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1 Introduction

The Agency for Electronic Communications of the Republic of Macedonia (AEC) has commissioned Analysys Mason Limited (Analysys Mason) and Grant Thornton LLP (Grant Thornton) to “*define measures for encouraging the competition development in the electronic communication services markets in Republic of Macedonia and encouraging investments in next generation networks, such as FTTH (fibre to the home), 4G mobile networks, DOCSIS 3.0 networks*”. This document is the draft report for the aforementioned study.

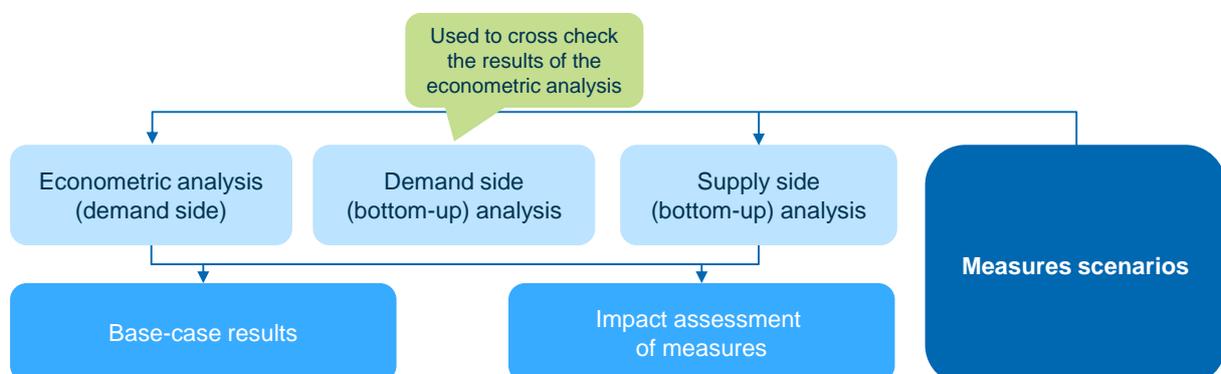
The main objective of this project is to define measures to encourage the development of competition in the electronic communication services markets in the Republic of Macedonia (Macedonia), with a special focus on next-generation networks, such as fibre-to-the-home (FTTH), fourth-generation (4G) and data-over-cable-services-interface-specification (DOCSIS 3.0 networks). The AEC also wishes to be provided with a tool that will enable it to understand market trends and to test the potential impact of proposed regulatory measures.

There is widespread agreement on the contribution of broadband to economic growth. To estimate the impact of potential different regulatory measures on the electronic communication services markets in Macedonia, we have reviewed the Macedonian broadband market from the demand side (e.g. take-up; average revenue per user (ARPU) and prices; service bundling) and from the supply side (e.g. technologies available; technological evolution; coverage viability).

We have based our analyses on historical data and data collected from the AEC and the main Macedonian operators, including Makedonski Telekom, One, VIP, T-Mobile, Kabelnet, Blizoo, TeleKabel, Neotel and Inel Internacional.

We have built a model to assess the impact of the proposed regulatory measures on the Macedonian broadband market in general and the market for high-speed broadband in particular. The model covers a time period of ten years (2014–2023) and the main structure is presented in Figure 1.1.

Figure 1.1: Model structure [Source: Analysys Mason, 2015]



The model estimates the likely evolution of the Macedonian broadband market over the next ten years (**base case**) based on historical trends, benchmarks, operators' views and data, and econometric analysis. Then a set of scenarios is defined to assess the relative impact of these measures on the base case.

Structure of this report

The remainder of this document is laid out as follows:

- Section 2 provides an overview of the Macedonian telecoms market
- Section 3 carries out an assessment of broadband market demand in Macedonia
- Section 4 carries out an assessment of broadband market supply in Macedonia
- Section 5 presents a benchmark of regulatory measures implemented in other countries for encouraging competition and investment in next-generation networks (NGNs).
- Section 6 assesses the impact of implementing specific measures in Macedonia.

The report includes a number of annexes containing supplementary material:

- Annex A presents the *Digital Agenda for Europe* (DAE) and the national broadband plan targets set out therein
- Annex B lists the benchmark countries that were used to validate our assessment
- Annex C provides more details on the econometric analysis of broadband demand drivers
- Annex D includes the country acronyms used in the figures presented throughout this report
- Annex E includes a glossary of terms used throughout this report.

2 The Macedonian telecoms market

In this section we summarise the demographic and macro-economic environment in Macedonia, followed by an overview of the Macedonian telecoms market. It is structured as follows:

- Section 2.1 provides an overview of the main demographic and macro- and socio-economic indicators for Macedonia
- Section 2.2 highlights the importance of the telecoms sector in Macedonia
- Section 2.3 describes the regulatory framework and environment governing the telecoms sector in Macedonia
- Section 2.4 describes the fixed and mobile markets
- Section 2.5 describes the broadband market.

2.1 Macro-economic outlook

2.1.1 Country demographics

Macedonia's population (2 million inhabitants at the end of 2013) increased at a growth rate of 0.1% per annum between 2009 and 2013. Euromonitor forecasts that the population of Macedonia will remain stable between 2013 and 2023. Euromonitor reports that Macedonia had around 619 000 households at the end of 2013, with around 3.3 people per household. Figure 2.1 shows the evolution of the population in Macedonia between 2005 and 2023.

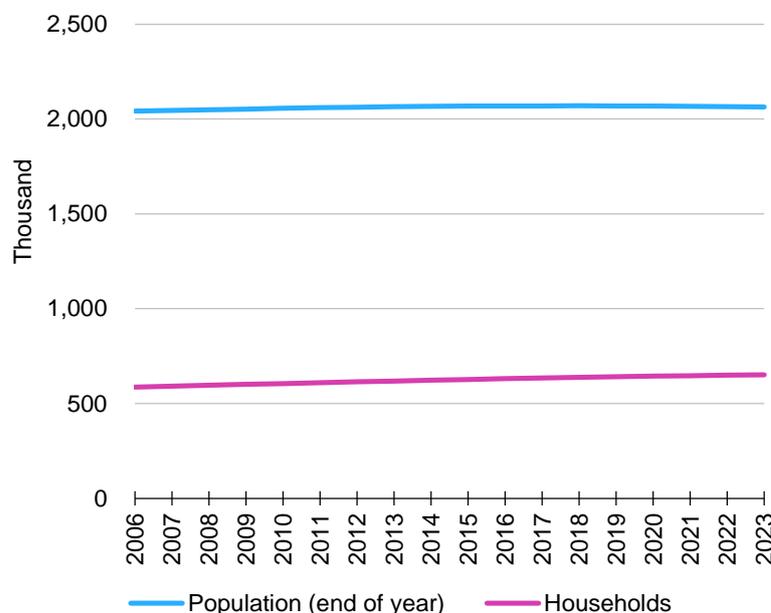


Figure 2.1: Historical evolution and forecasts of population and households in Macedonia [Source: State Statistical Office, Euromonitor, 2015]

Population density in Macedonia is around 82 inhabitants per square kilometre, which is higher than the European average of around 36 inhabitants per square kilometre but lower than most of the Western European benchmarked countries.

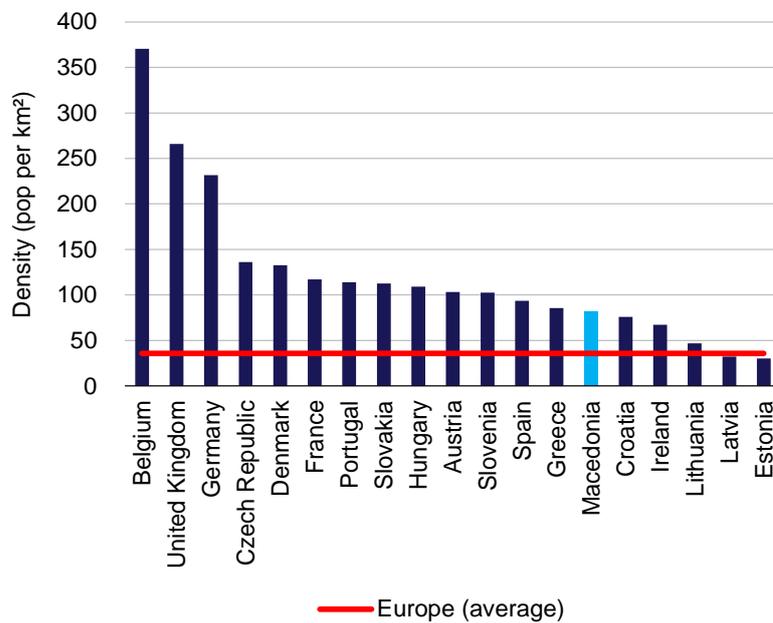


Figure 2.2: Benchmark of population density at the end of 2013
 [Source: State Statistical Office, Euromonitor, 2015]

According to the World Bank, 60% of the population lived in cities as of the end of 2013, which is a relatively low urbanisation ratio compared with benchmarked countries (71% on average), among which only Slovenia, Slovakia and Croatia have a lower urbanisation ratio. The capital, Skopje, including suburbs, accounts for 610,000 inhabitants. The top ten municipalities total around 1.3 million people, i.e. around 63% of the country’s population. Figure 2.3 shows population by city for the largest municipalities in Macedonia.

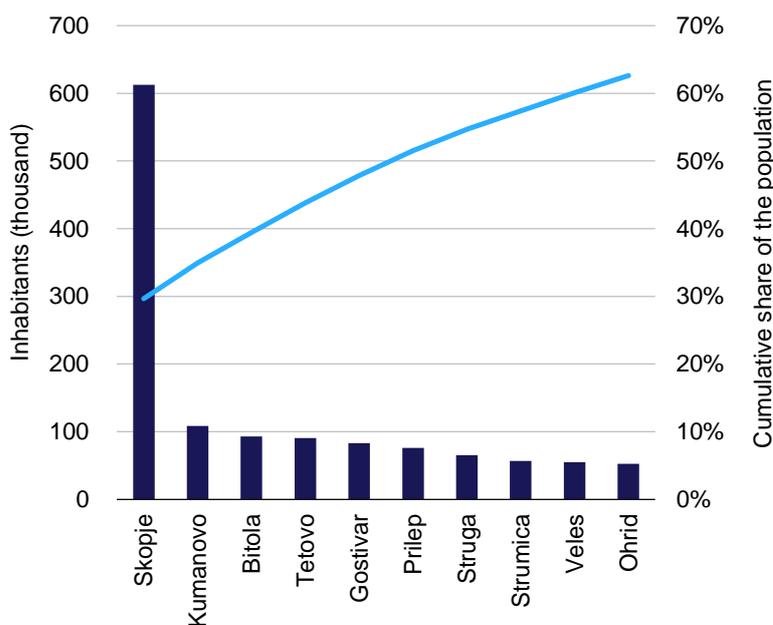


Figure 2.3: Population by city for the main ten cities in Macedonia at the end of 2013
 [Source: State Statistical Office, 2015]

As illustrated below in Figure 2.4, 90% of the population in Macedonia is spread across 55% of the land area. This population distribution curve will be a key input for the supply-side model analysis.

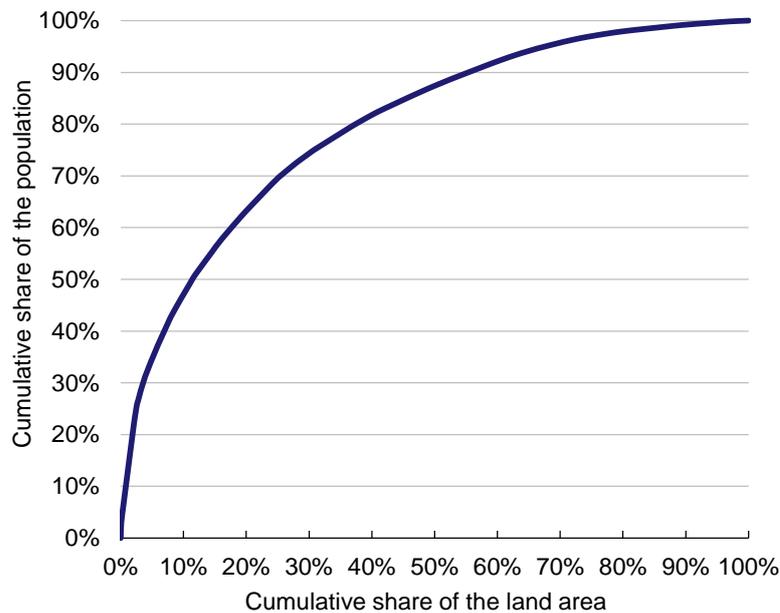


Figure 2.4: Population distribution across Macedonia at the end of 2013 [Source: National statistics, Analysys Mason, 2015]

The distribution of the Macedonian population shows that the 45% least dense areas correspond to 10% of the population. This makes it challenging to cover the last 10% of the total population in Macedonia with a fixed high-speed broadband infrastructure.

