into advanced infrastructure. In the rural areas unattractive to private operators, public intervention was implemented – State financed construction of backhaul (i.e. middle-mile) network in not served areas, in order to reduce the entry barriers (by lowering investment costs) for commercial operators and thereby encourage them to extend their broadband network coverage in rural areas.

The investments in NGA networks began shortly after liberalization of the electronic communications market in 2003. Around 2004, alternative operators were the first ones that started investing in fiber networks in Lithuania as a reaction to incumbent operator's (TEO LT, AB) upgrade of its copper network to ADSL and ADSL2+. The investments were facilitated by symmetrical regulation of infrastructure sharing and availability of access to ducts at competitive prices. The actions taken by alternative operators, consequently, fostered the incumbent operator's investments in its FTTx network from 2007. TEO LT, AB was mainly investing in FTTH, while the alternative operators in FTTB. Initially the investments were targeted at densely populated areas, but later operators started investing in less populated districts of main cities. NGA networks are based on deployment of FTTx technologies. DOCSIS 3.x is deployed scarcely and VDSL services are not available. EU funds and state-aid backed projects helped to construct fiber networks (backbone networks and last mile networks) in "white areas" where it was economically unfeasible to build NGA networks by private operators. Due to private and state investments in NGA networks, by the end of 2015, in Lithuania national NGA coverage reached 97.5 % of households.

Continuous State's strategy and State aid projects

Although Lithuania now has a well-developed NGA infrastructure and a high level of NGA infrastructure based competition, decade ago there was an obvious "digital divide" between rural and urban areas. However, things changed in 2005 as State has started implementing continuous strategy supporting development of broadband Internet access in rural areas. Development of safe and advanced electronic infrastructure, especially broadband Internet infrastructure, was one of objectives set in Lithuania's information society development strategy[100] approved by the Government in 2005, and subsequent strategic documents. This objective was detailed in Lithuania's broadband infrastructure development strategy 2005–2010[101], which foresaw public intervention for development of broadband infrastructure in underserved rural areas. In 2005 Lithuania's government initiated RAIN (Rural areas information technologies broadband network) projects[102], i.e. publicly financing (from European Regional Development Fund and national co-financing) the development of backhaul infrastructure in rural, underserved areas. The 1st phase (2005-2008) included construction of ~ 3400 km of fiber optical lines (467 rural townships connected to broadband infrastructure). The 2nd phase (2009-2015) included ~ 5800 km of fiber optical lines (982

[100] https://www.e-tar.lt/portal/lt/legalAct/TAR.A85ECD751A06
[101] https://www.e-tar.lt/portal/lt/legalAct/TAR.32F7B1D6EBC4
[102] State Aid Scheme SA.28192 „State aid N 183/2009 – Lithuania: Development of Rural Area Information Technology Network"

rural townships connected to broadband infrastructure). RAIN network is owned by the State and managed by state-owned non-profit legal entity which provides only wholesale services to all operators on non-discriminatory, equal terms. Operators can use its infrastructure to offer retail broadband services to end users in the rural areas. The infrastructure of RAIN is constructed only in areas where it doesn't exist, i.e. duplication of infrastructure is forbidden. The selected technologies – fiber lines – allow all potential users of the network to use the resources of the network freely without restrictions to technical solutions. It promotes development of a competitive environment.

Current strategic document for the information society development in Lithuania – Information Society Development Programme 2014–2020 "Digital Agenda for Lithuania", approved by the Government of the Republic of Lithuania in 2014 – among its priorities foresees to further develop broadband electronic communication networks in underserved areas. Main targets in this area for 2020 are as followed:

- 50 percent of all households would be using 100 Mbps or faster Internet (in 2014 – 7.2 percent);
- 100 percent of all households would be covered by fast broadband Internet, i.e. 100 percent fast broadband coverage of households (in 2014 – 73.3 percent);
- Penetration of broadband access (number of subscribers per 100 inhabitants) would reach 65 percent (in 2015 – 40.4 percent).

For 2014–2020, a plan of State's further broadband infrastructure investments and measures to stimulate private investment was approved by the Ministry of Transport and Communications. This Lithuania's New Generation Internet Access Development Plan 2014–2020[103] combines measures such as grants for project aimed at further development of fast broadband infrastructure in remote, rural areas, with additional measures aimed at increasing demand for fast broadband services among potential users (by informing them, providing access to relevant information about choices of operators/services, etc.) and creating more favourable conditions for private investment (e.g., by reviewing current regulatory norms and requirements).

Infrastructure competition in Lithuania

In Lithuania, infrastructure competition is one of the main drivers for NGA. Demand for copper and fiber local loop unbundling services and bit-stream services is negligible. Alternative operators prefer developing their own networks instead of buying local loop unbundling or bit-stream services. They are mainly using ducts of incumbent operator or in some rare cases construct their own ducts. It is considered that infrastructure based competition was enabled by the availability of access to ducts and particular strategical decisions of operators at particular periods.

Alternative operators which deploy FTTH/FTTB were forerunners of NGA investment. They started offering high speed connections to attract more consumers as a reaction to retail offers of TEO LT, AB. As it was mentioned earlier, the incumbent followed the alterative operators by also investing in FTTH solutions. In the last couple of years mobile operators

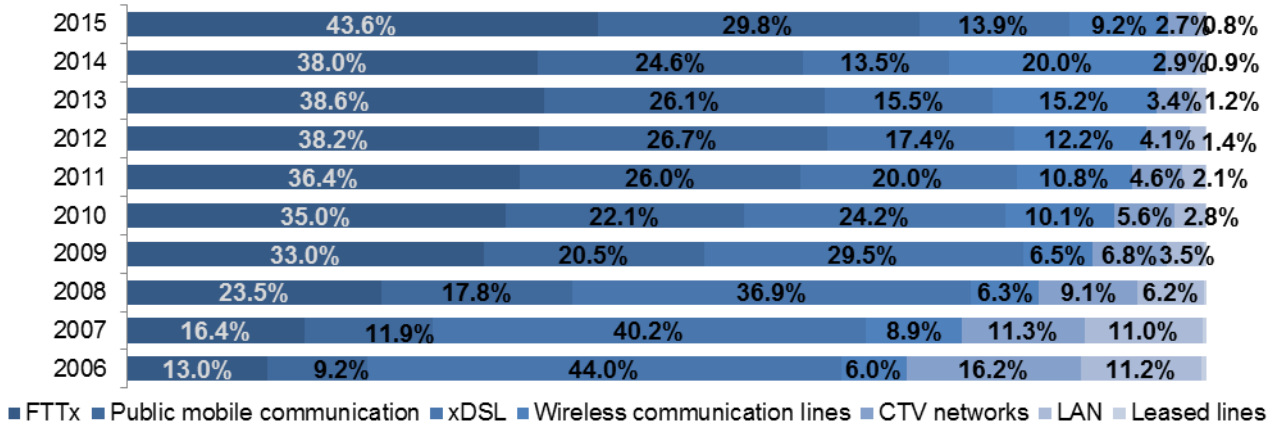
[103] https://www.e-tar.lt/portal/lt/legalAct/7e1fdab0600411e4bad5c03f56793630

have been investing in the development of LTE networks. At the moment 91 % of population can use LTE technology in Lithuania.

Demand side factors

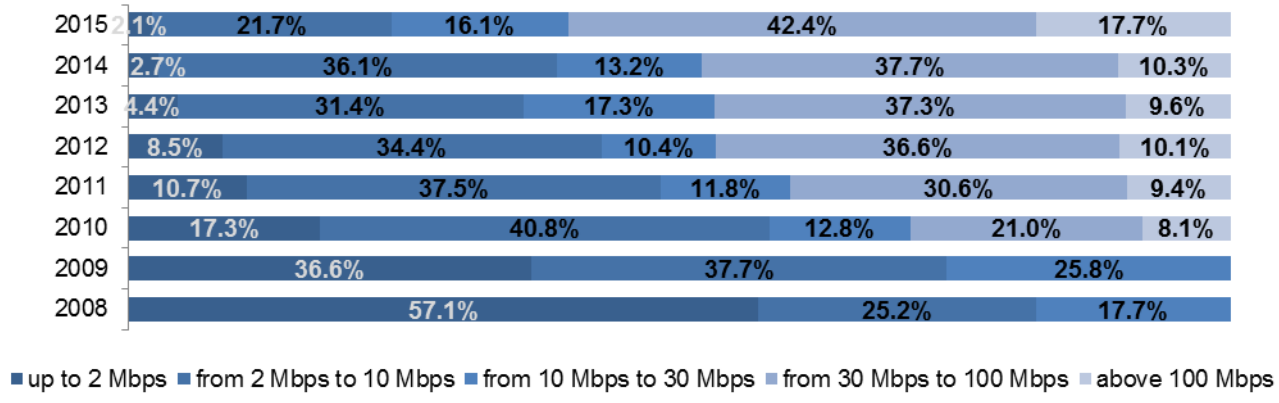
In Lithuania, there are two prevailing broadband Internet technologies, i.e. FTTx and mobile (see Figure 1). Mobile and fixed broadband technologies are considered as complements rather than substitutes as pricing for mobile broadband services and the threshold applied for mobile broadband usage is different from fixed broadband services. It is also worth mentioning that at the end of 2015 incumbent operator's (TEO LT, AB) market share of FTTx subscribers was 43.6 %.

Figure 24: Distribution of subscribers by the fixed and mobile communication technologies used for the access to Internet services in Lithuania in 2006–2015, in per cent[104]



FTTx technology ensures high speed connections for end users. Nowadays we can see that consumers prefer and are willing to move to higher speed Internet: by end-2015, 60.1 % of all subscribers had access of at least 30 Mbps and 17.7 % of subscribers subscribed to 100 Mbps or higher access (see Figure 2).

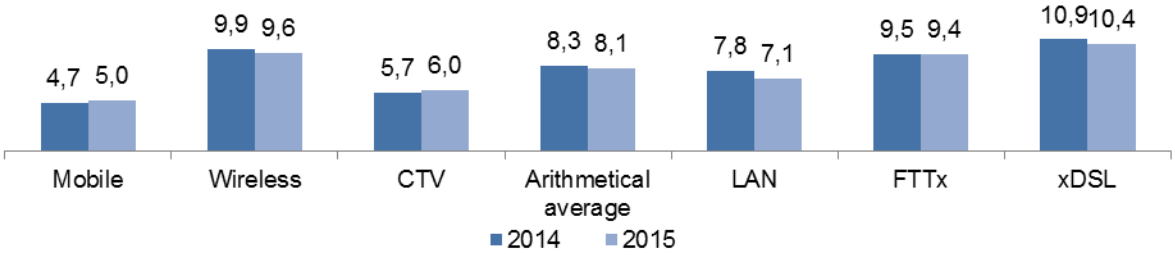
Figure 25: Number of subscribers connected to the Internet using fixed communication technologies by speed rates in Lithuania, in per cent, 2008–2015[105]



[104] Source: RRT.
[105] Source: RRT.

Availability of high speed services together with competitive and attractive pricing of FTTx services (see Figure 3) fosters migration from xDSL to FTTx services. End user demand for high capacity broadband connections and such demand promote competition between operators and force the investments in NGA networks.

Figure 26: ARPU for retail Internet access services by the technologies used in 2014 and 2015 in Lithuania, EUR[106]



Supply side factors

While demand side factors motivate to roll out NGA networks, access to ducts facilitates market conditions to do that. RAIN project (see above "Continuous State's strategy and State aid projects") helps to provide retail broadband services in the rural areas.

Aforementioned considerations create new trends in Lithuania. Last year incumbent operator purchased UAB "OMNITEL" (one of 3 main mobile operators). However, it should be mentioned that TEO LT, AB and UAB "OMNITEL" have always been considered as associated entities as they had been both owned by one company – "TeliaSonera AB". As a reaction to this market consolidation, stockholders of the main alternative internet services provider (UAB "Cgates") acquired other mobile operator (UAB "Bitė Lietuva").

Regulatory approach

The incumbent operator (TEO LT, AB) is designated as having significant market power (SMP) in 3a and 3b Markets of the Commission Recommendation 2014/710/EU of 9 October 2014. In both Markets (3a and 3b) the following obligations were imposed on TEO LT, AB: obligation to provide access, obligation of non-discrimination, obligation of transparency, price control and cost accounting obligation, accounting separation obligation. TEO LT, AB is obliged to provide access to unbundled copper lines, fibre lines, STP/UTP lines as well as access to ducts and dark fibre in market 3a. As for the market 3b, TEO LT, AB is obliged to provide access to xDSL and Ethernet bit-stream services. In addition to SMP regulation, a symmetrical regulation of access to infrastructure sharing is applied in Lithuania and applicable to all operators.

[106] Source: RRT.