In Macedonia, as in the benchmarked countries, the split of population by age is similar, with c.17% of the population below the age of 15, while the elderly population (above 60 years old) accounted for c.18% of the population in 2013. It is expected that the population will begin to age slowly in the period from 2013 to 2023, with the population below 15 years of age losing 1 percentage point by 2023 and the population between 15 and 60 years old losing 3 percentage points in favour of the population aged 60 and above. Figure 2.5 illustrates the evolution of the split of the population by age in Macedonia, over the 2013–2023 period.

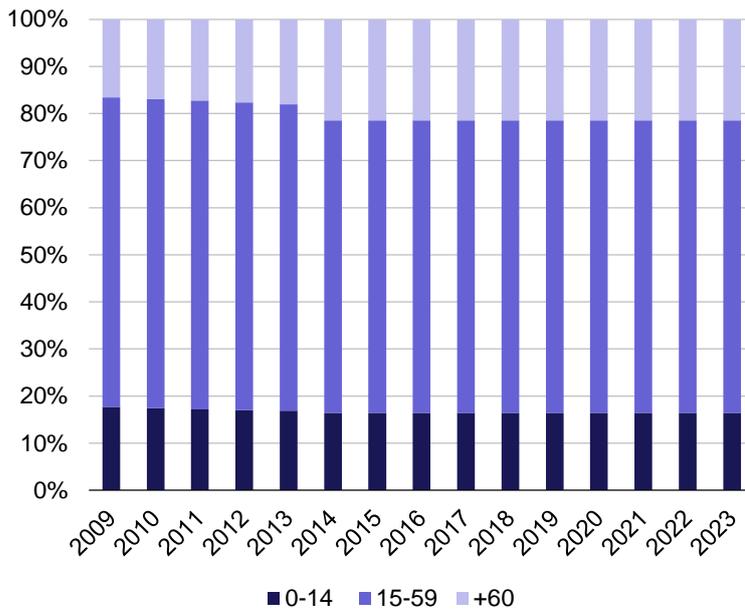


Figure 2.5: Split of population by age in Macedonia [Source: State Statistical Office, Euromonitor, Analysys Mason, 2015]

The business sector in Macedonia accounted for around 71 000 enterprises in 2013, with more than 98% of them being small to medium-sized enterprises (SMEs), defined as having fewer than 50 employees.

Figure 2.6 illustrates the number of enterprises by size in Macedonia.

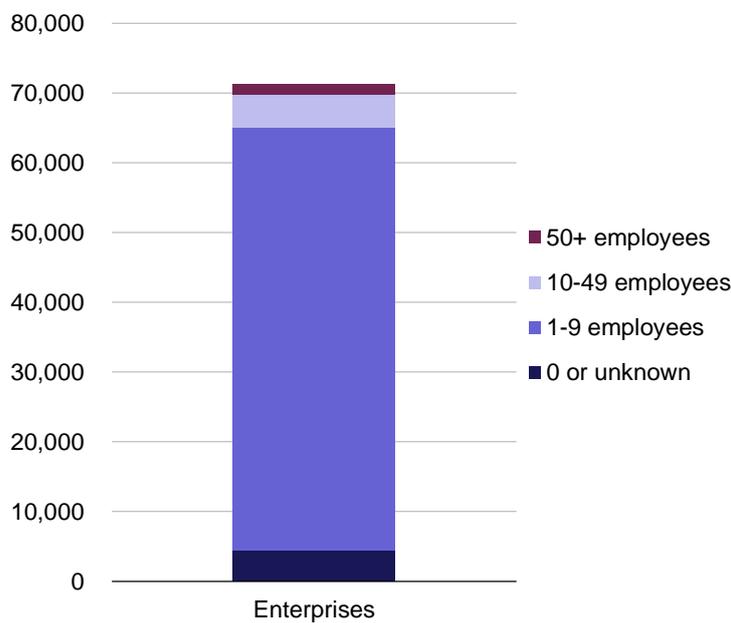


Figure 2.6: Number of enterprises by size in Macedonia in 2013 [Source: State Statistical Office, 2015]

2.1.2 Country economics

Macro-economic indicators

The growth rate in nominal gross domestic product (GDP) in Macedonia has been unstable in recent years, but with a yearly average growth rate close to 5% from 2009 to 2013. Euromonitor expects that the economy will grow at an annual average rate of c.6% between 2013 and 2020.

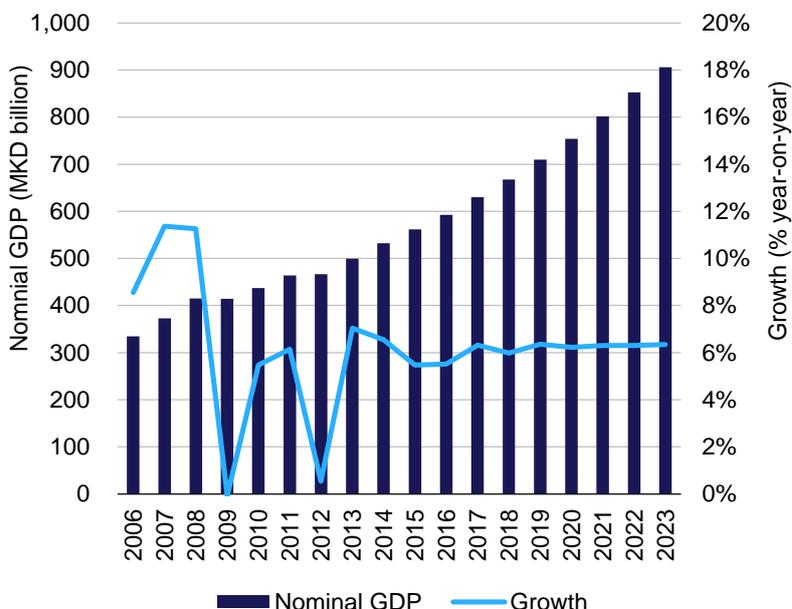


Figure 2.7: Historical evolution and forecasts of nominal GDP in Macedonia [Source: Euromonitor, 2015]

In Macedonia, the informal economy accounts for 20–45% of the overall economy, as estimated by Euromonitor. Nominal GDP per capita is also expected to rise significantly from around MKD240 000 in 2013 to around MKD440 000 in 2023, which represents a compound annual growth rate (CAGR) of around 6% per annum (see Figure 2.8).

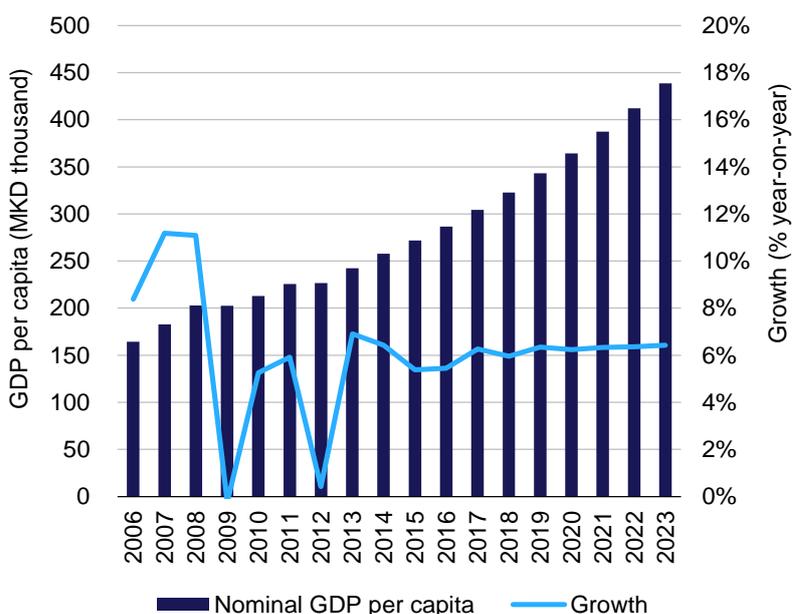


Figure 2.8: Evolution of nominal GDP per capita in Macedonia [Source: Euromonitor]

In 2013, Macedonia's GDP per capita was at the low end of other European countries, at around EUR3700 per annum (see Figure 2.9).

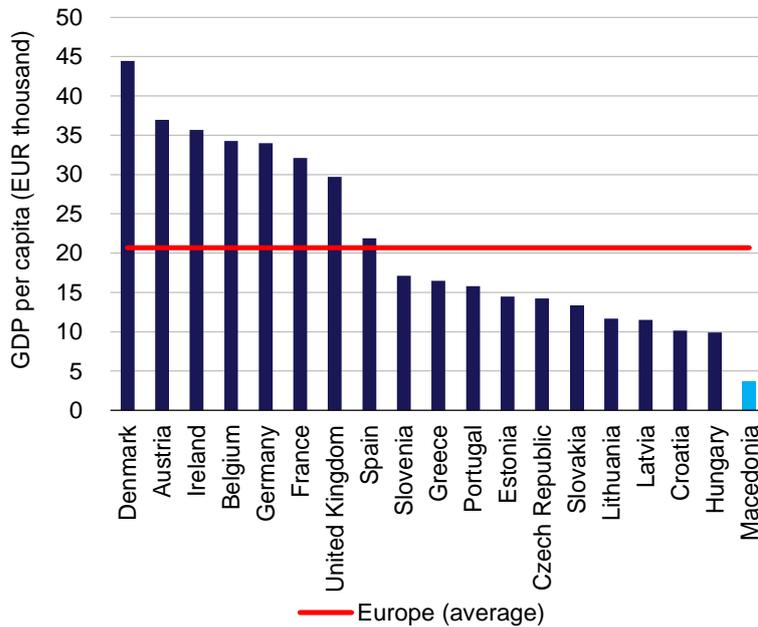
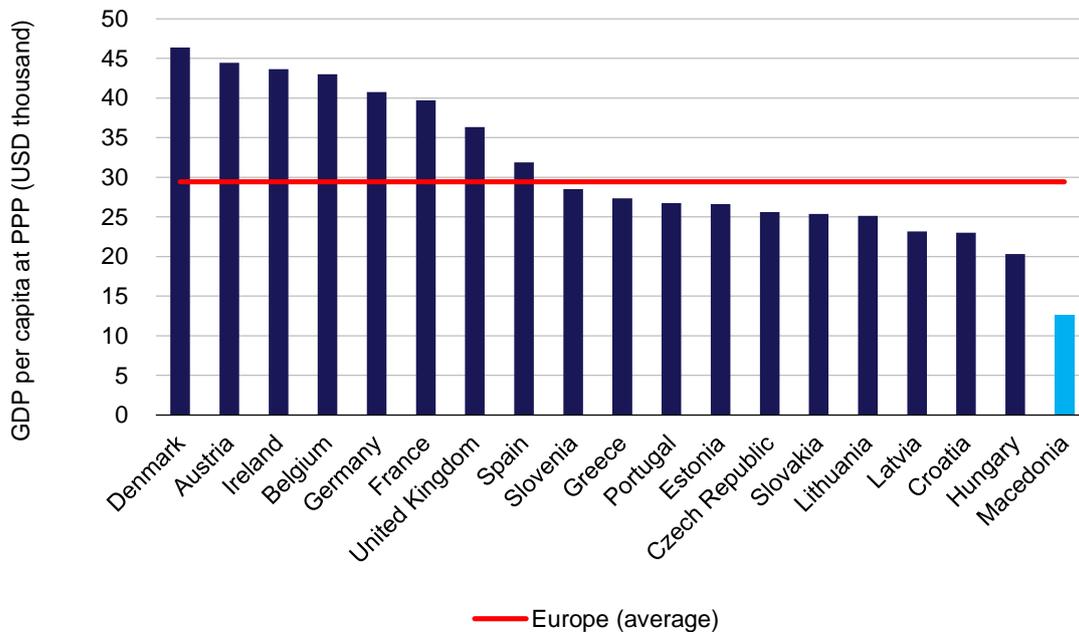


Figure 2.9: GDP per capita in European countries in 2013 [Source: Euromonitor, 2015]

Macedonia's position compared with the other countries included in the benchmark remains unchanged when using the purchasing power parity (PPP) equivalence. As can be seen in Figure 2.10, at USD13 000 Macedonia continues to be at the lowest end of the benchmark in terms of GDP per capita at PPP, behind Latvia, Croatia and Hungary.

Figure 2.10: GDP per capita at PPP in the benchmarked countries in 2013 [Source: Euromonitor, 2015]



As illustrated in Figure 2.11, the local currency unit (LCU), which is the Macedonian denar (MKD), is indexed to the euro as Macedonia is mainly exporting and importing from the European Union (EU). It is expected that this trend will continue as Macedonia seeks to remain close to the EU for exportation. According to Euromonitor, the exchange rate of the Macedonian denar to the euro was 62 in 2013; in the long term, it expected to decrease slightly to 58.

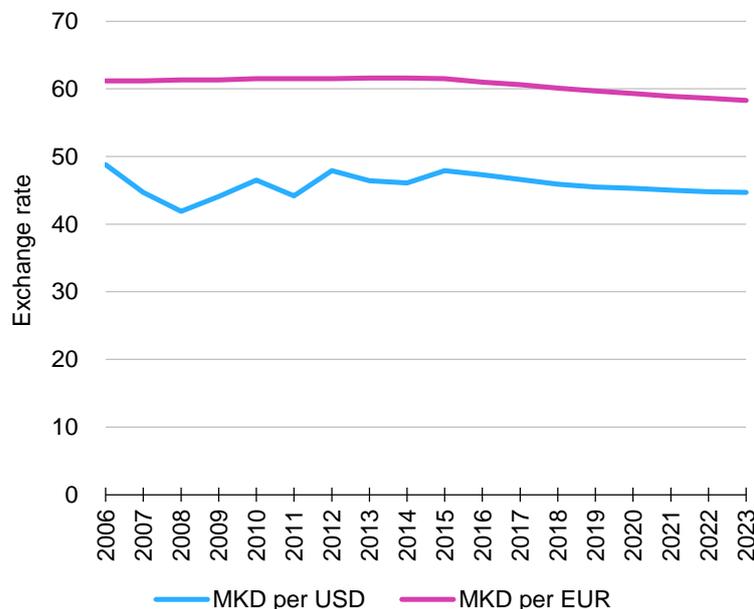


Figure 2.11: Historical evolution and forecast of the average exchange rate of the Macedonian denar to the US dollar and the euro [Source: Euromonitor, 2015]

Inflation in Macedonia has remained relatively low, below 4%, in the last few years, except in 2008 because of the international crisis. According to Euromonitor, the inflation rate is expected to average 2.3% per annum after 2017, as shown in Figure 2.12 below.

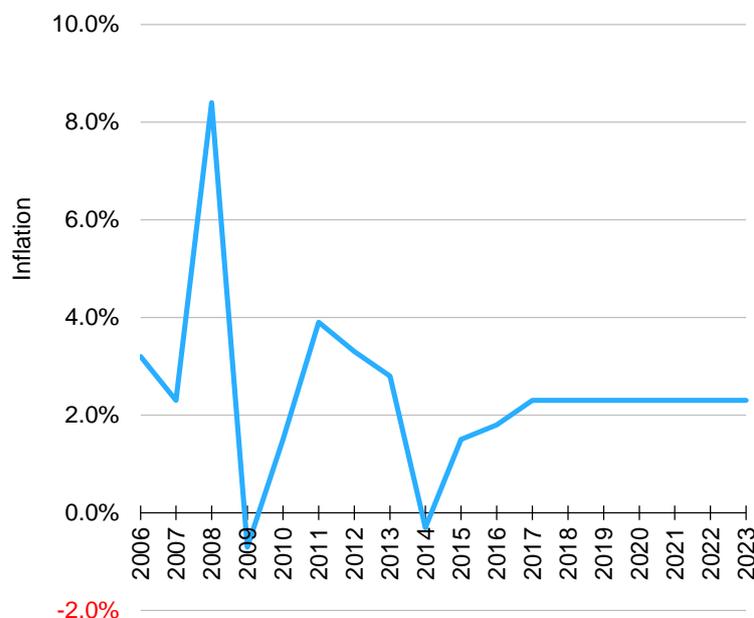


Figure 2.12: Historical evolution and forecast of inflation in Macedonia [Source: Euromonitor, 2015]

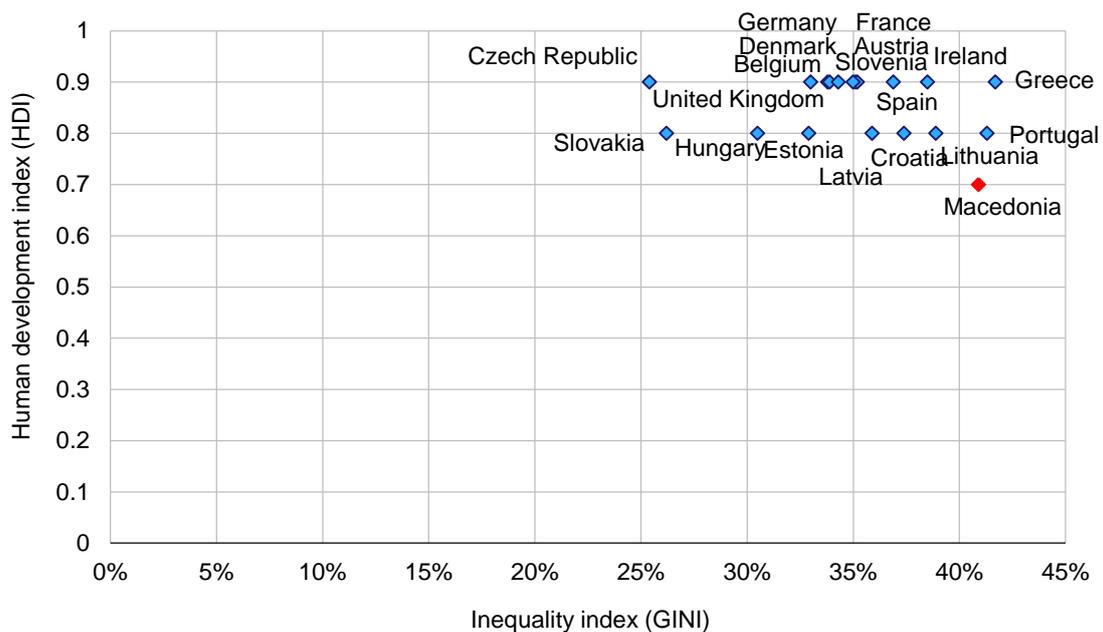
In Macedonia, the VAT rate is set at 18%; this is slightly low compared to the average VAT in Europe, which ranges from 20% to 25%.

Socio-economic indicators

The GINI coefficient measures inequality of income or wealth between various ranges of the population. A GINI coefficient of 0 indicates perfect equality, while an index of 100 indicates perfect inequality. Figure 2.13 illustrates the GINI and human development index (HDI)¹ for the benchmarked countries. The GINI average for the EU was 33% in 2013, as reported by Euromonitor.

Macedonia, with a GINI coefficient of c.41%, is at the higher end of European countries, whereas it is the European country with the lowest HDI, at c.0.7.

Figure 2.13: Benchmark of the GINI coefficient as a function of the HDI [Source: Euromonitor, 2015]



¹ HDI is an indicator taking into account life expectancy at birth, education index and GDP per capita in a country.

Private consumption in Macedonia represents the highest proportion of nominal GDP (c.77% in 2013) of all the countries included in the benchmark (see Figure 2.14), reflecting a lower share of public spending.

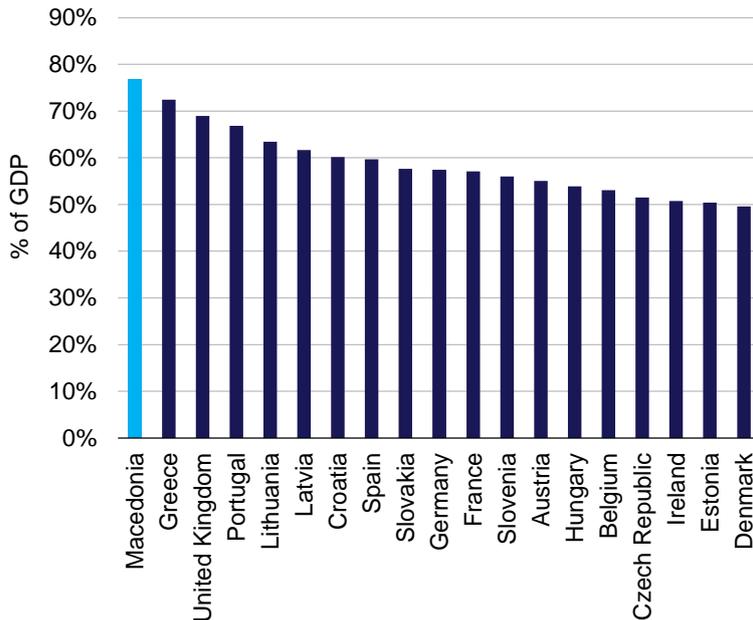


Figure 2.14: Benchmark of private consumption as a share of GDP in 2013 [Source: Euromonitor, 2015]

In terms of education levels, Macedonia is on a par with European benchmarks: c.98% of the country’s population aged above 15 is literate, compared to an average of c.99% for the benchmarked countries (see Figure 2.15) and for the EU15. High literacy rates may lead to high levels of access to, and consumption of, broadband services.

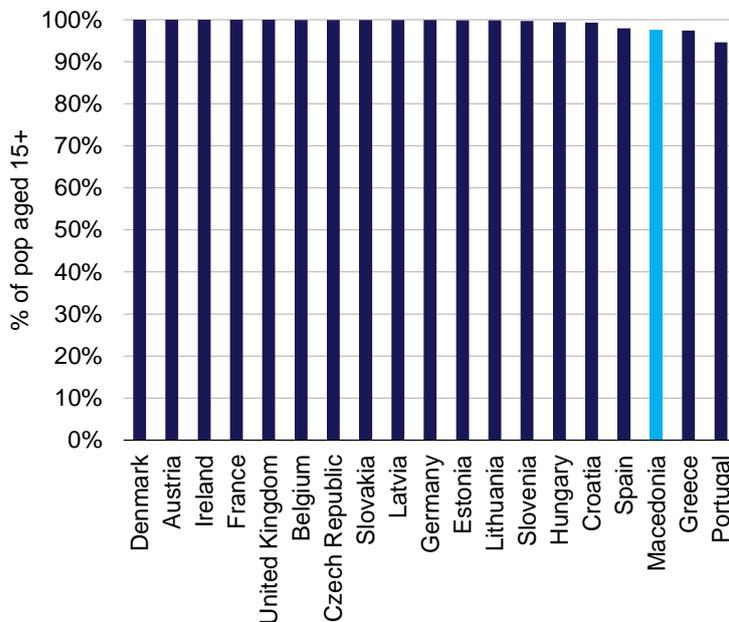


Figure 2.15: Benchmark of adult literacy rate in 2013 [Source: Euromonitor, 2015]

The rate of household access to electricity measures the share of households in a country that are connected to the electric grid and that are able to use electric appliances. In Macedonia, nearly 99.7% of households had access to electricity at the end of 2013, according to Euromonitor, which is in line with benchmarks.