NGA in Luxembourg

Before liberalization, coverage of copper was around 100% and cable was around 80% with a very high of penetration. The local networks of the incumbent (Entreprise des Postes et Télécommunications, EPT) have been rolled out partly with hybrid copper/FO cabling and in ducts. The incumbent is completely state owned and has recently split the retail activities into a separate legal entity called Post Telecom. Since 2008, the incumbent offered triple play very successfully including fixed telephony, Internet access and mobile services. Only since several years, the incumbent added TV access in his bundles. Bundled offers play a key role in the residential market in Luxembourg since several years and mobile only operators had to offer fixed services based on wholesale access or cable. The three large mobile operators in the market are running 4G networks covering the whole territory but are suffering from decrease in revenues coming from Roaming and termination regulation. One MNO (Orange Luxembourg) is trying to commercialize more products based on cable and not rely exclusively on wholesale products of the incumbent. Tango, second mobile operator is reselling with success VDSL and FTTP of the incumbent and gaining market share since several years. The largest cable operator Eltrona with coverage of about 50% of households in Docsis 3 and partly owned by EPT is not very present directly in the retail market and take up of cable in general is quite low, despite attractive prices.

Coverage of VDSL is over 90% and coverage of Eurodocsis cable 65% of all households. The decision to cover the whole country in FTTP architecture by EPT is based on the governmental strategy. Roll out is based on the hybrid cabling and after first roll out of P2M lines, the incumbent switched strategy to deploy FTTP in P2P architecture that should allow unbundling of fibre in the coming years.

A detailed map of current fixed broadband coverage can be found at http://ww.geoportail.lu → general portal → Infrastructure and Communications. The maps indicate coverage at municipality level of coverage above or equal 1Gbit/s, between 100Mbit/s and 1Gbit/s and between 30 and 100Mbit/s.

Other Statistical data may be found at http://www.ilr.public.lu/communications_electroniques/statistiques/index.html

Infrastructure competition

There has been limited infrastructure competition in Luxembourg that was driving the deployment of NGA. The cable is challenging the VDSL and FTTP infrastructure of the incumbent but the digital agenda of the government leaves open to network operators to invest. FTTP deployment is considered to be most future proof and possible low take up not an urgent concern. The incumbent fist upgraded its network with VDSL to facilitate competition with cable. This upgrade was rather easy as based mainly on existing decentralised DSLAMs in the networks with copper lengths below 1,2km. The deployment of the FTTP was facilitated by the hybrid cabling and responding to the obvious limitations of a copper infrastructure. The better service quality and guaranteed down- and in particular upload speeds were promoting FTTP, together with the bandwidth needed for multiple IPTV channels per household. The FTTP is also deployed in concertation with other utility providers, in particular the electricity network providers and partly the cable providers. All

cables in Luxembourg are in general in ducts. The roll out of VDSL is complete since serval years, as for Docsis 3 for large part of the country (around 75% of households). At the end of 2015, 50% of households are connected by FTTP and the next 20%-30% should follow in the coming years. It is for the moment not clear if the last 10% - 20% of households will be covered by FTTH as the estimated costs are very high for the last premises. The investments in the fixed networks by the incumbent were very large, the CAPEX largely above 30% during the last 5 years. Coverage is guaranteed by VDSL and cable, most household (around 2/3) can choose between the two infrastructures. Vectoring is only used as pair bonding to get a better performance of the existing copper cabling. The Point to Point rollout of FTTP, instead of the initially favoured Point to Multipoint has to some extend slowed down the roll out. A particularity in Luxembourg is that most MDF will be replaced by new POPs (Point of Presence) and that the concentration of FTTP lines in the POPs is rather small (maximum 2.000 lines) to secure the passive network. The mobile networks, despite the good coverage and quality (all 4G roll out almost completed) are not considered nor positioned by the MNOs as alternative to fixed connections.

Regulation

On market 4 and 5/2007, the incumbent EPT has been declared SMP and got imposed in 2014 a set of obligations. For these remedies the ILR took outmost account of the Commission's recommendations 2010/572/EU[107] and 2013/466/EU[108]. A new analysis of these markets is foreseen in 2017.

[107] Commission Recommendation 2010/572/EU of 20 September 2010 on regulated access to Next Generation Access Networks (NGA)

[108] Commission Recommendation 2013/466/EU of 11 September 2013 on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment

	M4/2007	M5/2007
Access	**Copper access network** EPT has to provide local full loop and subloop unbundling on the copper access network. In case the copper subloop is not available (e.g. if vectoring would be used), a VULA service has to be provided. **Fiber access network** EPT has to provide P2P fiber unbundling of the full loop and subloop. If technology would allow it (e.g. WDM), EPT has to offer access to the fiber P2M subloop. **Duct access** EPT has to provide complete or partial access to its ducts between the final client and the first concentration point, as well as between concentration points and exchanges. If no space is available, EPT must offer dark fiber	EPT has to provide access to naked bitstream at every exchange and at one national point (at least). The traffic handover should be realised either with “Layer 2” or “Layer 3” protocols. The ANO may ask for several profiles differing from those EPT uses for its own retail services. EPT should not impose unreasonable functional and capacity constraints.

	M4/2007	M5/2007
Non-discrimination	On top of a general non-discrimination obligation, EPT has also to assure equivalence of inputs (EOI) meaning that ANO get the wholesale products 1. according to the same procedures and with the same systems; 2. with the same delays; 3. according to the same terms and conditions and 4. with identical levels of reliability and performance than the own retail branch(es) of EPT. EPT has also to demonstrate to the ILR that all its retail services can technically be replicated with its inputs offered to the ANOs. Furthermore EPT has to publish standard service levels and propose superior service level agreements. On a regular basis EPT has to provide KPI which are published on the ILR website.	

Cost	**Copper access network** The incumbent has to respect cost oriented tariff ceilings for copper access products. The ILR fixes these ceilings on the basis of its own BU-LRIC model. **Fiber access network (NGA)** As long as the EOI is in place, the incumbent has to prove that its main retail products (flagships) can be economically replicated. This economic replicability test has to be performed according to the rules and parameters fixed by the ILR. In case the EOI is no more assured, the ILR will fix the price also for the wholesale NGA products. **Duct access** The incumbent has to respect cost oriented tariff ceilings for duct access. The ILR fixes these ceilings on the basis of its own BU-LRIC model.	The incumbent has to prove that its main retail products (flagships) can be economically replicated. This economic replicability test has to be performed according to the rules and parameters fixed by the ILR.

NGA in Malta

Summary of NGA situation in Malta

The local wired scenario is characterised by two nationwide fixed networks, the copper network owned by GO and the cable network owned by Melita. Both GO and Melita offer fixed telephony, broadband and TV broadcasting over their respective fixed wired networks. In addition, both GO and Melita own a mobile arm through which they effectively provide quad-play services. Vodafone Malta has a nationwide 4G mobile network

A few small ISPs have invested in their own wireless networks using the unlicensed spectrum band. The market presence of these operators remains negligible. At the same time, there is a potential that wireless networks will achieve further relevance as more advanced technologies continue being deployed, including networks that were initially deployed to provide mobile services.

In terms of the deployment of next generation access networks ('NGA'), Malta is very well positioned. The cable operator – Melita plc - has deployed DOCSIS 3 on a national scale and has been offering speeds of up to 100Mbps since 2013. In some areas, Melita is also offering speeds of up to 250Mbps. On its part, GO has also invested in NGA infrastructure and has upgraded a significant part of its copper network to FTTC and is attempting to offer speeds of up to 35Mbps on a national level subject to copper line attainability. In 2013, GO also started the deployment of its own FTTH network in selected areas and, as at end of September 2015, GO reported a coverage of 10.4% of residential households and registered business units.

Although the availability of NGA products has increased in the past two years, the demand for very high speed and ultra-fast broadband products remains low. Latest statistics as at June 2015 show that the total number of broadband connections with a speed of 100Mbps or more account for only 0.9% of total connections across all operators. Many a times, it is the operators themselves that increase the broadband speeds of end-users often in combination with special offers, or upon fixed-term contract renewals.

This scenario indicates that the investments made so far in NGA infrastructures have been initiated as a result of network improvement programmes rather than driven by consumers' demand for higher speeds and better products.

NGA in the Netherlands

NGA-rollout of incumbent and alternative operators and infrastructure competition

The Netherlands has the relative luxury that currently practically each household has access to two competing networks and can choose between service providers with high quality services. Almost every home has a xDSL (incumbent KPN) and cable connection (cable operator Ziggo) and – in case they have not – a fibre connection (FttH) of the main two operators (KPN/Reggefiber and CIF) is available. Also the large majority of businesses can choose between xDSL or fibre.

Cable operators have in the past ten years invested and gradually upgraded their access networks to Docsis 3.0 allowing customers to consume a triple play service at high speed. Consolidation of local and regional cable operators into finally one almost national operator Ziggo (owned by Liberty Global) last year was a main driver for investments in the transformation to two-way electronic communications networks.

Fibre rollout took initially place at a local level but in the last eight years Reggefiber, a joint venture between a construction company and incumbent KPN, ventured further rollout of FttH at a national level. Later on, CIF (communications infrastructure fund) also developed as an FttH operator in areas they acquired (the remaining) local cable operators. KPN eventually obtained full control by acquiring the remaining shares in FttH provider Reggefiber two years ago. At the moment, FttH coverage reaches around 30% of all residential households.

In areas, mainly without FttH, incumbent KPN has invested in upgrading its copper network by putting in fibre to the street cabinets (FttC). Recently KPN also started to upgrade the remaining part of the DSL access network through vectoring and pair bonding in areas where they do not have full FttH yet (DSL). ACM allowed incumbent KPN to upgrade their DSL access network by imposing VULA instead of SLU.

Finally, in the more remote areas in the Netherlands, cable is not present and DSL has not been upgraded, a.o. due to the length of the local loop. Local cooperatives have become active in accumulating demand for FttH networks and potential users willing to pay upfront payments to facilitate and to make rollout commercially viable. Also in local villages, cooperatives embrace open access in the sense that the network operator makes available passive fibres or Ethernet access voluntary, and allow network operators, but mostly service providers to offer services on local FttH networks. Last year KPN also started upgrading its DSL network in these relatively small areas.

The role of alternative operators – DSL access operators – in NGA rollout has been important in introducing better equipment and protocols and offering higher speed.

Demand side and supply side factors

The rivalry between the incumbent KPN and cable operators has pushed ahead the speed and quality of electronic communication services. Prices of electronic communications services in the Netherlands are moderate in international perspective and allowed these operators to invest and improve the quality of networks and services. On the demand side, citizens have been willing to buy the improved services and pretty much followed the supply-

driven race of operators to boost speed, also stimulated by the marketing of these operators to buy NGN services. In the more remote areas, as said, citizens are willing to pay upfront payments to have access to high quality services. Public sector involvement in generating demand has been relatively limited.

Supply side conditions for NGA rollout are relatively favourable. Population density and urbanisation is high allowing operators to decrease average cost per connection in more dense and also suburban areas. Also the quality of the copper access network is good and the average length of the local loop allow for upgrading to reach higher speeds in a large part of the country.

In the Netherlands, no ducts and poles are available to use for alternative networks. Communications providers have invested in (the upgrade) of fixed networks for their own risk and return. Therefore the CAPEX investments for new FttH-networks are relatively expensive compared to some other countries. The joint venture Reggefiber could be seen as an example of co-investment, but in practice functioned as a revenue sharing arrangement between incumbent KPN and the construction company. Investments in NGN's are helped by the fact that law for rolling out fibre infrastructure is favourable (it has to be only 2 feet underground). A downside is that this leads to frequent cut-offs due to (other) civil construction works. Operators often outsource civil infrastructure work and this has led to the use of cheaper labour from abroad. The investment in FttH is relatively inexpensive (below 1000 euro in case cable is only buried 30cm deep) and increases to around 2000 euro per line in less dense areas. The investment in upgraded copper (VDSL/vectoring) are compared to investment in FttH very low and cost a fraction in euro's per line.

Municipalities occasionally play a role in trying to include and cover remote areas. They sometimes do make money available to finance the unprofitable part of projects for rollout but run across the issue of state aid. In the past several cases have been investigated by the Commission as being unlawful state aid, also the ones brought forward by cable operators. In recent years, local and regional government initiatives have been lingering due to state aid issues.

Regulation

Regulation is aimed at promoting competition between networks and allowing entrants to use access to networks as an extra competitive pressure on top of infrastructure competition between the incumbent and cable operators. So, service competition supplements infrastructure competition. The concept of the ladder of investment has been followed by ACM/OPTA right at the start. Regulation was aimed at creating opportunities for entrants to rollout their own networks up to the local nodes of the DSL network of the incumbent operator. Entrants were favoured to buy unbundled access in order for them to provide their own retail services to end-users. Over time the initial entrants that accessed the copper network have rolled out their own networks to the most important MDF's: the largest entrant (Tele2) has finally covered the majority of the copper based connections, the second largest (M7) also covered an important part of the country. The remaining connections were covered by buying active wholesale services from incumbent KPN through regulated access.