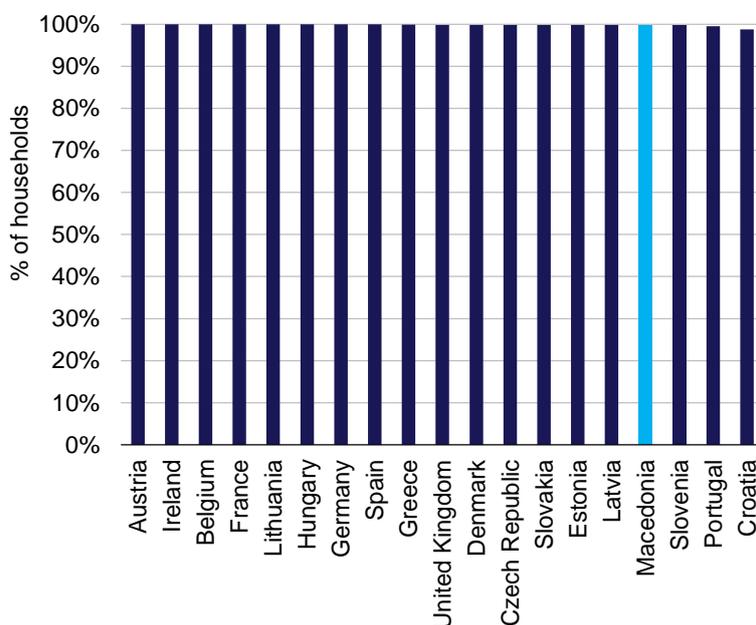


Figure 2.16: Benchmark of the proportion of households with access to electricity as a share of total households in the country [Source: Euromonitor, UNDP, 2013]

2.1.3 Impact of the macro-economic outlook on broadband development in Macedonia

Below we outline the main macro-economic factors that may have a positive or negative impact on broadband development in Macedonia.

Factors that may have a positive impact on broadband development

The main macro-economic factors promoting broadband development are:

- Macedonia is a relatively young country: it gained its independence peacefully from Yugoslavia in 1991, and the country's **infrastructure market is still under development**.
- **Macedonia enjoys political stability** and has been a **candidate for accession to the EU** since 2005. These two factors will continue to encourage the inflow of foreign direct investment, including in the telecoms sector.
- **Electricity is widely available throughout the country**, which is crucial for delivering broadband.
- Its **proximity to the EU** makes it easier for Macedonia to have access to affordable international bandwidth.
- Macedonia has a **high literacy rate**, which means that a higher share of the population will be able and willing to access the Internet for personal use.

Factors that may have a negative impact on broadband development

The main macro-economic factors hindering broadband development are:

- Macedonia has a **low population density**, making it economically unviable for operators to invest in infrastructure to cover the less densely populated areas.
- Macedonia has a low GDP per capita, which translates into relatively **low disposable income for people to spend on broadband**, which will in turn have an impact on broadband take-up.

2.2 Importance of the telecoms sector in Macedonia

Telecoms revenue has been growing steadily in the last three years to reach c.EUR380 million in 2013, with mobile revenue accounting for c.50% of total revenue over that period. Despite this growth, however, total telecoms revenue is still significantly lower than in 2008, when it peaked at c.EUR430million, as shown in Figure 2.17 below.

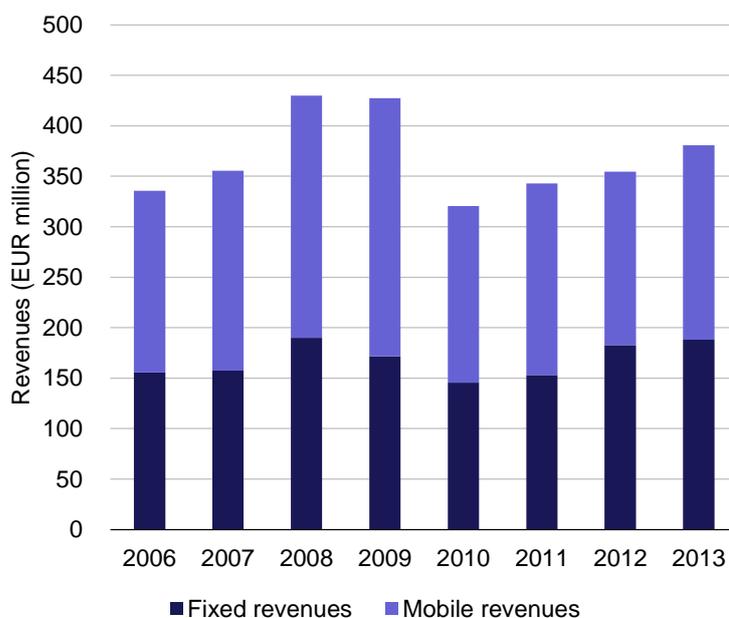


Figure 2.17: Historical evolution of telecom revenue in Macedonia [Source: Euromonitor, 2015]

Telecoms revenue accounts for 5% of Macedonia’s GDP, which is the highest of the benchmarked countries. In Europe, telecoms revenue as a share of GDP typically ranges from 1.5% to 4%, as can be seen in Figure 2.18 below.

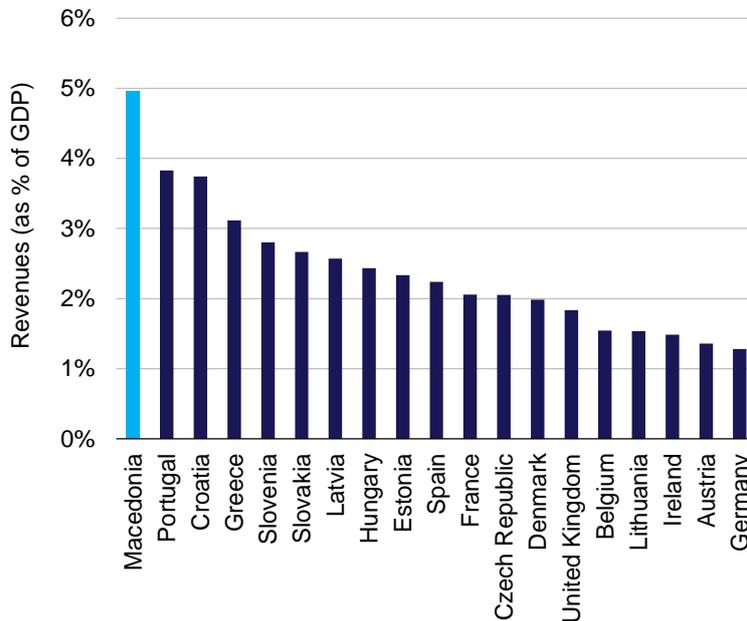


Figure 2.18: Benchmark of telecom revenue as a share of GDP in 2013
[Source: Euromonitor, 2015]

In Macedonia, telecoms operators invest c.12% of their revenue (MKD2.7 billion) in infrastructure, which is in the low range of European benchmarks; in Europe, operator investment as a share of revenue typically ranges between 10% and 30%, as shown below in Figure 2.19.

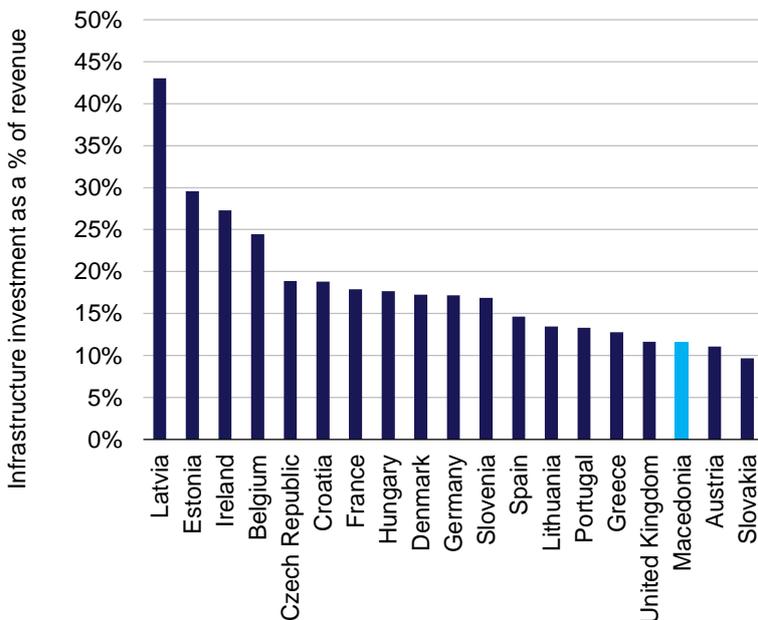


Figure 2.19: Benchmark of operator investment as a share of telecoms revenue in 2013
[Source: Euromonitor, 2015]

International bandwidth usage in Macedonia grew strongly from 1Gbit/s in 2006 to 206Gbit/s in 2013, principally due to the development of video-on-demand (VoD) services and Internet protocol television (IPTV); this is illustrated below in Figure 2.20. The share of this bandwidth used for Internet traffic rose significantly in 2013, reaching 99%.

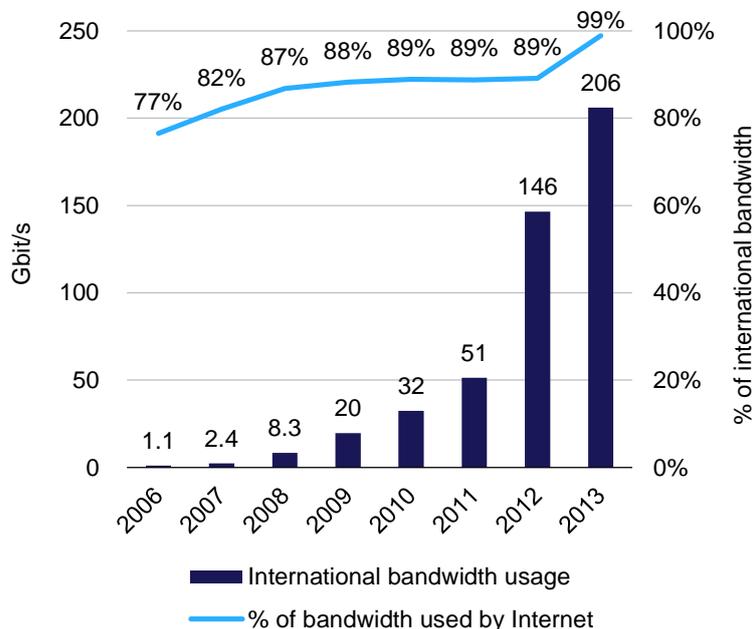


Figure 2.20: Evolution of international bandwidth usage in Macedonia [Source: TeleGeography, 2014]

2.3 Regulatory environment

The Macedonian telecoms regulator, the Agency for Electronic Communications (AEC), was established in March 2005 as an independent regulatory body by the new Law on Electronic Communications. This law also brought the end of the monopoly of Makedonski Telekom. The AEC is responsible for the regulation of the markets for fixed and mobile telephony, broadband, radio and television. The AEC also aims at achieving the *Digital Agenda for Europe* targets, which are summarised in Annex A of this report.

The government of Macedonia has imposed a set of universal service obligations on service providers:

- provide users on request with a connection to the public telephone network at a fixed location and at an affordable price
- provide directory and information service records of all telephone subscribers
- provide public payphones
- ensure equal access and use of telephony services by end users with disabilities.

In the retail and wholesale markets, the AEC has imposed a set of obligations on operators that have been designated as having significant market power (SMP) in each of the relevant markets as defined by the European Commission (EC). These are listed in the table below:

Figure 2.21: List of relevant markets defined by the AEC in line with the EC Directive on the definition of relevant markets [Source: Analysys Mason, 2015]

Relevant market	Definition
Market 1	Access to publicly available telephone networks at a fixed location for residential and business customers
Market 2	Publicly available telephone services at a fixed location for residential and business customers
Market 3	Minimum set of leased lines
Market 4	Call origination on the public telephone network provided at a fixed location
Market 5	Call termination on individual public telephone networks provided at a fixed location
Market 6	Transit in public telephone network provided at a fixed location
Market 7	Wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location
Market 8	Wholesale broadband access
Market 9	Terminating segments of leased lines
Market 10	Wholesale trunk segments of leased lines
Market 11	Access to public mobile communication networks and services for origination on the public mobile communication networks
Market 12	Voice call termination on public mobile communication networks
Market 13	Service for broadcasting transmission over digital terrestrial networks for free end-user access
Market 14	SMS termination on public mobile communication networks

Any undertaking with SMP in the relevant market has an obligation to provide cost-oriented prices, and the regulator can use a long-run incremental cost (LRIC) model to regulate the prices of certain services.² The last review of wholesale prices undertaken by the AEC dates back to 2012 and covered the markets for fixed networks, bitstream access, leased lines and mobile networks.

The mobile market

The AEC manages radio frequency spectrum and is responsible for assigning spectrum to mobile operators. In 2013, the AEC awarded LTE licences to each of the three existing mobile operators, with each operator receiving spectrum in the 800MHz (2×10MHz) and 1800MHz bands (2×15MHz). In that year, the AEC also authorised the entry of a new mobile virtual network operator (MVNO), Albafone, in the Macedonian mobile market.

At the wholesale level, the AEC has identified three relevant markets: mobile voice termination, SMS termination on mobile networks and mobile access and call origination. The retail mobile market is not regulated.

² Source: TeleGeography.

The fixed market

In Macedonia, broadband is provided mainly through DSL, cable and WiMAX, and the incumbent operator Makedonski Telekom has the obligation to provide an access offer to its network to other Internet service providers (ISPs). The prices of Makedonski Telekom's wholesale offer for fixed network access and for fixed broadband access, including local loop unbundling (LLU) and bitstream, are regulated.

In 2008, the AEC developed its first cost model based on a LRIC methodology to set LLU access prices. The prices for local bitstream access, leased lines and digital leased lines are also regulated in Macedonia. At present, the prices for bitstream access to high-speed broadband networks are not regulated in Macedonia, although this is something that the AEC is considering introducing in the near future.

2.4 The fixed and mobile markets

In this sub-section we provide an overview of the fixed and mobile markets in Macedonia.

2.4.1 Overview of the fixed market

As at the end of 2013, 48 companies had been officially notified by the AEC and 39 were providing public telephony services at a fixed location for national and/or international traffic. Fixed operators in Macedonia provide their services using two main types of technologies:

- wired technologies, used by, for instance, Makedonski Telekom and ONE on their copper networks, but also by Blizoo and Telekabel to a smaller extent, which have deployed their own cable network
- wireless technologies, used by, for instance, Neotel and ONE's WiMAX network for the provision of voice and data services.

Makedonski Telekom is the incumbent operator in the Macedonian fixed-line market; it is 45% owned by Macedonian institutions. Makedonski Telekom had a monopoly on the fixed-line market until January 2005, investing heavily in its local access network in the run-up to liberalisation.

Fixed-line penetration declined from 94% of households in 2005 (when the market was liberalised) to 64% in 2013, as shown below in Figure 2.22. However, this decline was largely a result of the high-growth of mobile services, as mentioned in Section 2.4.2.

Makedonski Telekom is planning to gradually shut down its PSTN in the coming years and to migrate all its subscribers to VoIP. By the end of 2013, VOIP lines represented more than 50% of the total fixed lines in the country.

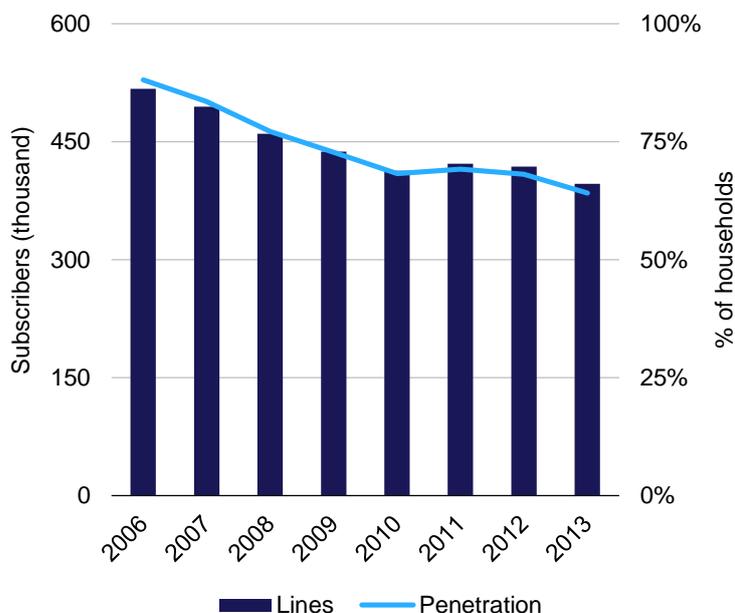
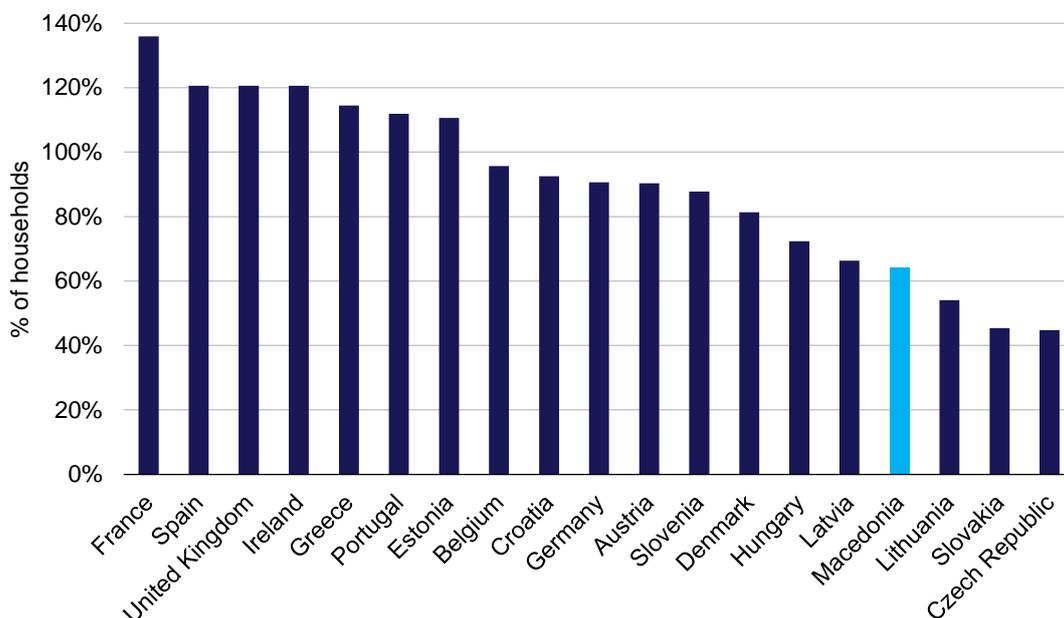


Figure 2.22: Historical evolution of fixed-line subscribers in Macedonia [Source: TeleGeography, Euromonitor, Analysys Mason, 2015]

At 64% of households in 2013, Macedonia’s fixed-line penetration (including VoIP and PSTN lines) was relatively low compared to benchmarks, as illustrated in Figure 2.23.

Figure 2.23: Benchmark of fixed-line penetration [Source: TeleGeography, Euromonitor, Analysys Mason, 2015]



As the incumbent operator, Makedonski Telekom is still leading the Wireline market with 64% market share. Despite the liberalisation of the market in 2005, Makedonski Telekom retained its monopoly until the beginning of 2007, and by 2013 its market share had shrunk by 36 percentage points. As a result, Makedonski Telekom lost almost half of its fixed-line subscribers over the period, from 460 000 in 2008 to 250 000 in 2013.

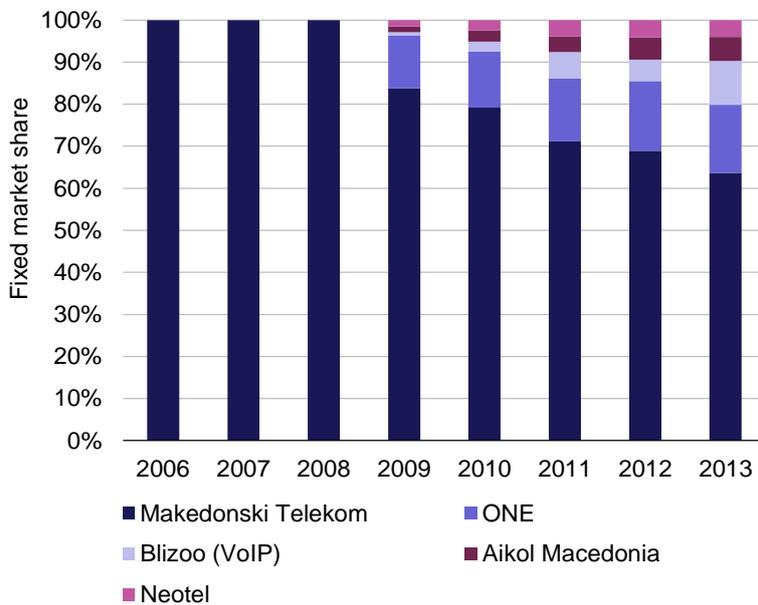


Figure 2.24: Historical evolution of the market share of fixed lines of the main fixed operators in Macedonia [Source: TeleGeography, 2015]

2.4.2 Overview of the mobile market

Mobile penetration in Macedonia grew slightly over the 2009–2013 period, from 103% of the population to 108%, as shown in Figure 2.25. According to TeleGeography and mobile operator data, in 2014, 99.9% of the population was covered with 2G, more than 90% with HSPA+ and 40% with LTE (launched in July 2014).

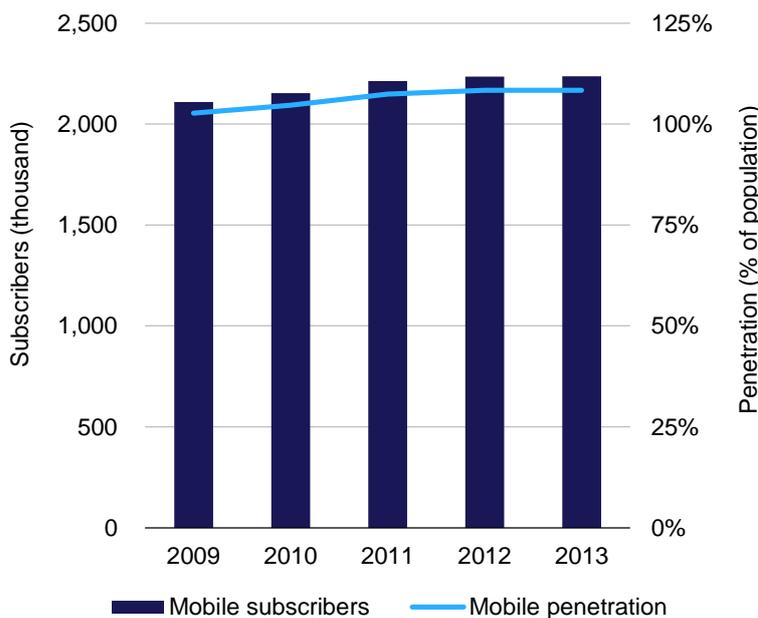
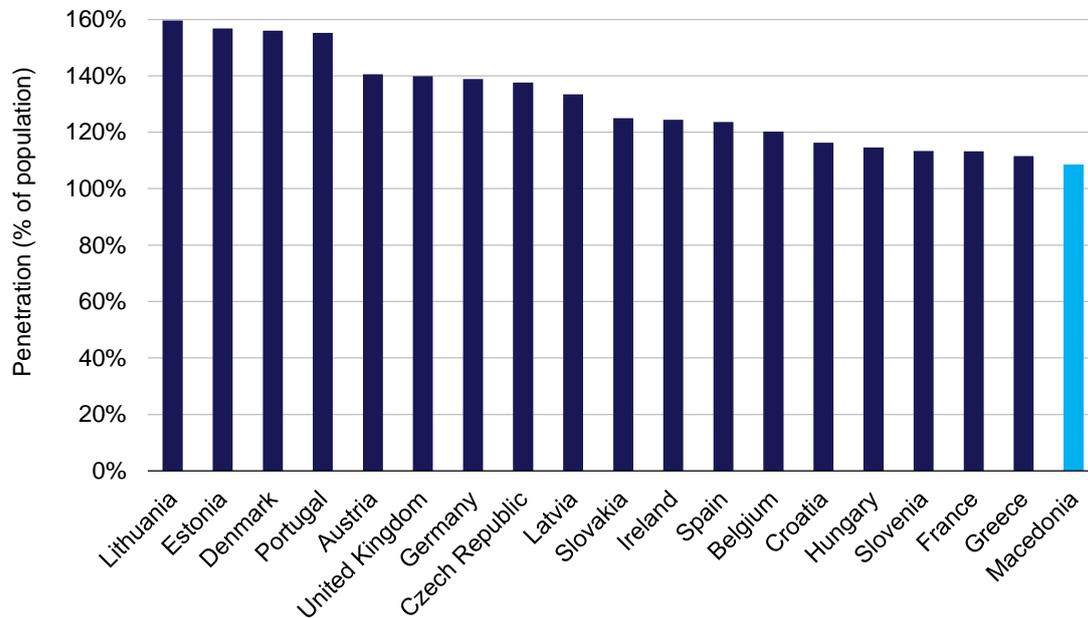


Figure 2.25: Historical evolution of mobile subscriptions and population penetration in Macedonia [Source: Analysys Mason, AEC, operator data]

In 2013, mobile penetration in Macedonia was at the low end of our benchmark and so we may expect an increase in penetration in the coming years.