In the last eight years these entrants have not further invested in covering all remaining MDF's and therefore reaching nationwide coverage. The remaining share of the households is serviced by small MDF locations and therefore commercially not attractive for further rollout by entrants. The incumbent's plans for migration to all IP have also caused uncertainty for further investments. Cable operators gradually transformed their cable networks from one-way transmission of TV-signals to two-way electronic communications networks provided bundled services of broadband, voice and TV and increased their presence and importance in electronic communications markets. The last eight years also saw the growth of fibre-based networks first rolled out to businesses and later on to households via Reggefiber. The other reason was the increasing relative attractiveness to buy active services instead of unbundled services, but this development has stopped in the last regulatory period. Based on these developments it is foreseen that all steps on the ladder of investment have been taken by the entrants that initially started with accessing the DSL-network of the incumbent. Infrastructure competition between the incumbent and cable operators has driven investments by these parties to upgrade their networks, jointly with the investment in fibre that took place.

In its latest decision regarding unbundled access (market 3a) ACM introduced VULA as a substitute for LLU. This is partly a choice in favour of the incumbent to further upgrade their copper access network in competition with cable operators, but it implies that physical unbundled access at MDF's will be replaced by virtual access. This will cause a more balanced playing field for the incumbent vis-à-vis cable operators, but will also imply that traditional access seekers will have to invest and catch up to compete future proof.

NGA in Poland

Network deployment

Poland's current National Broadband Plan was adopted in November 2013 and remains valid until 2020. Poland's national broadband plan foresees that until 2020 100% of households and companies should have access to internet connectivity of at least 30 Mbps and 50% of households and companies should have access to internet connectivity of 100 Mbps. National Broadband Plan mainly focuses on promoting broadband investments and expansion through initiating regulatory measures.

Poland uses the EU funds for deployment of the network and so under the previous financial perspective 2007- 2013 about 14 large backbone and distribution network projects and more than 850 access network projects were implemented in Poland for about 1.4 billion EUR. 60,000 kilometres of networks were built, including 24,000 kilometres of new optical networks. About 280,000 households gained Internet access, including 200,000 in FTTx technology.

Under the financial perspective 2014-2020, Poland will receive approximately EUR 2 billion for digital foundations for the national development (this will include common access to high-speed internet, e-government and open government, digital competences of the society and technical assistance). Funding will be carried out mainly via a dedicated Operational Programme Digital Poland. The intended intervention regarding broadband investment will focus on white areas where the networks will be sustainable, taking into account take-up potential. The programme will apply the NGA definition in the NGA Recommendation and will build on the premise of technological neutrality, where the requirement of 'guaranteed' 30 Mbps speed will refer to 'functional' best effort speed, thus allowing for grants to advanced mobile solutions.

As regards current coverage of broadband networks, in 2015 60.7% of households had access to NGA in Poland.

Regulatory approach

The regulation of NGA networks in Poland is implemented on the BSA and LLU markets.

On the BSA market, in 2014 President of UKE introduced new regulations concerning wholesale broadband Internet access services. The results of the market analysis have led to delineation of two separate markets in the scope of broadband Internet access. On the first of them, comprising predominant number of municipalities in Poland, due to the lack of effective competition and still strong position, Orange Polska S.A was identified as an operator with significant market power and a full range of regulatory obligations was imposed on it. The second market, comprising 76 municipal areas in Poland, was recognized as effectively competitive.

On the LLU market since the end of 2010 the remedies enabling access to copper, fiber and mixed networks are applied (as regards cable ducts, cabling, dark fiber and other elements of infrastructure). As regards fiber loop and active fiber, incumbent operator is obliged to grant access to cable ducts on the whole segment of loop or to dark fiber. The tariffs are regulated by the President of UKE and apply on the basis of the reference offer.

In 2014 the President of UKE issued a decision amending the reference offer on the BSA and LLU markets. The Decision regulates access to subscriber's loop implemented on the basis of fiber architecture (FTTx) both on the LLU market (conditional access) and BSA market. On the BSA market Ethernet level and access to high speeds (up to 80 Mb/s) was introduced. On the basis of the reference offer:

- alternative operators might build new broadband offers, characterized by higher capacities, on the basis of digital parameters of the transmission equipment installed by the operators on the subscribers' connections (acquired through FTTx);
- the installation of the equipment with higher transmission speeds allows operators to offer, next to telephone services (using VoIP), access to various electronic communications services, including access to internet (mail box, browsing websites), access to multimedia services (VoD, IPTV) or streaming TV.

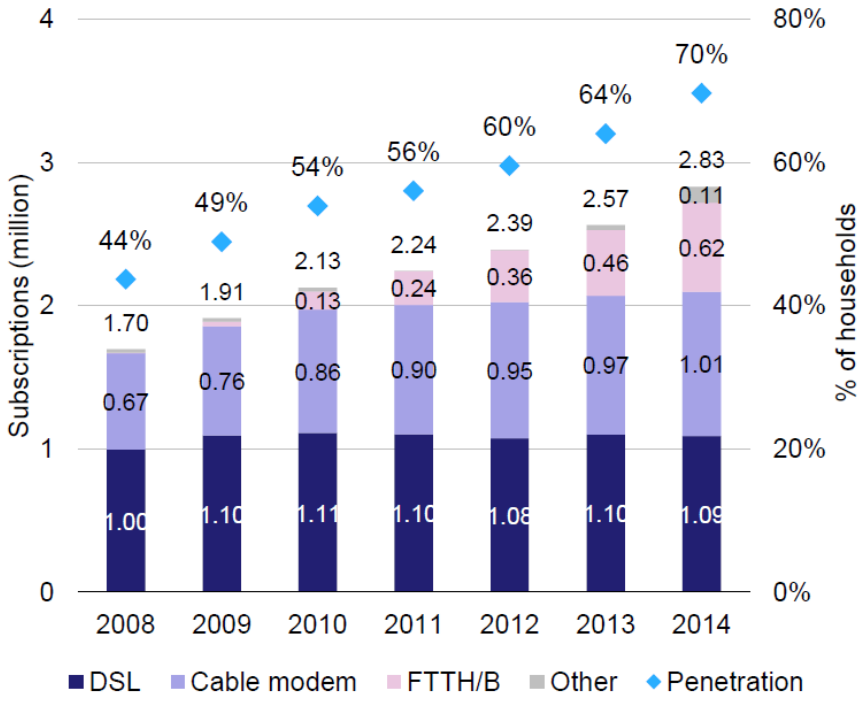
NGA in Portugal

In Portugal, the evolution of access networks has been observed in HFC networks and in FTTH networks. The development of these NGA networks is the result of a combination of competitive strategies adopted by leading operators and the role played by the intervention of the NRA and the State.

The combination of government initiatives and regulatory measures undertaken have driven operator investments, whereby, in the 3rd quarter of 2015, the number of households cabled with high-speed access exceeds four million homes, corresponding to more than 80% of overall NGA coverage (with 71% coverage on DOCSIS 3.0 and 67% coverage on FTTH-GPON).

NGA is increasingly becoming important – almost 60% of the (retail) broadband accesses are supported on NGA – although xDSL (mostly used by the former incumbent, MEO) has still a relevant share of the market. FTTH (GPON) is the third most common technology, already representing more than a quarter of total subscribers:

Figure 27: Retail subscribers by technology and broadband penetration in Portugal



FTTH continue to be the preferred means of access for new customers and the main driver of overall growth in the number of broadband accesses, mostly included in multiple-play bundles.

It is estimated that about 8 out of 10 private households had a multiple-play bundle at the end of 2015 (+7.3% versus 2014). In terms of subscriber numbers at the end of 2015, MEO was the provider with largest share of bundled services (41.1%), followed by cable operator NOS (39.4%), FTTH operator Vodafone (13.8%) and cable operator APAX (5.6%).

Infrastructure competition

The investments have focused (primarily) on the most densely populated coastal regions, where infrastructure competition is possible and, in many cases, is already a reality.

Hence, infrastructure competition was and is the main driver for NGA (fibre) investment. After the incumbent's spinoff in 2007 of its cable operations, cable exert a strong competitive pressure on the incumbent and also on (smaller) LLU operators. Cable coverage – with a footprint amounting currently to around 71% overall –, and (broadband) penetration has been very high since the "beginning" (due to the historic demand for payTV) and that played a role for the incumbent's strategic decision for the quicker rollout of FTTH-GPON starting in 2009.

The incumbent operator, MEO/Portugal Telecom (PT), invested heavily in FTTH between 2009 and 2012, reaching around 1.6 million homes passed in the end of that year. However, it is important to note that one alternative operator was the first to invest in fibre:

- Optimus was the first operator to deploy FTTH in 2008, in Lisbon and Porto. It exceeded 200k homes passed at the end of 2009 and has reached an estimated total footprint of 400k homes passed which was possible with an agreement with Vodafone in 2010 under which each operator gave the other access to its FTTH network.
- Vodafone the alternative operator deploying fibre in Portugal has expanded its FTTH-GPON footprint (more rapidly in the last two years and is closing the gap with the incumbent).

The two FTTH operators – MEO, the incumbent and Vodafone – concluded in July 2014 a network sharing agreement to deploy FTTH complementing the individual plans of the companies. The terms of the agreement gave each party an effective control over PON network infrastructures belonging to the other party. The agreement covers the sharing of fibre networks reaching 900k homes (approximately 450k homes for each party).

The incumbent has publicized in November 2015 its plans to invest in further FTTH rollout (with a NG-GPON2 internal solution), aiming to cover ~100% of the population, installing more 3m fibre lines until 2020 (~50.000 new lines per month).

Vodafone also recently announced a €125m expansion of its FTTH network in Portugal, offering speeds of up to 1 Gbps to 2.75m homes and businesses across the country by the end of 2016.

NOS, the main cable operator is also investing in FTTH on new coverage.

There are also two operators that have installed fiber networks in rural areas, with public aid.

Demand side factors

Demand is also acknowledged as an important factor determining the NGA rollout. With respect to the strategies followed by the operators, they were also driven by the demand side with the growth of (demand for) bundled offers.

In 2015, the number of broadband accesses increased by 10 percent, to 3.14m, exceeding the average annual rate of growth seen over the last five years (~9%). As mentioned above, FTTH continue to be the preferred means of access for new customers and the main driver of overall growth in the number of broadband accesses, mostly included in multiple-play bundles, along with payTV.

There is also an increasing demand for higher speeds: at the end of 2015, 60% of subscribers had accesses with download speeds of more than 30 Mbps, while 30% with equal to or greater than 100 Mbps.

Supply side factors

The investments have focused (primarily) on the most densely populated coastal regions, where infrastructure competition is possible and, in many cases, is already a reality. In fact, coverage still varies depending on population density and to promote NGA rollout in the more remote/rural areas, the government has decided to grant concessions for the operation of NGA networks in those areas.

In any case, the rapid deployment of FTTH by both the incumbent and alternative operator(s) can be explained by the low cost per house passed, mainly due to the possibility of (re)using the excellent duct and pole system, ensuring that few civil works are needed to deploy fibre.

Beyond access to ducts, the low cost of labour in Portugal is another important factor reducing fibre deployment costs and driving rapid rollout.

Hence, NGA investment requirements are relatively low mainly due to low “civil engineering costs” in Portugal, including the regulated access to the incumbent’s ubiquitous network of ducts (including poles and other installations).

On the other hand, since mobile broadband is still a complement rather than a substitute of fixed broadband, it is not considered an important driver of rollout, although it plays a certain role in pricing of other services, since the main NGA operators are integrated, having fixed and mobile operations.

Finally, it was decided by the Government in 2008/2009 to launch public tenders for the deployment of State aided NGA networks in the inner regions (more remote/rural) as part of a broad plan aiming to maximize the available coverage across the municipalities (former ‘white areas’), with a minimum coverage of 50% of the population in each area. These State aided concessions where awarded in 2011, the rollout took two years and the FTTH-GPON networks installation was finalized in general terms between end of 2013 and beginning of 2014.

Regulatory approach

Generally, SMP regulation is applied. The incumbent MEO (Portugal Telecom) has a nationwide obligation to provide access to the copper local loop (cost-oriented price control, nationwide) and active access (standard bitstream) on ADSL in non-competitive areas.

There is currently no regulated access to MEO's fibre over 'traditional' wholesale products such as fibre unbundling, VULA or other wholesale broadband access. There are, however, other regulatory measures/access obligations in place that, at least to some extent, provide relevant regulated wholesale access and that have been instrumental in allowing alternative operators to deploy their own networks.

Effective cost-oriented duct access exists

As stated above, the duct network is extensive and has good quality (compared to other European countries), and so the access obligation is effective in encouraging alternative operator investment.

Therefore, a special note is made to the pioneering role of the reference duct access offer determined by ANACOM (and in operation since 2006), an offer which facilitates investment in NGA. This access to the incumbent's ubiquitous network of ducts (including poles and other installations) is regulated under SMP regulation, following the previous market analysis on markets 4 and 5 of the Commission's Recommendation on relevant markets of 2007.

Moreover, in 2009, by Decree-Law, it was established an effective, transparent and non-discriminatory symmetric access to all ducts and other infrastructures suitable to hold networks, regardless of the respective owner.

"Vertical" in-building access is also regulated

The sharing of in-building wiring and in-building deployment costs is mandated by law: in new buildings, building owners must install copper pair, coaxial cable and fibre and operators share the cost of infrastructure. In fact, "unproblematic" access to buildings and sharing of in-house wiring is also considered relevant to ensure effective competition.

ANACOM considers that ex-ante regulation should be imposed preferentially in non-replicable assets (e.g. civil infrastructures, such as ducts and poles), promoting investment from alternative operators and also ensuring sustainable long-term competition.

Regarding State Aid, NGA concessions awarded in remote/rural areas are also contributing to the national drive for digital inclusion. There is a specific framework regarding the FTTH deployment in those areas and it should be noted that the wholesales offers in place are the result of the public tenders, which were carried out by ANACOM.

NGA in Romania

NGA-rollout of incumbent and alternative operators

In Romania, fixed networks capable of providing at least 30 Mbps are available for 72% of the households (as of June 2015):

- VDSL networks coverage was 12% households
- DOCSIS 3.0 networks coverage was 28.9% households
- FTTP technologies coverage represented 61% of the households

Telekom Romania Communications (the incumbent) implemented VDSL technology mid-2009, followed by VDSL2 in 2011. The geographical coverage of VDSL networks was 12% households at June 30 2015, decreased with 2% compared to December 31, 2014, as for part of households with VDSL coverage FTTH technology was implemented. The number of Internet access connections provided by VDSL/VDSL2 technology represented 5% of total NGA connections (4% of total broadband connections), as of December 31 2015.

At the moment, the leading providers of Internet access services using FTTP technology are RCS & RDS and Telekom Romania Communications.

RCS & RDS, the main provider of internet access services using fiber, invests in new technologies and the ongoing expansion of the optical fiber network, both backbone network and access network, gradually replacing coaxial cable connections with FTTP. Telekom Romania Communications, the second largest provider of Internet access at fixed locations, accelerated investment in FO infrastructure.

At December 31 2015 over 250 operators were providing Internet access via FTTP technology.

Regarding DOCSIS 3.0, there were 13 operators providing internet access using this technology at the end of 2015. The geographical coverage of DOCSIS 3.0 networks was 28.9% households at June 30 2015, while the number of internet access connections represented 12% of total broadband connections (15% of NGA total connections), as of December 31 2015. The main provider of Internet access using DOCSIS 3.0 technology is UPC Romania.

Moreover, there are around 200 operators providing Internet access using FTTC/FTTN + UTP/FTP. The number of internet access connections using FTTC/FTTN + UTP/FTP represents 7% of total broadband connections (9% total connections NGA), as of December 31 2015.

Infrastructure competition

In Romania, the driver of NGA rollout is infrastructure competition. FTTP rolled out by RCS&RDS, an alternative operator which is the main provider of internet access services using fiber has put pressure on the incumbent’s investments on FTTP and also on the other alternative operator’s investments in FTTP. The main alternative operators are providing services through their own access networks and they rolled out their networks in the absence of regulation on the wholesale broadband access market, which was never

regulated in Romania and, before the deregulation of market 3a (see the Regulation part), despite a very low demand for access provided through local loop unbundling, coupled with no demand for sub loop unbundling.

Demand side factors

At the end of 2014, only 58% of households had a broadband subscription, considerable lower than EU average (78%), but higher than 2012 with 8 percentage points.

In the fixed broadband market, bundles with other services (especially IP TV) are frequently offered and are also rising in numbers.

Supply side factors -including state aid if applicable

Although the competition on the electronic communication market increased considerably, this is concentrated in the urban areas, many rural areas are white areas, with no broadband coverage.

In 2014, the Romanian government awarded by auction a contract worth EUR 84 million to the incumbent Telekom Romania to connect 783 localities in disadvantaged and mostly rural areas under the Ro-NET project. The investment project was financed through the European Fund for Regional development and was set to run throughout 2015. The Ro-NET project aims to develop a backhaul network infrastructure in selected areas where there is no available infrastructure and will foster to offer internet services to around 138.000 households.

Legislative factors

The General Urban Planning Regulation which prohibits deployments of networks on street lighting poles and distribution of electricity, the alignment plantations and the building's facade elements or other elements / structures of this nature was amended, the new provisions allowing the aerial deployment of networks on rural localities. In some urban localities local authorities have taken some measures which are dealing with the banning on the installation of aerial networks.

After the transposition into national law of the EU Broadband Cost Reduction Directive, will accomplish the following objectives:

- Encouraging access to the existing passive infrastructure;
- Improving the transparency and coordination in the relevant civil works;
- The elimination of any tariffs requested by local authorities in addition to the tariff for the exercise of the access right;
- To hold at the national level of an inventory of the networks and associated infrastructure, in view of favoring the identification of future sites for networks and elements of the electronic communications networks;
- The simplification of the authorization procedure for the construction of electronic communications networks and related infrastructure;
- The elaboration as fast as possible of the Technical Norms for infrastructure deployment.

Regulation

All wholesale access regulations previously imposed on Telekom Romania were removed.

Context of the Romanian broadband market (end of 2014)

The national circumstances of the Romanian broadband market were significantly different from the ones in other EU MS. The retail market was characterized by a low market share of the incumbent (around 30% in December 2014, being the second largest player on the retail market) and by a very dynamic competitive environment characterized by more than 750 operators competing intensely over a range of different network infrastructures. Average broadband speeds were high (over 50% of the connections above 100 Mbps and over 60% are above 30 Mbps), while the retail prices charged to end-users were the second lowest in the EU. The competition in the retail market is infrastructure-based (most operators rely on providing services through their own access networks and their business plans are not based on purchasing broadband access services from other operators) and has developed in the absence of regulation on the wholesale broadband access market, which was never regulated in Romania, and despite low and decreasing demand for access provided through local loop unbundling, coupled with no demand for sub loop unbundling.

On November 2015 ANCOM notified the Commission concerning market for wholesale local access provided at a fixed location and market for wholesale central access provided at a fixed location for mass-market products (mkt 3a and 3b).

For market 3a, ANCOM concluded that no operator holds individual SMP on the market for wholesale local access provided at a fixed location. Taking into consideration the market analysis did not reveal competition concerns at retail level that could have justified maintaining or imposing additional regulation at wholesale markets or retail markets level, ANCOM withdrew all the remedies that have been imposed on the market for wholesale local access provided at a fixed location.

Regarding market 3b, given that the wholesale market for central access provided at a fixed location for mass-market products was never regulated in Romania and the retail market for broadband internet access was considered to be competitive absent wholesale regulation, ANCOM considered that the introduction of ex ante regulation was not justified.

NGA in Slovakia

FTTx of Incumbent

In 2016, the incumbent presented a new roll out plan for the NGA deployment comprising FTTH, FTTB, FTTC and FTTN technologies. VDSL2 technology is being used within FTTC and FTTN scenarios, partially with vectoring technology. Incumbent foresees to cover ~90 % of households by 2020. Actual coverage amounts to approx. 40% of households (including FTTN + VDSL).

FTTP (FTTH/FTTB) technologies

- TOP NGA (FTTP) performer covered 20% of households, 2nd undertaking less than 18% and 3rd undertaking less than 7%.
- The prevailing technology currently rolled out in Slovakia is fibre to the home (FTTH) in the point-to-multipoint topology.
- Total FTTP Coverage: 48 % by IHS and VVA methodology
- 235 is the total number FTTP undertakings; TOP15 covering at least 1 % of Slovak households,
- TOP15 reported 66% of total number of covered households.
- Rate of Adoption of TOP15 (number of active lines/number of households passed):
- 1th 32%; 2nd 32%; 3rd 30%; First two undertakings with the highest rate of covered households have less than 20% active lines.
- Dense areas (approx. half of population) to high extent covered by multiple NGA infrastructures – strong infrastructure based competition

LTE

Slovakia's largest mobile operator by subscribers, Orange Slovensko, announced the launch of 225MbpsLTE-Advanced (LTE-A) services in seven cities in December 2015. The operator is utilizing carrier aggregation technology across the 800MHz and 2600MHz bands which increases data transfer speeds and improves in-building coverage. Orange reported 4G network coverage 64% of the population in 137 cities/towns and 313 villages, while its 3G networks provide 93% coverage.

Slovak Telekom announced the launch of 300Mbps LTE-Advanced (LTE-A) services in Bratislava in October 2015. The new offering uses a 2×2 multiple input, multiple output (MIMO) system with bandwidth of 2×40MHz in the 2600MHz band. In April 2016, Slovak Telekom covered with 4G networks 76.2% of Slovakia's population in 140 cities and towns.

The latest operator to enter the Slovakian mobile market SWAN, which offers services under the '4ka' banner, says its LTE-only network now covers 50% of the country's population.

O2 Slovakia has confirmed that it is testing LTE-Advanced (LTE-A) technology using carrier aggregation in the 800MHz and 1800MHz bands. The operator says tests in three areas of Bratislava have already achieved speeds of 165Mbps. O2 adds that its 75Mbps LTE network now covers 25% of the population.

Infrastructure competition in Slovakia

More than ¾ of urban areas is covered by fibre providers, mainly represented by alternative service providers, although the incumbent owns the most extensive fibre network. Average number of fibre ISP's available in all urban areas is 3. The alternative fibre providers have to compete with cable operators present in more than half of urban areas. Together, they exert strong competitive pressure on the incumbent not only in dense urban areas with overlapping NGA infrastructures, but they constrain the incumbent within the whole country pushing its nationwide prices to competitive levels. RU revealed that DSL network in sparsely populated areas (no fibre available) has to compete with WiFi providers exerting strong pressure on ADSL technology with maximum download speeds at 10 Mbit/s (longer local loop lengths). All of these findings are in line with the incumbent's mid-term strategy of extensive NGA deployment, as there is no other way how to remain competitive and safeguard its market share. LTE is not considered as strong substitute to fixed infrastructures for the time being, mainly because of pricing of mobile services making this service more complement than a substitute. RU is of the opinion, that the main driver for the NGA development is the current state of competition in particular area together with the factors influencing company's decision making such as estimated cost of deployment, household density, demand perspective (predicted rate of adoption), prices of competition etc.

Figure 28: Distribution of speeds for different technologies in Slovakia – Half of 2015

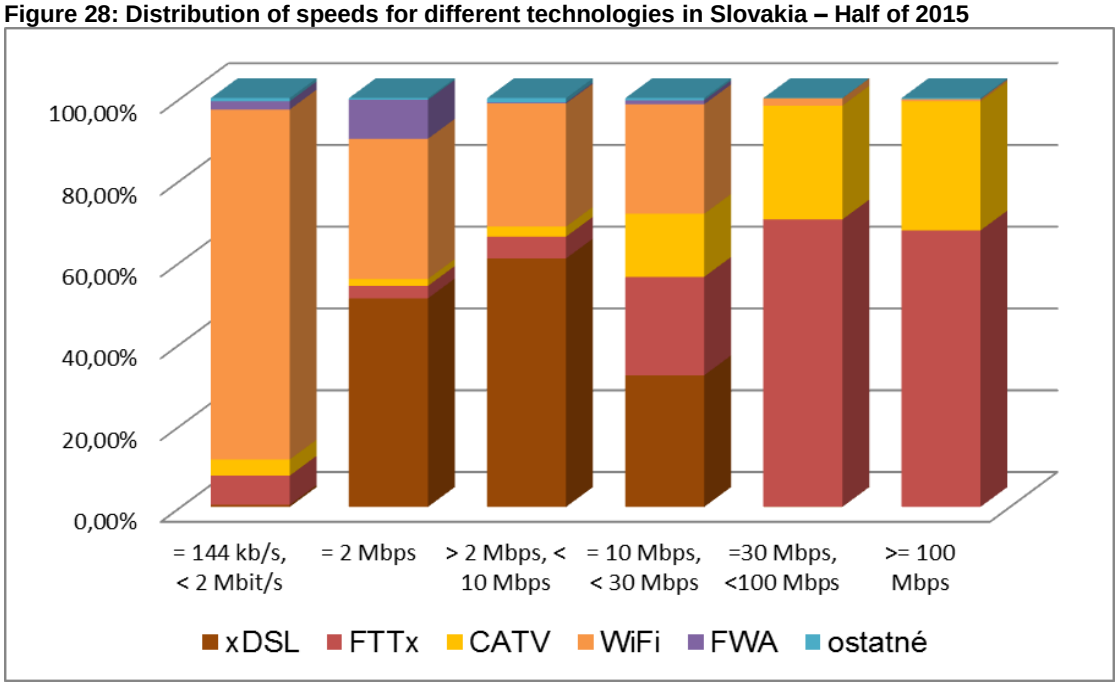


Figure 29: DSL platform competition in Slovakia – Market shares of ST and Altnets