Figure 2.26: Benchmark of mobile penetration by population, 2013 [Source: Analysys Mason, AEC, operator data, Euromonitor, 2015]



Macedonia’s mobile market is mainly prepaid, with prepaid subscribers accounting for over 62% of total mobile subscribers. However, mobile operators are increasingly migrating their prepaid customers to postpaid contracts in order to reduce churn and increase ARPU. As a result, the share of prepaid subscribers is expected to decline in the period to 2020, to reach 55% of total mobile subscribers.

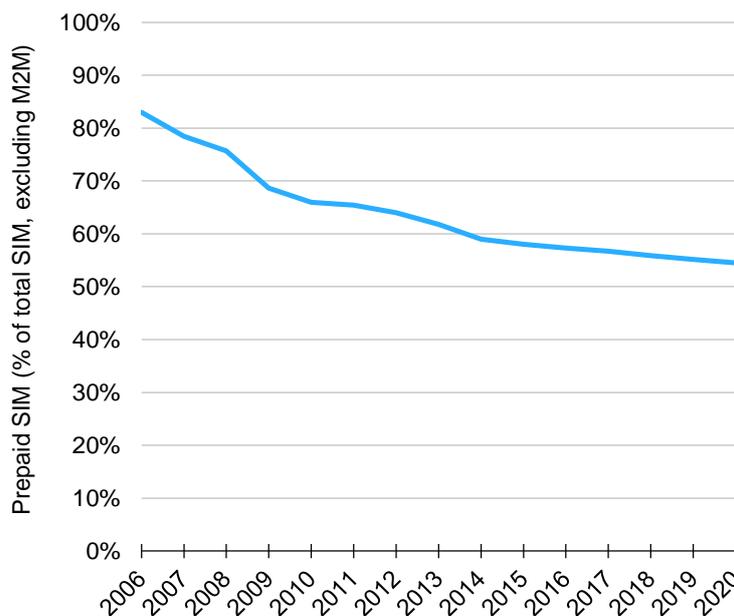


Figure 2.27: Historical and forecast evolution of the share of prepaid subscriptions in Macedonia [Source: Wireless Intelligence, 2015]

3G was launched in 2008 in Macedonia and by the end of 2013 3G subscribers accounted for nearly 30% of all SIMs. According to Wireless Intelligence, the cumulative share of 3G and 4G is expected to grow quickly over the 2014–2020 period, from 33% to 58%.

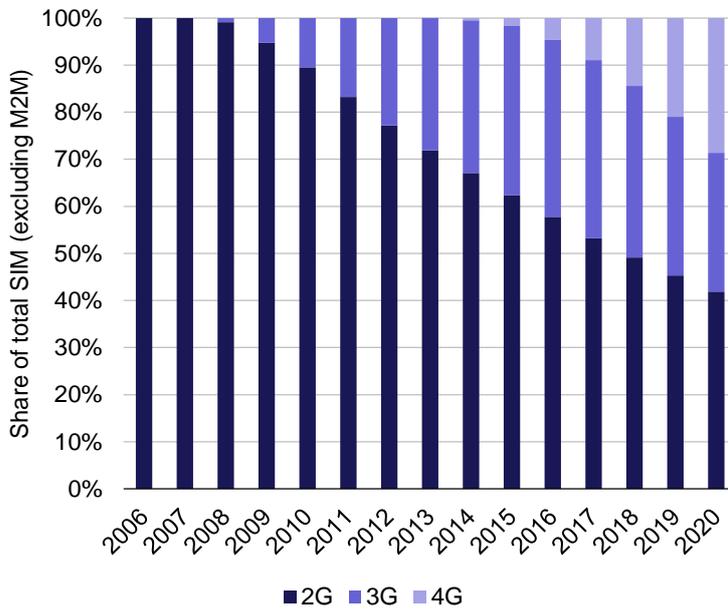


Figure 2.28: Historical and forecast evolution of the share of mobile subscribers in Macedonia, by technology [Source: Wireless Intelligence, 2015]

Mobile ARPU in Macedonia declined from MKD407 in 2010 (EUR6.6) to MKD311 in 2014 (EUR5.1), representing a CAGR of 6%. This decline in mobile ARPU is mainly explained by the high competition in the mobile market.

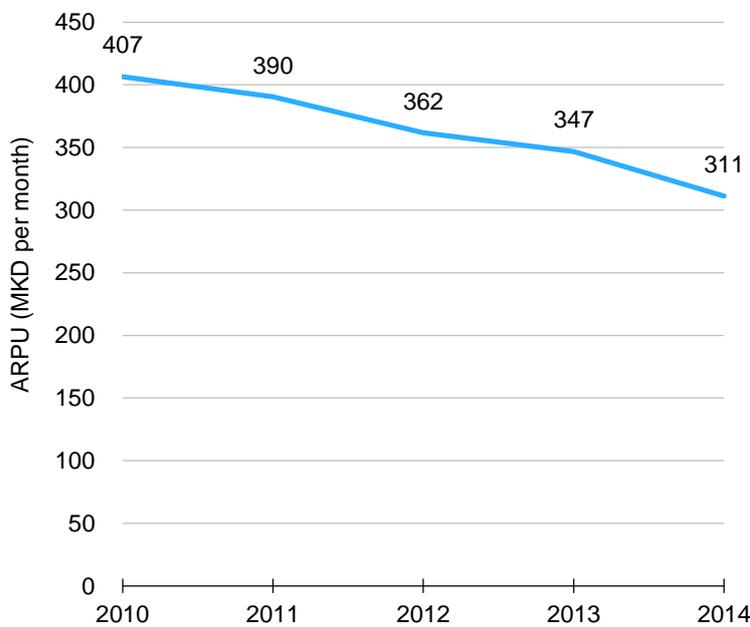


Figure 2.29: Evolution of mobile market ARPU in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

Note: ARPU in 2014 is based on the first three quarters

There are three mobile network operators (MNOs) in Macedonia, all of which own 2G, 3G and 4G licences, and one MVNO:

- T-Mobile (Makedonski Telekom's mobile division) launched services in 1996
- ONE launched services in 2003
- VIP launched services in 2007
- Albanofee, an MVNO, launched services in 2013.

T-Mobile has been facing increased competition in the mobile market from ONE, VIP and more recently from Albafone. As a result, T-Mobile's market share declined from 66% at the end of 2009 to 47 at the end of 2014, a decline of almost 20 percentage points in five years. Over the same period, ONE and VIP managed to increase their market shares to 24% and 27%, respectively.

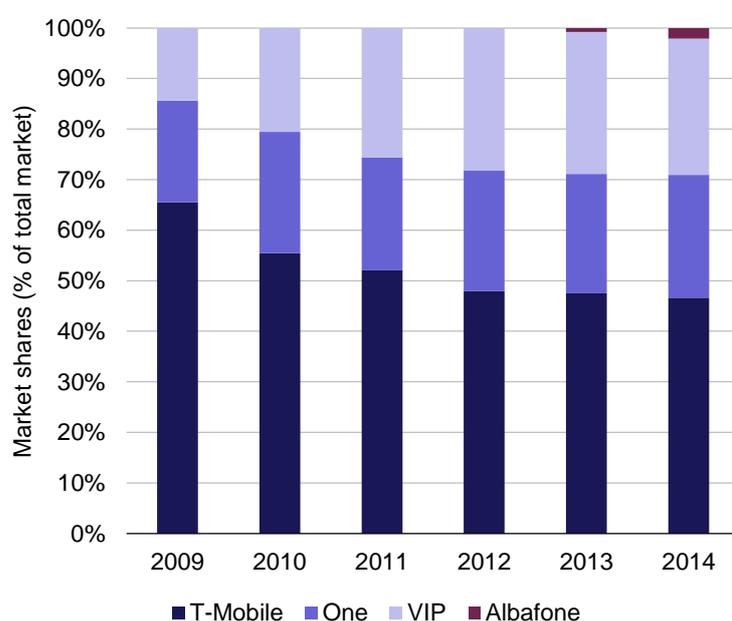


Figure 2.30: Historical evolution of the market shares of the four Macedonian mobile operators [Source: Analysys Mason, AEC, operator data, 2015]

2.5 The broadband market

In this sub-section we provide an overview of the fixed and mobile broadband markets in Macedonia.

2.5.1 Overview of the fixed broadband market

In the second quarter of 2014, 111 active operators were providing broadband Internet access in Macedonia. However, five of these operators have a majority share of the broadband market:

- Makedonski Telekom, the incumbent operator, provides DSL and fibre access
- Blizoo is a cable and local area network (LAN) operator
- Neotel operates a fixed wireless access (FWA) network
- ONE provides DSL and FWA services
- Telekabel is a cable operator.

As at the end of 2014, the vast majority of Macedonian households were covered by DSL. As far as the other technologies are concerned, FWA and cable coverage stood at more than 50% and 40% of households, respectively, while less than 20% of households were connected to a LAN. Additionally, operators in Macedonia have started deploying fibre-to-the-home (FTTH), and coverage of this technology at the end of 2014 was estimated at 15–20% of households, as shown in the table below.

Technology	Estimated household coverage (end of 2014)	
DSL	>98%	
Cable ³	HFC (DOCSIS 2.0)	40–50%
	HFC (DOCSIS 3.0)	<5%
LAN ³	15–20%	
FWA	>60%	
FTTH	15–20%	

Figure 2.31: Estimated household coverage by technology [Source: Analysys Mason based on operator information, 2015]

The number of Internet-capable PCs in Macedonia has increased considerably between 2005 and 2013, from 13% to 65% of households. According to Euromonitor, this figure is expected to continue rising over the period to 2023, to reach 81%.

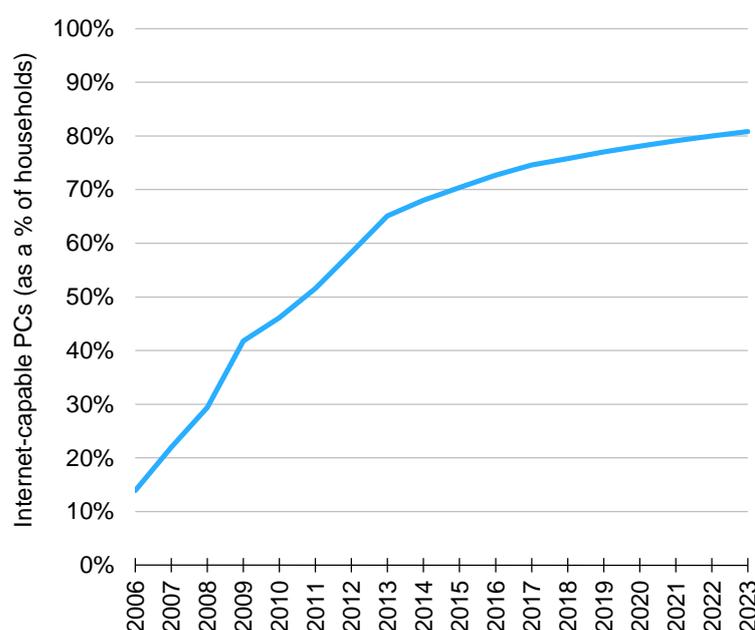
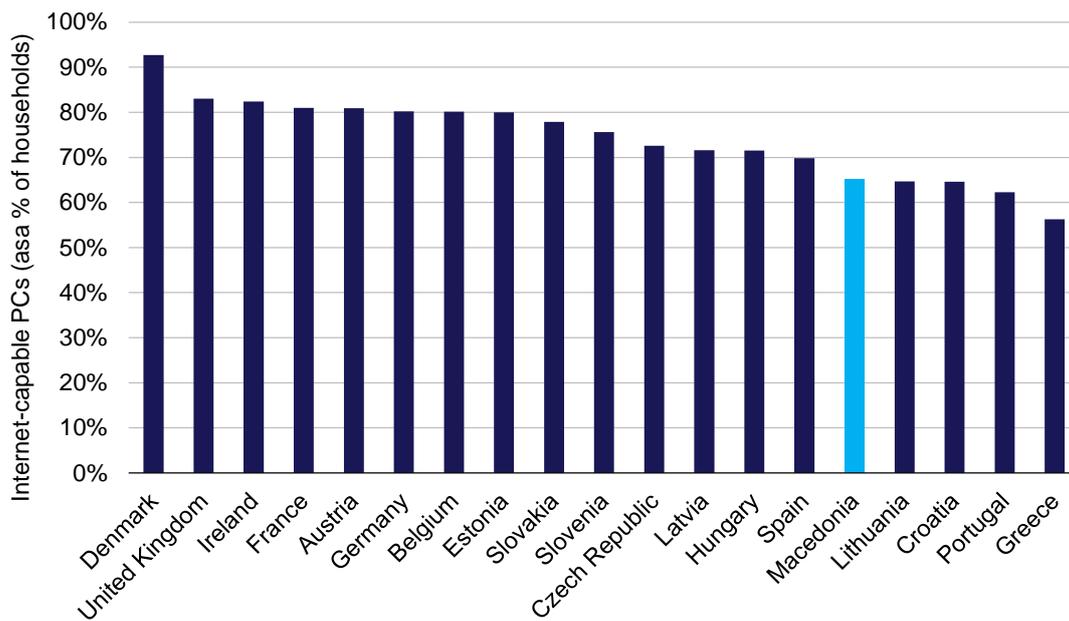


Figure 2.32: Historical evolution of the penetration of Internet-capable PCs in Macedonia [Source: Euromonitor, 2015]

Notwithstanding this notable increase in Internet-capable PCs in the last few years, PC penetration as a share of households in Macedonia is still at the low end of European benchmarks, as shown below in Figure 2.33. However, as illustrated in Figure 2.32 above, by 2023 PC penetration among Macedonian households is expected to be at a similar level as in France.

³ It should be noted that the cable and LAN coverage are based on the information provided by the biggest operators using such technologies including Blizoo, Telekom, Inel Internacional and CableNet. As previously mentioned there are 111 active operators in the market while most of them having rollout cable or LAN networks in local areas.

Figure 2.33: Benchmark of PC penetration as a share of households, 2013 [Source: Euromonitor, 2015]



The number of fixed broadband subscribers in Macedonia rose from 210 000 in 2009 to just under 350 000 in Q2 2014, which represents a household penetration of 56%.

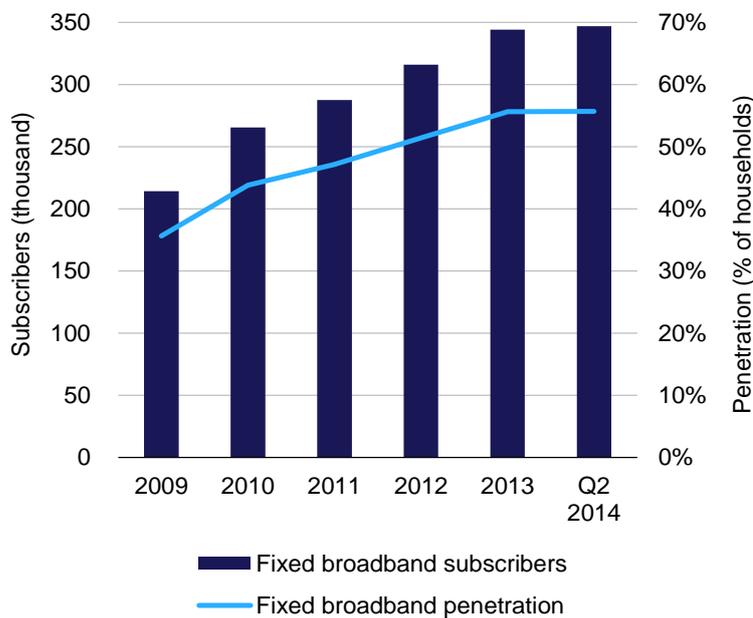


Figure 2.34: Historical evolution of fixed broadband subscribers in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

The number of businesses with a broadband subscription increased at a CAGR of 6% between 2011 and Q2 2014, to reach 27 000 connections. Similarly, the number of residential subscribers rose from 266 000 in 2011 to 320 000 in Q2 2014 (which also represents a CAGR of 6% over the period).

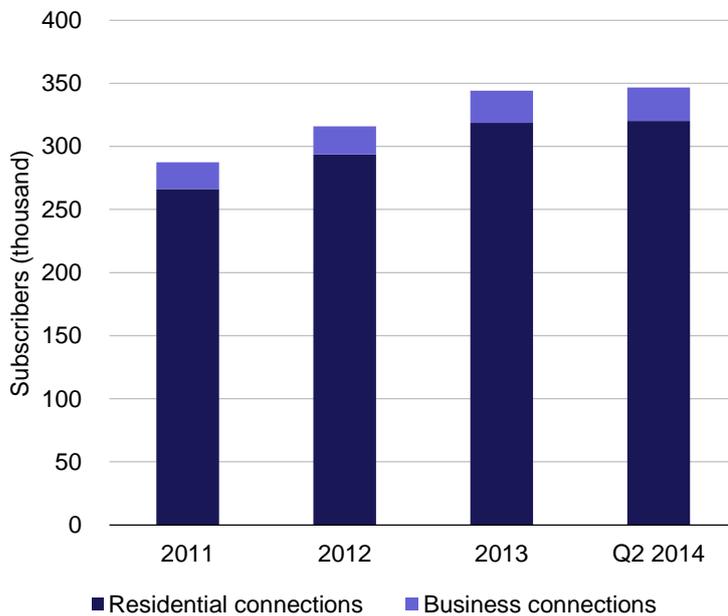


Figure 2.35: Historical evolution of residential and business broadband subscribers in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

Broadband-only subscribers accounted for less than 20% of all broadband subscribers in Q2 2014, which is mainly due to the availability of double-play bundles including broadband and telephony. The number of standalone broadband connections is expected to continue to decline in the future, principally due to the introduction of triple-play packages (broadband, telephony and television) and quadruple-play offers (which combine combining television, broadband, fixed telephony and mobile services).

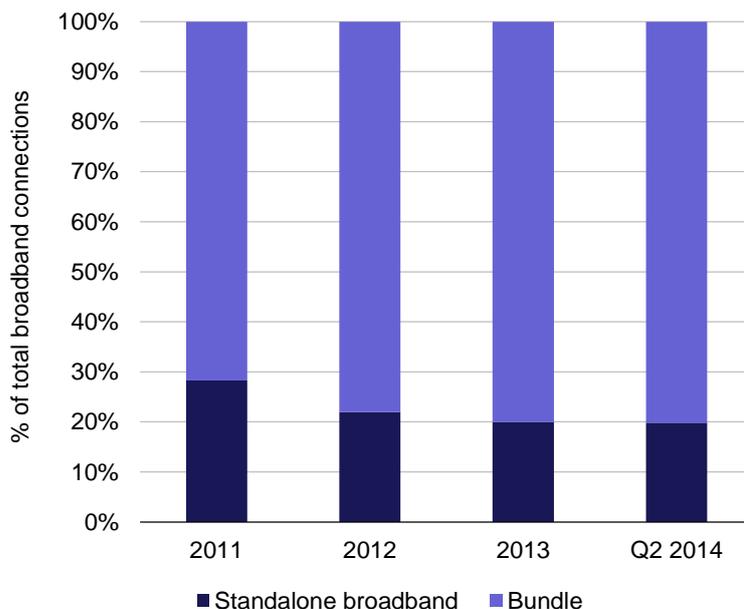
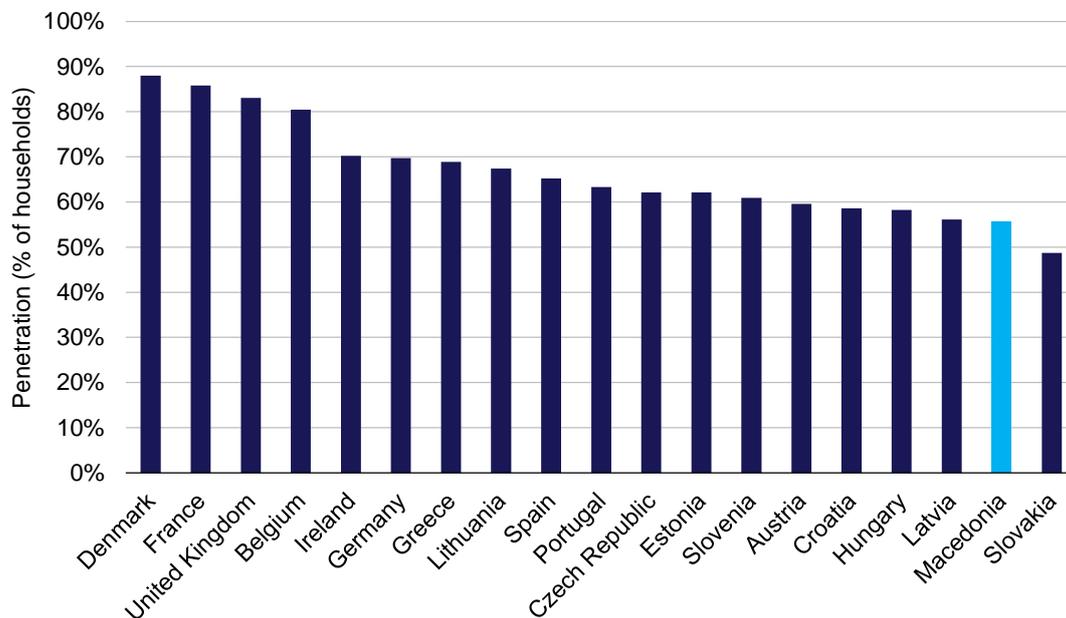


Figure 2.36: Historical evolution of residential broadband connections in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

Fixed broadband penetration in Macedonia is at the low end of European benchmarks, only ahead of Slovakia, as illustrated in Figure 2.37 below.

Figure 2.37: Benchmark of fixed broadband penetration, 2013 [Source: TeleGeography, Analysys Mason, AEC, operator data, 2015]



Blizoo, Telekabel, ONE and Cablenet have managed to retain their broadband market shares, while Makedonski Telekom has been losing market share in favour of smaller operators. Over the period 2010–2013, Makedonski Telekom’s market share fell by 5 percentage points from 48% to 43%, while small operators (besides the five main operators) increased their combined market share by 4 percentage points, to reach 17% in 2013.

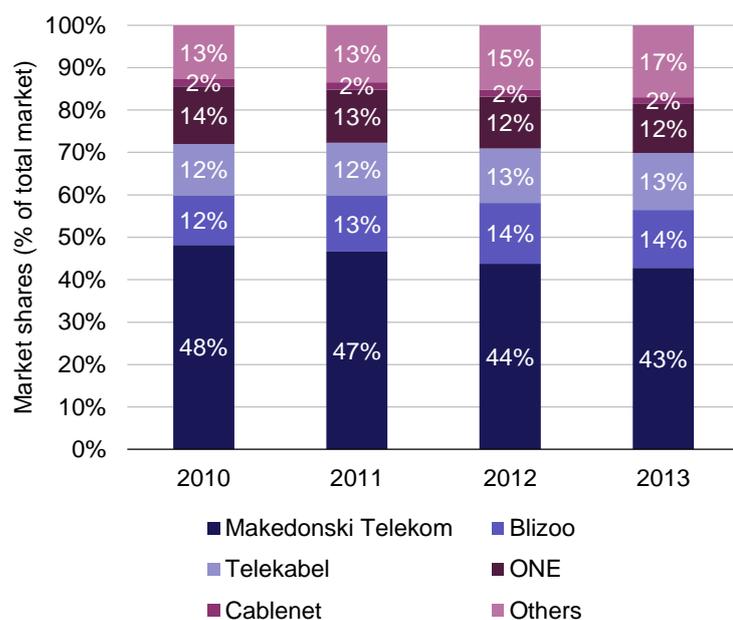


Figure 2.38: Market shares of the main broadband operators in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

The number of DSL, cable and FWA connections in Macedonia has also declined in recent years, principally driven by the deployment of new-generation broadband technologies such as FTTH (see Figure 2.39). The number of FTTH/B and LAN connections as a share of total connections rose from 3% in 2009 to 18% at the end of 2013, and this trend is set to continue in the period to 2023.