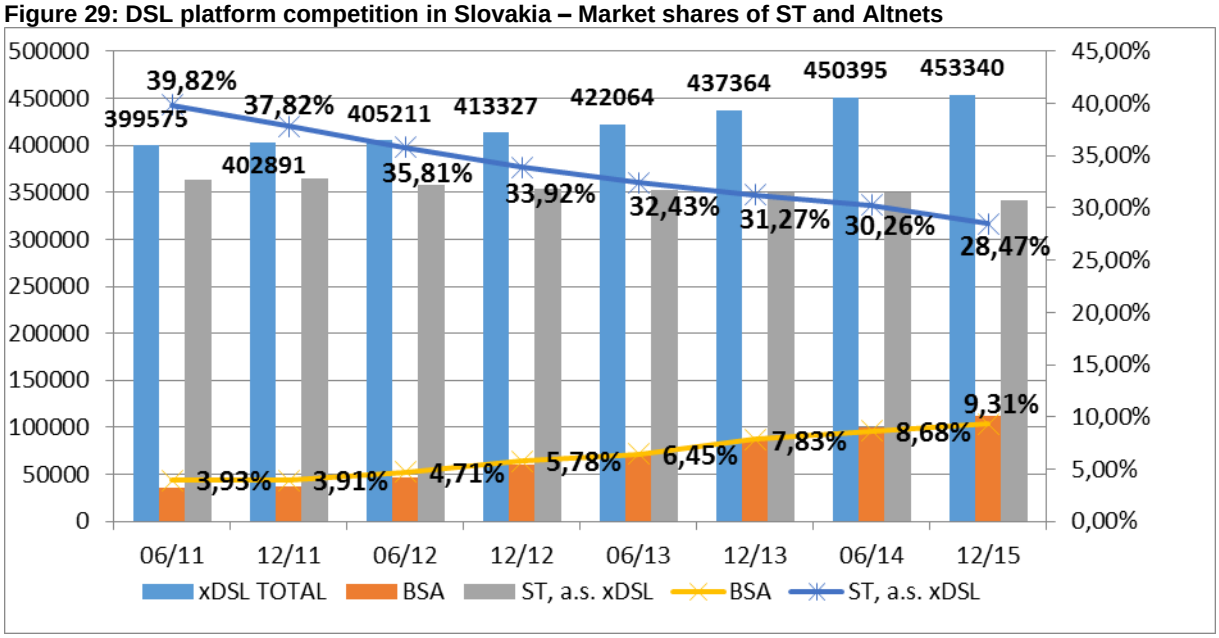
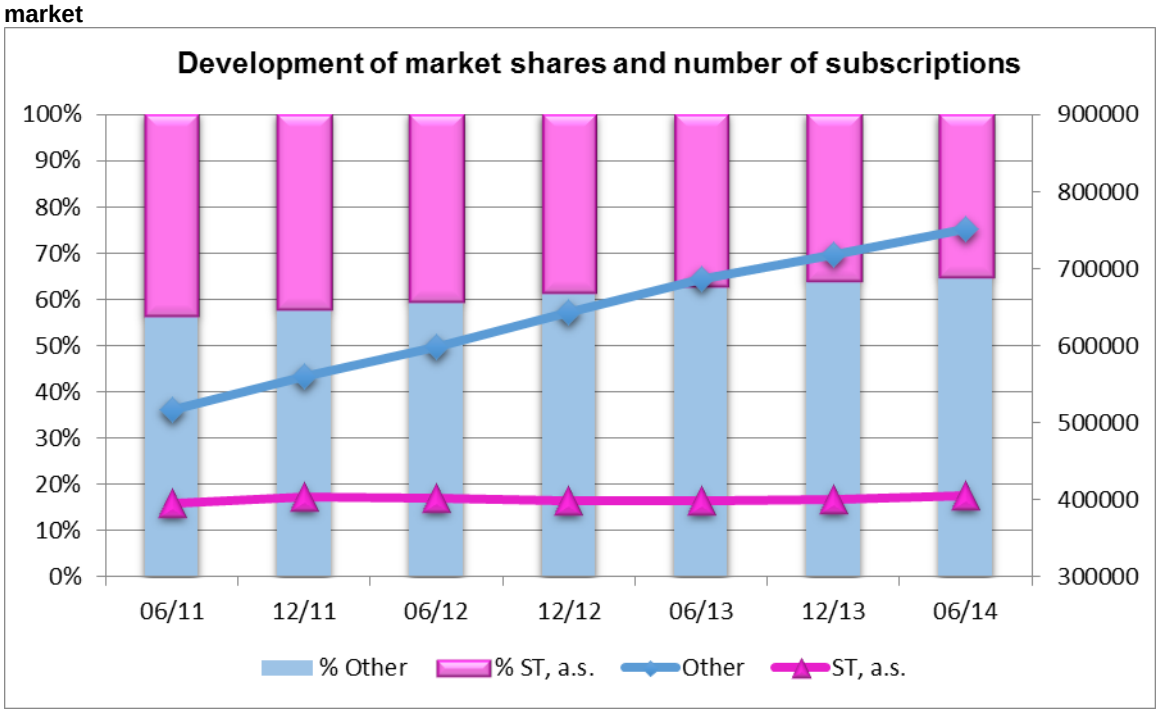


Figure 30: Development of market shares and number of subscriptions in Slovakia – Retail broadband market



Demand side factors

From the demand side factors RU considers the willingness to pay for the increased capacities as the most important one, especially in areas, where there is at least one infrastructure available. In rural areas with lack of NGA infrastructure available, there is a population with elder people, with lower skills in informatics, lower income. These factors are strongly raising a risk of lower rate of adoption for potential NGA roll out plans.

Supply side factors

Low population density is a very important factor influencing every roll out plan of NGA infrastructure. Approx. half of population is inhabited in rural areas, where the population density falls down to 40 inhabitants per square km.

Naturally, the best way how to ensure competition is to have more independent infrastructures; however we should bear in mind existing inverse correlation between number of infrastructures and sustainability of competition (strong competition based on presence of 3 or more NGA infrastructures significantly affects return on investment). One open infrastructure with wholesale regulatory remedies might be suitable scenario how to ensure effective use of deployed infrastructure, especially in the areas with lower population density. State aid in Slovakia will help to deploy backhaul networks for rural areas, while the terminating parts must be deployed by service providers.

Optimal investment strategy would opt for step by step process of NGA deployment which would be in line with demand for increased capacities. This means for instance use of FTTC/N with alternative ways of last mile used to cover areas with lower population density, lower purchasing power of population and lower expected rate of adoption might be appropriate. All investment decisions should be based on economic efficiency primarily.

Regulation

Generally, SMP regulation is applied. The incumbent has a nationwide obligation to provide access to the copper local loop and the local subloop (cost-oriented price control, nationwide). The incumbent is obliged to provide access to its fibre access network on 3a and 3b markets, on 3a market as PtP fibre unbundling, and PtMP VULA, on 3b market as regional and national L2 Ethernet access service. Prices on 3a market are cost-oriented. Concerning bitstream access, there is currently a L3 and L2 product, L3 only for DSL at the national level.

NGA in Slovenia

In March 2016, the government adopted national broadband strategy with the goal to reach 96% coverage of households with 100 Mbps and the rest 4% with 30 Mbps until 2020[109]. By mid-2015, national fixed broadband coverage of households with at least 30 Mbps amounted to 78.8%.

NGA-roll out of incumbent and alternative operators

In 2007, the incumbent operator, Telekom Slovenije started to deploy FTTH network in several densely populated cities as an immediate response to a large scale deployment of FTTH by alternative operator T-2. Incumbent in that time used cable ducts which were available in the network. Later, the fiber roll-out was suspended due to financial issues of competitor and low take-up of FTTH services by consumers. Recently, incumbent continued to roll-out NGA network, which was caused by cable operator Telemach that started to offer high-speed Docsis 3.0 connections, but had meanwhile changed its strategy to deployment of FTTC network. The main reasons behind the decision were high costs of FTTH network deployment and lack of cable ducts in the access network. To date, implementation of vectoring that would further increase access speeds is still in testing phase.

In mid-2015, alternative operators acquired up to 66% market share in the fixed broadband internet access. T-2, the first infrastructure based alternative broadband operator, started to deploy FTTH network already in 2006. Its primary strategy was to build a parallel fiber access network next to the legacy copper network provided by the incumbent and to take over its existing customers. Due to issues with financing network roll-out further plans had to be abandoned and later T-2 had to go through several restructuring programs. Besides operating its own FTTH network and providing retail services, T-2 also provides services based on LLU and recently also via bitstream access. In early nineties, cable operator Telemach started network consolidation by acquiring local cable TV operators, which is still viable strategy for its network expansion. In 2009, it started with upgrading its network to Docsis 3.0 standard and offering triple play services, which proved to be attractive to retail market. Further upgrades of its HFC network enabled Telemach to provide 120 Mbps to majority of its connections. In addition to cable network, Telemach also provides FTTH connections at some locations.

Infrastructure competition in Slovenia

In Slovenia, the main driver for NGA roll-out is infrastructure competition. In mid-2015, coverage with copper broadband network based on xDSL was available to 90.9%, while VDSL was available to 57.5% to households. Cable networks, which are almost all upgraded to Docsis 3.0, were available to 37.3% of households with very high presence also in rural areas, while FTTH networks are available to 45.0% of households. Competitive pressure on incumbent is exerted by alternative fiber mostly rolled-out in the past but recovering as well as cable networks, which aggressively compete on the market with price/speed performance.

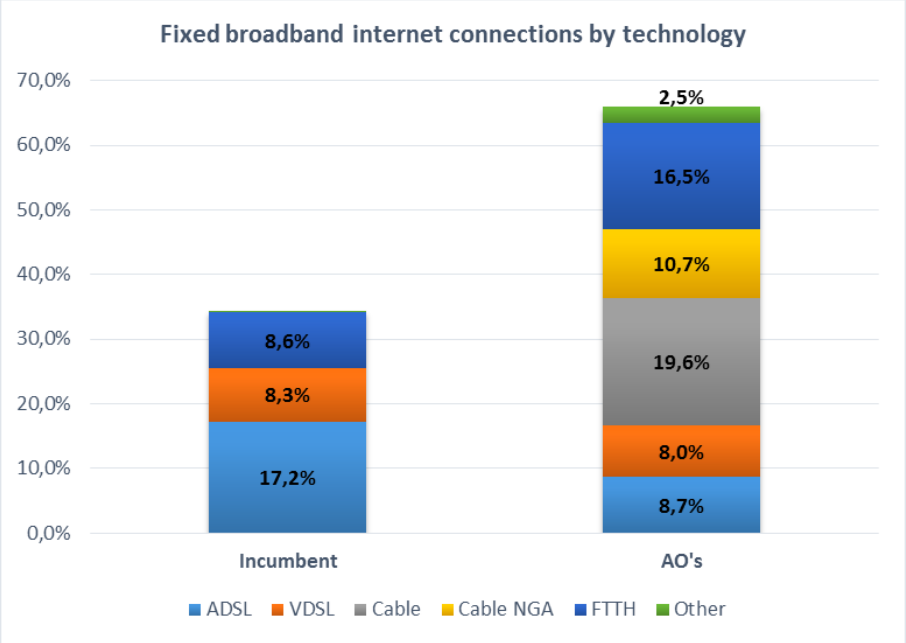
[109] National broadband strategy Digitalna Slovenija 2020, http://www.mizs.gov.si/si/delovna_podrocja/direktorat_za_informacijsko_druzbo/digitalna_slovenija_2020/

By end-2015, the most used wholesale access product on incumbent fixed network is local loop unbundling on both copper and fiber access lines. Local loop unbundling accounts for 66.1% of copper and 76.8% of fiber access lines, where the rest accounts for bitstream access. Due to low economies of scale, sub loop unbundling is not used by alternative operators. Mobile infrastructure wasn't yet considered as an important driver for fixed network roll-out, but rather as a complementary infrastructure for coverage of underserved rural areas, where LTE coverage accounts for 96.9% of households.

Demand side factors

Consumer demand for high speed offers, which is next to infrastructure competition another driver for NGA roll-out, was low to moderate in the past. By end-2015, penetration of fixed broadband internet connections accounted for 70% of households, where a half of those were serviced by NGA technologies[110]. The figure below shows retail market shares by technologies provided separately for incumbent and alternative operators. Overall, xDSL is still the leading technology with 42.2% of all broadband internet connections, followed by cable with 30.3% and FTTH with 25.1%. Connections provided by NGA technologies, which include FTTH, cable with Docsis 3.0 and VDSL are growing and reached 52.1% of all broadband internet connections.

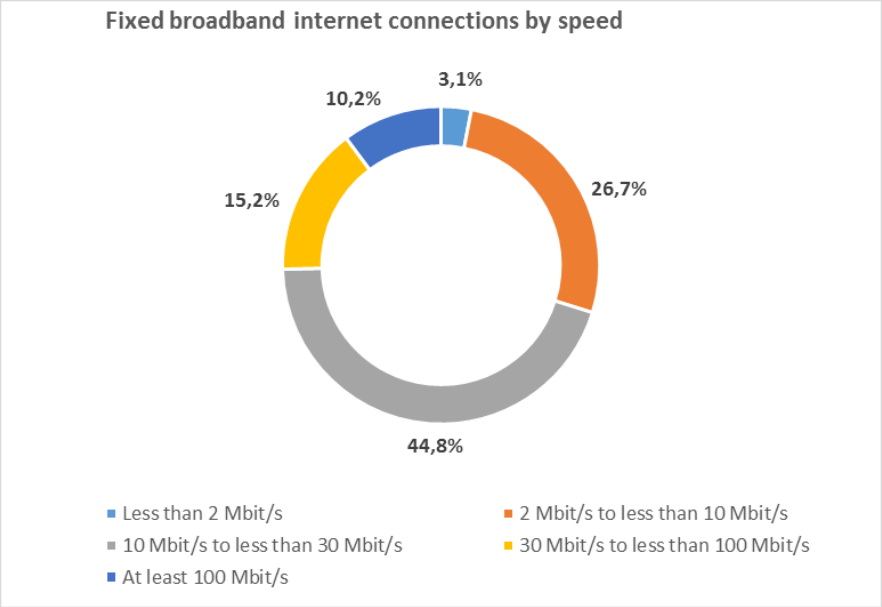
Figure 31: Fixed broadband internet connections by technology in Slovenia.



In 2015, demand for higher speeds started to pick up, which is result of intense price competition that was caused by high speed offers on cable networks. The outcome of rivalry on the market was that consumers got higher speeds for the same price. By end-2015, majority of connections provided 10 to less than 30 Mbps, which corresponds to 44.8% of the market. Also speeds 30 to less than 100 Mbps and speeds 100 Mbps and above accounted for moderately high 15.2% and 10.2%, respectively (figure below).

[110] AKOS quarterly market report end-2015, http://www.akos-rs.si/files/Telekomunikacije/Porocila_in_raziskave/Cetrtletna_porocila/2016/Popravljeno-Cetrtletno-porocilo-Q4-2015-26-02-2016.pdf

Figure 32: Fixed broadband internet connections by speed in Slovenia.



Consumer demand for bundles with other services (i.e. fixed telephony, TV and mobile telephony) is very high and plays an important role in provision of competitive offerings by operators. Triple play offers account for 60.4% of the market, double play offers for 19.8%, quad play offer for 12.0% of the market, while pure broadband internet connection only for 7.9%.

Supply side factors

NGA coverage depends greatly on population density which is higher in urban areas due to lower cost of network deployment per connection. However rural fixed NGA broadband coverage of households with at least 30 Mbps amounted to 62.4%, which was caused by cable networks upgrades to Docsis 3.0, deployment of open-access broadband networks as well as FTTC deployments by incumbent.

In the financing period 2007 to 2013 public private partnership projects in “white spot” areas led by municipalities with open-access networks reaching the consumers were supported by a total amount of approximately 84 million EUR public resources, which were split in two phases. There are also future plans of Ministry for Education, Science and Sport responsible for the use of structural and other public funds for further NGA broadband deployment in rural areas to achieve targets set in national broadband strategy until 2020, which are aligned with Digital agenda for Europe by 2020.

Regulatory approach

Incumbent, Telekom Slovenije as an SMP operator has nationwide obligation to provide wholesale access to copper local loop and subloop, access to fiber local loop, and bitstream access provided over cooper as well as fiber. Bitstream access includes L2 and L3 products at local, regional and national levels based on non-discriminatory conditions, which includes also provision of VoIP, TV and other services provided by incumbent on the retail market

NGA in Spain

There are 3.119.597 FTTH accesses in service Spain, which account for 23.34% of the total number of broadband connections. In the case of HFC technology this percentage is 20.68%. In the last year, the number of FTTH lines increased by 101.38% while HFC ones did by 10.54%[111].

On the other hand, the footprint of NGA networks (i.e. the number of building units covered by an NGA network) has significantly increased over the last years, having grown approximately 320% between 2010 and 2015.

NGA installed accesses	2010	2011	2012	2013	2014	2015
FTTH	524.370	1.596.863	3.237.431	6.171.161	15.043.865	22.657.037
FTTN	668.724	691.156	700.193	709.616	716.396	717.162
HFC (DOCSIS 3.0)	6.789.566	8.914.681	9.477.539	9.701.047	10.013.861	10.122.894
Total	**7.982.660**	**11.202.700**	**13.415.163**	**16.581.824**	**25.774.122**	**33.497.093**

According the European Commission document Study on broadband coverage in Europe, Spanish NGA networks cover by 73,20% of national households. This percentage is higher than the EU average, which is 68.10%.

Infrastructure competition in Spain

The competitive pressure exerted by both cable and LLU operators appears to be one of the key drivers for the high level of NGA investment in Spain. In light of such competitive pressure and the loss of market share Telefónica, the incumbent operator, started to intensively roll-out a FTTH network in 2013. By the first quarter of 2016 the footprint of its FTTH network reaches a coverage of approximately 15 million building units (i.e. close to 60% of the total number of building units)., Vodafone and Orange reacted by acquiring ONO[112] and Jazztel[113] in July 2014 and May 2015, respectively, in order to effectively compete in a market where they were lagging behind in terms of investment on NGA infrastructure. Their respective NGA networks reached around 8.5 and 5 million building units by mid-2015.

Vodafone and Orange have an agreement to form a joint venture for the fibre roll-out. According to the terms of the agreement, both parties will deploy individual fibre networks in complementary areas and will facilitate mutual infrastructure access. A network sharing agreement was also signed between the Vodafone/Orange joint venture and Telefonica, allowing Vodafone/Orange access to fibre infrastructure within multiple dwelling buildings, such as tower blocks (vertical fibre infrastructure). Thanks to this agreement, Telefonica have access to Vodafone/Orange's network where it has no coverage.

[111] Source: CNMC. 4th Quarterly Report 2015
[112] Ono was the main cable operator that had upgraded its network with DOCSIS 3.0.
[113] Jazztel was one of the main LLU competitors and had deployed a FTTH network with coverage of 4 million building units by mid-2015.

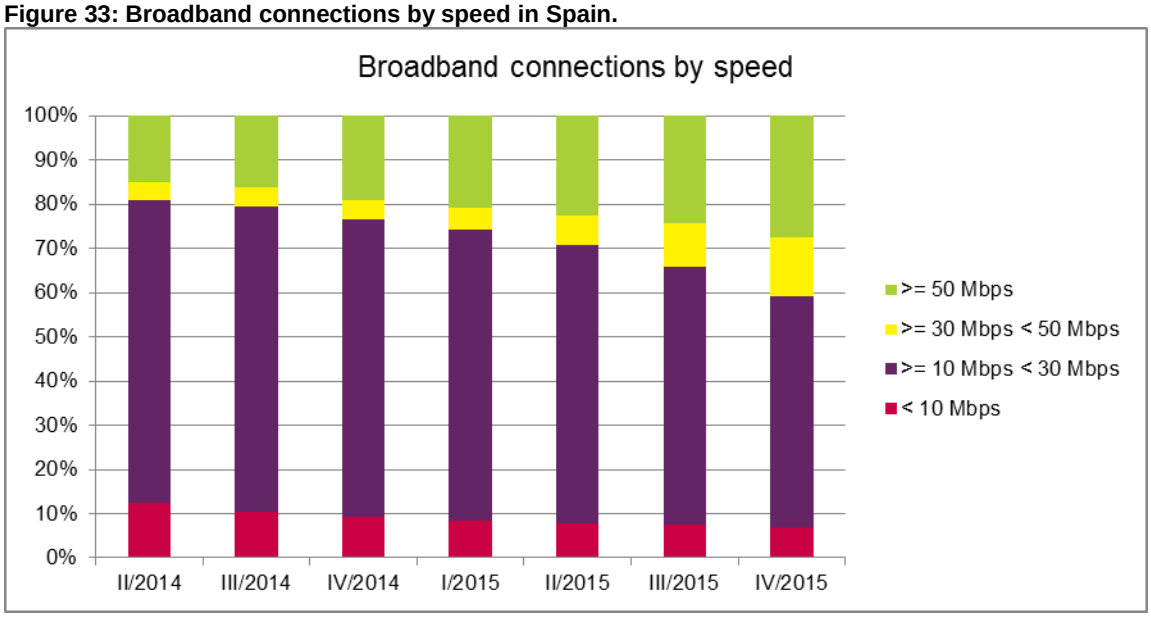
Demand side factors

In December 2015 the penetration of fixed broadband (subscriptions per 100 inhabitants) is at 28.8%. In 2014 the fixed broadband take-up (as % of households) was below the EU average[114]. Moreover, with regard to the connection bandwidth, the take-up of high speed broadband subscriptions (above 30Mbps download) lies below the EU average[115] while the very high speed broadband subscriptions (above 100Mbps download) is above[116].

The upgrade of broadband connections to higher speeds is intense. In the 2nd quarter of 2014, the percentage of broadband connections offering at least 30Mbps was approximately 17.89%. This percentage increased up to 40.81% in December 2015. 52% of these connections are provided over a FTTH network while the remaining 40% belongs over an HFC network.

One of the reasons that can explain that circumstance is that Telefónica doesn't apply a Premium price for FTTH services. In fact, the prices of xDSL based 20Mbps and FTTH bases 30Mbps connections are the same.

Figure 33: Broadband connections by speed in Spain.



Spain is characterized by a high use of bundling as a way to commercialize broadband connections. In fact, 96.7% of them are provided on a bundled basis. Convergent bundles, including both fixed and mobile telephony and broadband services, (i.e. quadruple play bundles) are particularly relevant in Spain. In particular 72.56% of broadband connections are part of such convergent bundles.

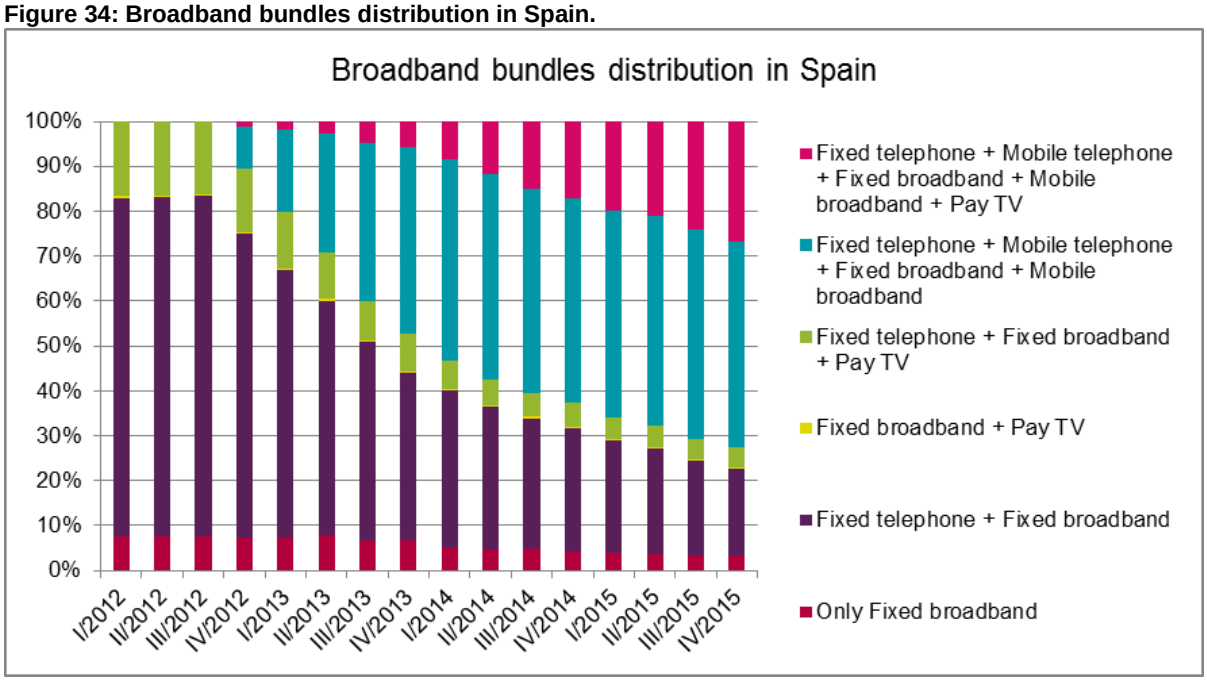
Bundles comprising Pay TV service are also becoming increasingly relevant in Spain since 2014, when Telefónica decided to add the standard Pay TV to its main broadband products at no price increase (i.e. quintuple play bundles). In 2015 Telefónica acquired DTS (the main

[114] Commission Staff Working Document. Implementation of the EU regulatory framework for electronic communication – 2015. Brussels, 19.6.2015.
[115] 23% in Spain vs. 26% in the EU. Chapter about Spain of the above mentioned EC Staff Working Document.
[116] 11% in Spain vs. 9% in the EU.

provider of Premium TV contents such as football, sports, movies, TV shows) and enriched the 5-play bundles with such contents at a premium price. Alternative operators mainly followed such bundling strategy; firstly by offering convergent bundles and more recently by offering Premium TV contents on a bundled basis. The latter is consequence of the wholesale offer of Premium channels which is part of the commitments that Telefónica agreed upon in order to obtain the approval of the acquisition of DTS by the Spanish Competition Authorities. The take-up of 5 Play bundles has significantly increased in the last two years and in December 2015 amounted to 31.70% of total broadband connections.

The migration from xDSL to NGA networks can be partially boosted by the customer's preference for higher quality Pay TV services.

Figure 34: Broadband bundles distribution in Spain.



Supply side factors

In the Spanish case various supply side factors exist that, if accompanied by the necessary operators investment, will foster the development and implementation of new generation networks. Firstly, there is an extensive duct network that is available in most Spanish municipalities, whose high capillarity enables reaching the vast majority of building units. Duct quality is high given their size, condition and capillarity, being the high availability of chambers (manholes, handholes) a very relevant aspect that permits operators to easily inspect ducts and install fibre cables through them (as opposed to other practices based on direct buried cable installation).

This facility strongly supports not only the rapid fibre deployment of the owner of the civil infrastructure but also the alternative operators that are granted with access to it on a cost oriented prices thanks to the access regulation that CMT imposed in 2009.

The presence of densely populated urban areas also favours of NGA rollout in Spain, where multi-dwelling deployment is a regular circumstance. Such structural factor benefits NGA

deployment by significantly reducing deployment costs when compared to those that operators encounter when deploying their networks in less dense population areas.

Regulatory approach

On 24 February CNMC approved the review of wholesale markets for broadband access (i.e. markets 3a 3b and 4 according to the 2014 EC Recommendation). The adopted measure identifies a number of administrative units (municipalities) where Telefónica would be obliged to provide access to its FTTH network at the level of civil infrastructure as well as terminating segment (in-house wiring). Therefore Telefónica is not required to provide a VULA like access product over its FTTH network to alternative operators. The criterion that CNMC uses to identify such municipalities is the presence of sufficient level of (i) retail broadband competition (measured in terms of market share of the incumbent operator and alternative operators) and (ii) infrastructure based competition on NGA networks (i.e. at least three NGA networks with a sufficient level of coverage). By contrast, in the remaining municipalities Telefónica is obliged to provide a VULA type product over its FTTH network (the so called NEBA local) where the access prices would be subject to the economic replicability test (instead of cost orientation as for the access to the civil infrastructure and copper LLU).

NGA in Sweden

NGA-rollout of incumbent and alternative operators

The NGA deployment in Sweden is focused solely on fibre. Multi dwelling units and densely populated areas in Sweden have to a large extent been covered, and current deployment is focused on single dwelling units and rural areas. As of 2014, 75% of Swedish households and companies are located in, or near, a fibre connection. 61% of Swedish households have access to broadband with at least 100 Mbps. In 2014 the number of fibre subscribers surpassed xDSL subscribers, as the influx of new fibre users is growing steadily and the number of xDSL users continuous to decline. In December 2014, the number of fixed broadband subscriptions was 3.3 million. The number of subscriptions via fibre has increased significantly, from 400.000 in 2006 to 1.4 million in 2014. A trend towards growing demand for broadband speed of 1 Gbps has also been observed in recent years.

Infrastructure competition in Sweden

The use of broadband over cable-TV networks has been stable since 2006 with around 20% of the broadband subscriptions (600.000 subscribers) and account for around 20% of the total existing subscriptions with at least 100 Mbps. The cable TV network is dominated by one operator, ComHem. The operator is a major competitor on the fixed broadband market. It is not expanding its coax network but is upgrading it.

Fibre networks in Sweden are primarily made up by local and regional networks that have been realised by municipalities, utilities and independent investors of varying size and geographical presence. There are around 180 municipal[117] networks in Sweden, which altogether are responsible for 58% of the existing fibre lines. As competition from municipal networks has gradually increased, the traditional operators have been quick to pick up the pace in their own investments in fibre. Currently, the largest fibre operator TeliaSonera[118] is extensively rolling out fibre networks to single dwelling units. Another important player, IP-Only, has in recent years invested in new fibre networks to single dwelling units, both in rural and urban areas. Also, end-users and interest groups in rural areas, where the investment in high speed broadband has had limited commercial attractiveness, have taken matters into their own hands and started building their own local fibre networks. These village fibre networks in rural areas are often partly state aid funded.

Demand side factors

The end user demand and the high willingness to pay for high capacity broadband connections are considered to be two of the most important factors behind the investment in fibre deployments in Sweden. This is even though the established practice is that owners of single dwelling units pay an installation fee of around EUR 2000. Increased demand for mobility, capacity-demanding services (such as VOD and games), financial and public services, social media and simultaneous use of more services leads to increased capacity needs among Swedes.

[117] The geographic scope of the networks is usually municipal. Most networks are owned by one or several municipalities, a few are owned by private companies.
[118] TeliaSonera is the SMP-operator on the 3a market (including copper and fibre)

Sweden has a history of political initiatives that also has had an effect on demand for high speed internet. The municipalities' involvement in broadband is to a large extent driven by a need to be able to offer welfare services, i.e. municipal information, services in education, health and social care over broadband networks. Fibre networks are initiated as a part of municipal IT-strategies about connecting schools, hospitals and municipal buildings to fibre broadband. Public e-services to the general public are of great importance as well. In 2014, 70% of taxation returns were provided electronically and increasing shares of interactions with public authorities are handled over the internet in almost every field.

The Swedish government regards fibre network as a future-proof technology, although the regulation and broadband policies are technology neutral, and high broadband take-up was an objective already in the 90s. High-speed broadband was therefore early perceived as an established matter of course among Swedes, not something new and unknown. This has contributed to the emergence of an early adoption of public e-services. In Sweden, the relation between high demand and high take-up is interdependent and has been driving forces to each other. Sweden has an ecosystem where politics and technology, government and commercial operators, as well as users and services providers have had a positive impact on each other which has resulted in high demand and fast expansion.

Supply side factors

State aid has contributed to increased market investments, especially as regards municipal networks and for commercially less attractive areas.

The Swedish Association of Public Housing Companies entered into an agreement with the Swedish Union of Tenants allowing property owners to add a mark-up to the rent for every apartment equipped with fibre broadband connection. This led to extensive fibre investments to rental apartments which are now almost completely deployed. The rollout to rental apartments probably also had a spill over effect on co-operative (tenant owned) apartments and single dwelling units and contributed to the general demand for fibre broadband.

Regulation

Sweden has the highest proportion of fibre connections in Europe and the presence of NGA infrastructure is mainly driven by demand from end users. NGA investments in Sweden can be traced back to strong competition as operators strive to deploy their networks in areas which of long-term strategic importance and to obtain market shares and thereby generate a return. The fibre deployment has been extensive despite the introduction of cost-oriented price regulation on the SMP-operator in 2011. At that time, a concern was raised that regulation would inhibit investments. This has been disproved by the rapid pace of fibre deployment.

NGA in Switzerland

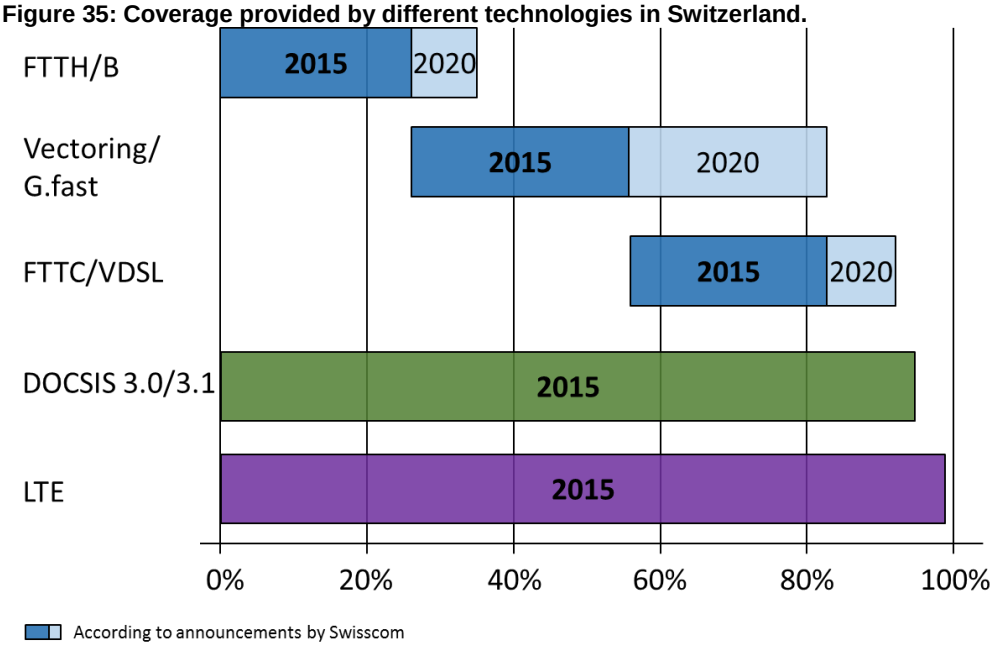
Switzerland's telecom market is characterized by a strong incumbent, by a high DOCSIS 3.0 cable coverage, FTTH initiatives by major local utilities, somewhat high ARPUs and high investment in telecommunications (~ 200 Euro per capita).

In the broadband market, the incumbent has a market share of 55%, whereas the largest unbundling operator has 9% of the market and the largest cable operator (offering up to 500 Mbps download speeds to approx. 60% of the population) has a market share of 19%. Around 200 small cable operators and 8 small unbundling operators share the remaining 17% of the market.

The incumbent's NGA coverage is currently ~85% (announced target is 95% by 2020). FTTH is currently deployed in more than 28% of households, with a FTTH take-up rate of around 27%. In rural areas, the incumbent is rolling out FTTC or FTTS (Fibre-to-the-street) with vectoring and recently announced plans to deploy G.fast where appropriate. Cable operators cover ~95% of the population with DOCSIS 3.0 and several operators announced that they plan to deploy DOCSIS 3.1 in the near future. The LTE coverage of all three mobile network operators is high, resulting in almost 100% coverage of the population.

The following graph summarizes the coverage of different networks in Switzerland:

Figure 35: Coverage provided by different technologies in Switzerland.



Infrastructure competition

Infrastructure competition is widely acknowledged as one of the main drivers for NGA deployment. The high network investment by the incumbent is a response to the high DOCSIS 3.0 cable footprint as well as to the investments of local utilities in FTTH. FTTH deployment is driven largely by infrastructure sharing and co-investments between local utilities and the incumbent operator based on a multi-fibre model. Despite high LTE coverage, mobile networks do not seem to be a main driver for NGA investment.

The trigger for FTTH investment by the incumbent was the initiatives of local utilities in several major cities. In 2008, several local utilities announced plans to deploy a FTTH network in their own coverage area by using spare capacity in their own ducts to a large extent. After implementation of these plans was commenced, the incumbent announced plans to deploy a parallel FTTH network in those cities. To avoid unnecessary duplication of investments and to create a framework for the rollout of FTTH, the regulator ComCom launched a round table for moderated discussions among the market players. Following these round tables, the incumbent operator and major local utilities agreed on infrastructure sharing and co-investment schemes based on a multi-fibre model. Furthermore, uniform technical standards (e.g. for the installation of fibre in individual dwellings) have been drawn up in various industry working groups.

Overall, cooperation activities agreed to date between the incumbent and local utilities cover almost 30% of all households in Switzerland. Experts estimate that the implementation of a four-fibre-per-household-network increases the rollout costs by 10 to 20% compared to a single-fibre point-to-point network architecture. This results in two fibre networks, each with one spare fibre. The incumbent usually provides 60% of the required investment costs and 60% of the maintenance and operating costs, while the local utility contributes the remaining 40% (according to the expected long-term market shares). Both partners have granted each other long-term indefeasible usage rights (IRUs). The incumbent and all utilities offer wholesale access to their FTTH-network on commercial terms.

Demand side factors

The significance of demand in relation to NGA investment is not very clear. In Switzerland, broadband penetration is high (44%). Furthermore, the prices for telecommunication services, and also the willingness to pay, are both generally somewhat high (as is the general income level). As a result, ARPUs (and investment per capita) are high when compared to other EU countries. However, though there is a willingness to pay an extra premium for very high-speed connections, so far this has proved somewhat limited. The growing demand for bundles, especially with sophisticated TV services, plays an important role for very high-speed subscriptions. However, the demand for speeds above 30 Mbps, at 37% of subscriptions, is somewhat higher than the EU average though far below that in other countries.

Supply side factors

Switzerland is characterized by a high population density of 200 inhabitants per km^2, while in a third of the country there are 450 inhabitants per km^2. Most premises are covered by ducts of the incumbent operator and 95% of households have cable access. The average length of the local loop is approximately 1800 meters, while the average length of used ducts per access line is 19 meters. Many local utilities, owned by the respective municipalities, have a high quality duct network with spare capacity and they have constructed their own fibre network (in most cases in cooperation with the incumbent).

There are no direct state aid projects; however the investment of municipality-owned local utilities may be regarded as indirect state aid in certain cases (low financing costs, deficit guarantees).

Regulatory approach

Switzerland is not a member of the EU and therefore has a different legal framework: Regulation occurs only upon request by an alternative operator (ex post regulation); ULL regulation is by law limited to copper local loops such that fibre local loops are not regulated (though fibre leased lines are partially regulated), bitstream access is not regulated. However, the incumbent operator and local utilities, which own a fibre network, offer bitstream products and fibre local loops on a commercial basis. Furthermore, access to ducts, including cost-oriented prices, is mandated for the incumbent. The incumbent may meet around 90% of the demand for ducts.

The light-touch regulation for NGA-based services is often considered to be an important driver for NGA investment in Switzerland.

NGA in the United Kingdom

NGA-rollout of incumbent and alternative operators

The UK Government's goal is to provide superfast (30Mbit/s or more) broadband coverage to 90% of the UK by early 2016 and 95% by December 2017.[119]

The UK's incumbent operator, BT, commercially launched NGA services in 2010. As of June 2015, superfast speeds were available to 83% of UK premises, whereas speeds of 100Mbit/s and 300Mbit/s were available to 46% and 2% respectively of UK premises.[120]

BT Openreach (the functionally separate subsidiary of BT which provides Access Services to downstream communication providers) has largely deployed FTTC; only 1% of its NGA deployment has been FTTP. FTTC been deployed via VDSL2 street cabinets, whereas FTTP has been deployed using GPON. Openreach provides CPs (including BT's downstream unit, BT Retail) access to its NGA products via Virtual Unbundled Local Access (VULA), as set out in section 5 below.

The large ANOs which use Openreach's infrastructure (notably TalkTalk and Sky) have made considerable use of LLU and were initially slow to upgrade their networks or to market superfast services. However, ANOs now account for nearly 2 million of the 5.5 million active VULA lines.

Openreach is currently trialling FTTdp with G.fast and commercial rollout is expected to begin in 2017. Openreach state that they expect to deliver ultrafast speeds (download speeds greater than 300Mbit/s) to 10 million premises (just under 40% of households) by the end of 2020, and to most of the UK by the end of 2025.[121]

However, around 2.4 million, or 8% of premises in the UK are connected by lines that are unable to receive broadband speeds above 10Mbit/s. Many of these premises are in rural areas, where about 1.5 million, or 48%, of premises are unable to receive speeds above 10Mbit/s

Infrastructure competition

As of 2015, Virgin Media offered superfast cable (HFC) broadband to around 13 million UK premises (45% coverage), and intend to grow their network further to cover nearly 17 million premises (about 60% coverage) by 2020. This is the first large scale expansion of the cable footprint since the late 1990s. Virgin Media has been driving broadband speed competition by periodically upgrading customers to faster speeds, with 50Mbps now being the slowest speed it offers.

Smaller providers are extending the reach of superfast broadband to new areas. These providers often operate in areas where there is little or no existing provision of superfast

[119] https://www.gov.uk/guidance/broadband-delivery-uk

[120] http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/connected_nations2015.pdf

[121] http://www.btplc.com/Sharesandperformance/Industryanalysts/Newsletter/Issue39/Feature/index.htm

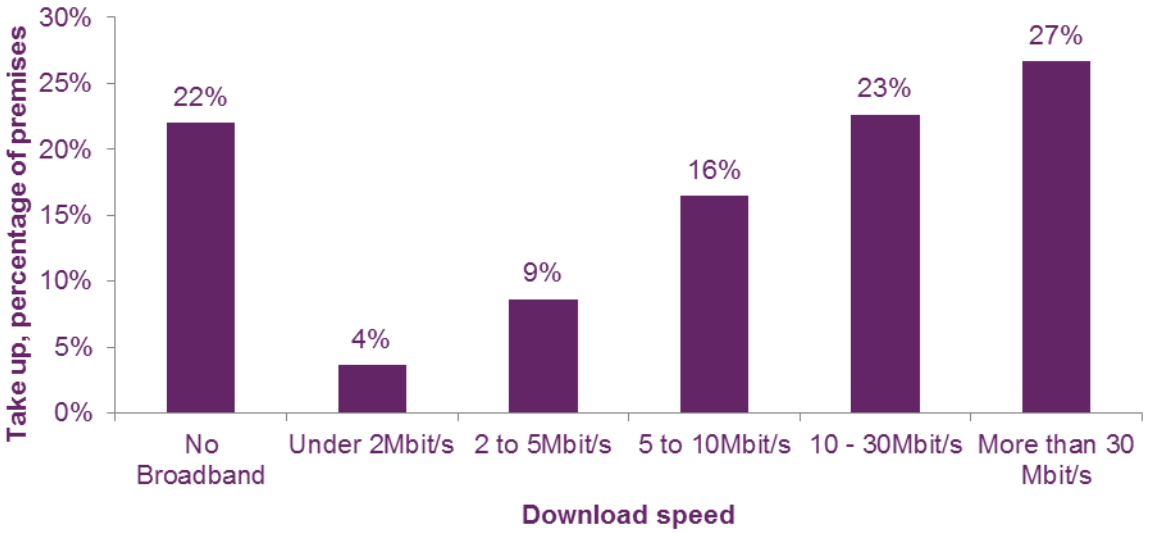
broadband. There are a variety of business models and one interesting example is deployed by CityFibre, an alternative fibre optic network infrastructure service provider that operates as an independent wholesale provider of fibre infrastructure to mid-sized cities and major towns across the UK. To date the Company has launched six 'Gigabit' City projects in York, Peterborough, Coventry, Aberdeen, Edinburgh and Glasgow, where city-wide pure fibre networks known as 'COREs' bring the benefits of ultrafast broadband to corporate clients, local government and to other carriers that can then serve residential households and SMEs with a FTTP service.

However, the UK currently has very low coverage of FTTP corresponding to around 2% of households.

Demand side factors

As of 2015, superfast broadband had been taken up by almost 8 million, or 27% of all premises in the UK. This corresponds to about 33% of coverage so two thirds of households that are covered by superfast broadband have not yet opted to subscribe or upgrade their service.

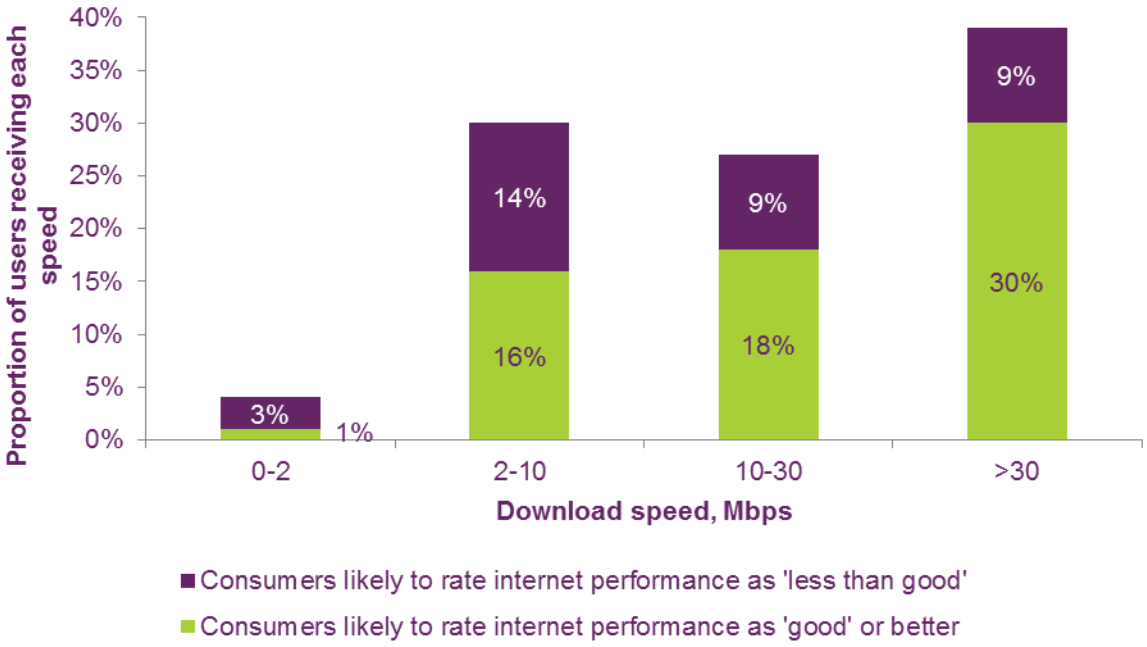
Figure 36: UK take-up of fixed broadband, 2015



In 2015 the average broadband download speed was 28 Mbit/s, whilst the average superfast download speed was 63Mbit/s.

In terms of demand side factors playing a strong current role in driving the deployment of higher speed networks, the UK picture is mixed. Figure 1 indicates that those consumers with faster connections are more likely to rate their broadband experience good, as shown below:

Figure 37: UK customer rating of their internet experience.



In general, 10Mbit/s appears to be the tipping point beyond which most consumers rate their broadband experience as 'good'. Ofcom has stated that a download speed of at least 10Mbit/s is necessary to deliver an acceptable user experience and it is currently evaluating an updated USO that reflects this speed. It has also noted that the USO specification will need to be reviewed and potentially updated as consumer needs evolve.

However, service providers that offer a mix of ADSL2 and FTTC broadband services to their customers (mostly using regulated services offered by BT Openreach) do not appear to have suffered any competitive disadvantage in terms of losing customers or market share to the cable operator (Virgin Media) which offers faster speeds. This suggests that FTTC enabled broadband speeds (30-80 Mbit/s) are sufficient to provide a satisfactory customer experience (based on their consumption needs and patterns) for a majority of customers for now. This situation may evolve in the future of course – enabled by new services and requirements (e.g. increase in video traffic or high definition IPTV) and BT Openreach is scheduled to start rolling out its faster G.fast service from 2017.

Supply side factors -including state aid if applicable

There have been a number of UK Government interventions under the Broadband Delivery UK (BDUK) initiative to improve broadband access:

i. Rural Broadband Programme (Phase 1): A £530m scheme aimed at rural areas to achieve 90% coverage of superfast broadband (in this case defined as having a download speed faster than 24Mbit/s).
ii. Superfast Extension Programme (Phase 2): A £250m scheme aimed at extending superfast coverage to 95% of premises by 2017.
iii. Competitive Fund (Phase 3 pilots): A competition for a pot of £10m of funding to pilot potential solutions for the final 5% of premises not covered by phases 1 or 2.

Regulation

The SMP operator (BT Openreach) is required to offer regulated access in the form of both passive (duct access) as well as active remedies (VULA). To date, ANOs have relied primarily on VULA, and there has been very little use of NGA passive remedies.

The two key aspects of VULA (L2 WAP) regulation in the UK are:

i. The requirement for Openreach to offer VULA on an EOI basis;[122] and
ii. The requirement for BT to maintain a minimum margin between its wholesale VULA and retail superfast broadband prices.[123]

Regulation has also been put in place to protect investment in vectoring, but to date vectoring has only been deployed on a limited basis.

[122] http://stakeholders.ofcom.org.uk/telecoms/ga-scheme/specific-conditions-entitlement/market-power/fixed-access-market-reviews-2014/statement/
[123] http://stakeholders.ofcom.org.uk/consultations/VULA-margin/statement/

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