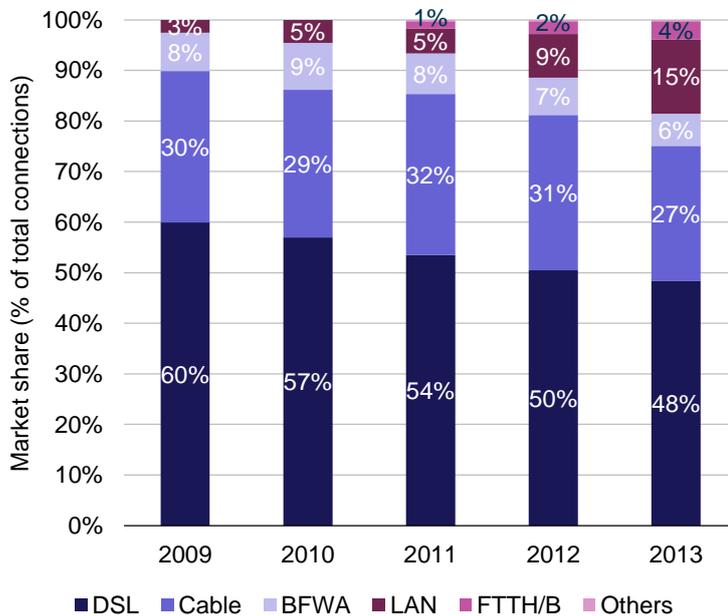


Figure 2.39: Broadband connections by technology in Macedonia [Source: Analysys mason, AEC, operators' data, 2015]

Macedonia's broadband market ARPU remained broadly between 2011 and Q3 2014, at c.MKD630 per month (EUR10.2), as shown in Figure 2.40. However, the market ARPU for Macedonia may increase in the future driven by the higher estimated ARPU and market share of high-speed broadband services.

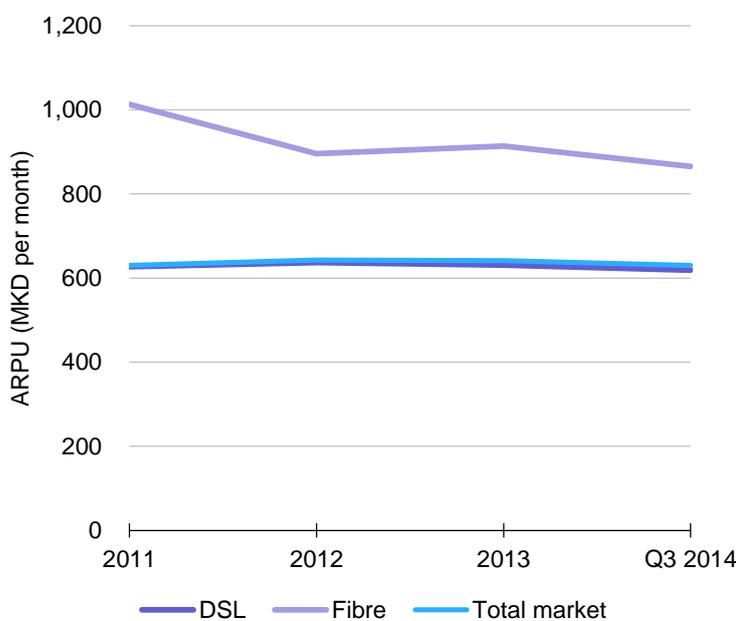
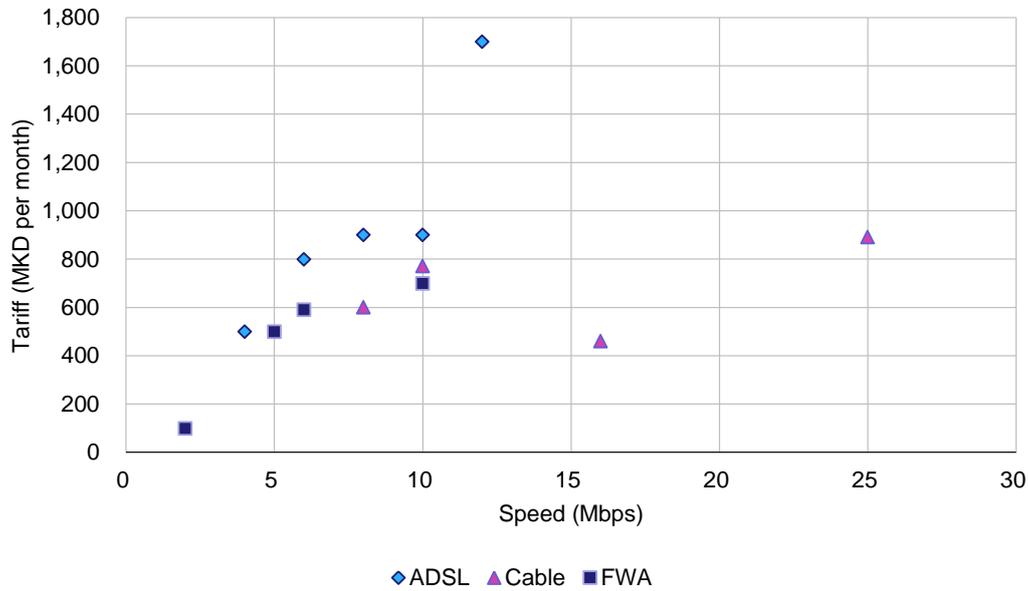


Figure 2.40: Broadband ARPU in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

Note: ARPU in 2014 is based on the first three quarters

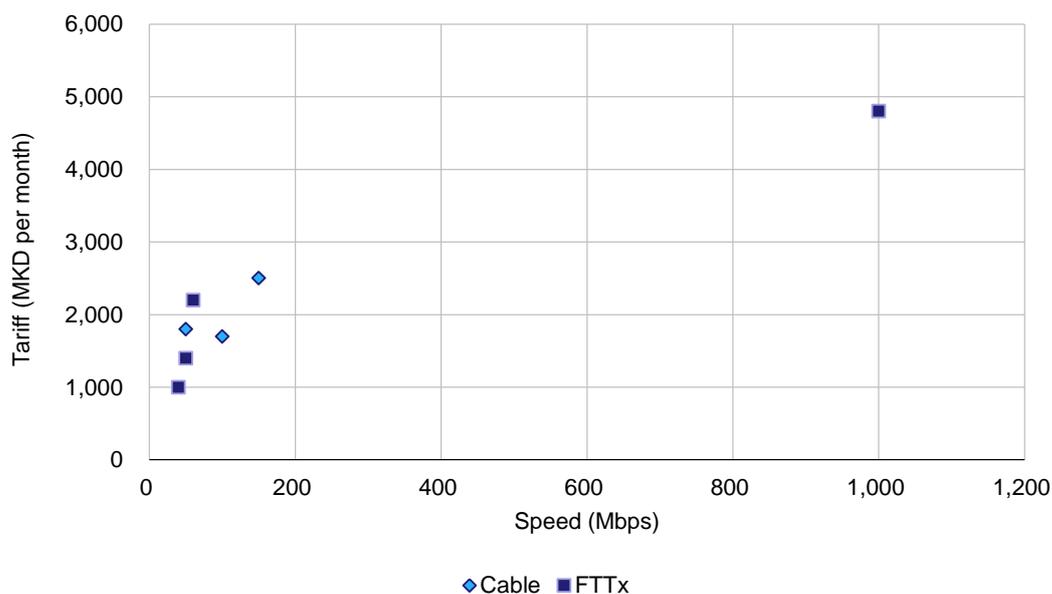
Regarding basic broadband offers, operators are either providing very cheap offers or more expensive offers with higher speeds; a selection of these are shown in Figure 2.41. Many broadband offers are subject to a data usage cap of 30GB per month, except for FWA operator SunWireless, which offers a lower monthly data allowance. If users exceed their monthly data allowance, in some offers their broadband connection may reduce in speed, or alternatively users may be charged an additional fee per MB.

Figure 2.41: Selection of basic broadband offers by speed and technology [Source: Analysys Mason, operator websites, 2015]



All high-speed broadband offers currently available in the market have unlimited data usage. The prices of the high-speed broadband offers provided by three of the five main operators are more than twice as expensive as their basic broadband offers, as shown below in Figure 2.42.

Figure 2.42: Prices of a selection of high-speed broadband offers by speed and technology [Source: Analysys Mason, operator websites, 2015]



2.5.2 Overview of the mobile broadband market

T-Mobile was the first Macedonian operator to launch an LTE network in December 2013, followed by VIP and ONE during the summer of 2014.

2G networks cover 99.9% of the population and can only provide very limited data services over EDGE technology. 3G technology enables the provision of mobile broadband services with a download speed of up to 42Mbit/s. At present, 3G coverage stands at more than 90% of the population, while 4G networks only cover 40% of the population but they are capable of supporting download speeds of up to 150Mbit/s.

Figure 2.43: Speed and coverage by mobile technology, end-2014 [Source: AEC, operator data, Analysys Mason, 2015]

Technology	Coverage (% of population)	Headline download speed
2G	99.9%	Up to 296kbit/s
3G	>90%	Up to 42Mbit/s
4G	>40%	Up to 150Mbit/s

Mobile broadband subscriber numbers (which include data-only subscriptions – e.g. dongles, modems and datacards – and mobile devices enabled with data service) increased from 110 000 in 2009 to 1 000 000 in Q3 2014, representing a population penetration of nearly 50% (see Figure 2.44). This trend is set to continue in the future driven by the deployment of 4G in 2014.

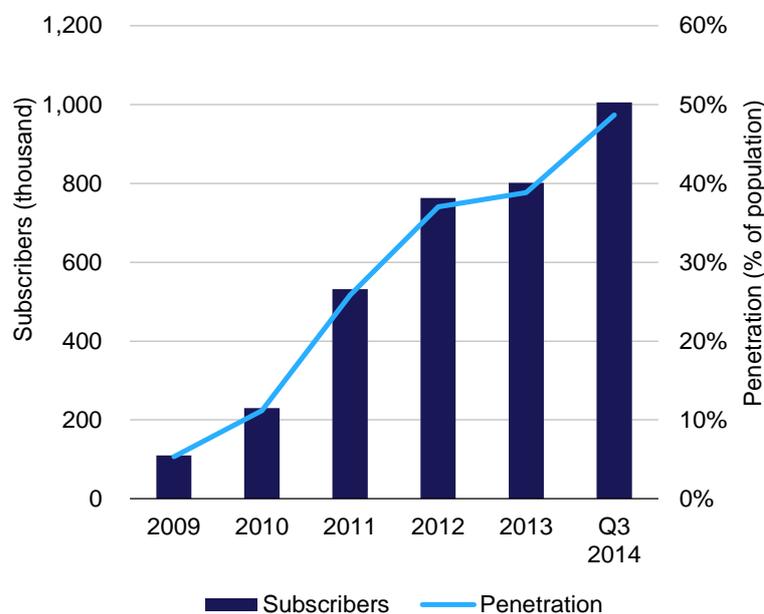


Figure 2.44: Mobile broadband subscribers (dongle + data-enabled devices) in Macedonia [Source: AEC, operator data, Analysys Mason, 2015]

Note: 2014 figure is estimated on the basis of data up to Q3 2014

The share of mobile broadband connections increased from 5% in 2009 to 43% in Q3 2014, as shown below in Figure 2.45, and this trend is also set to continue in the coming years driven by the deployment of 4G.

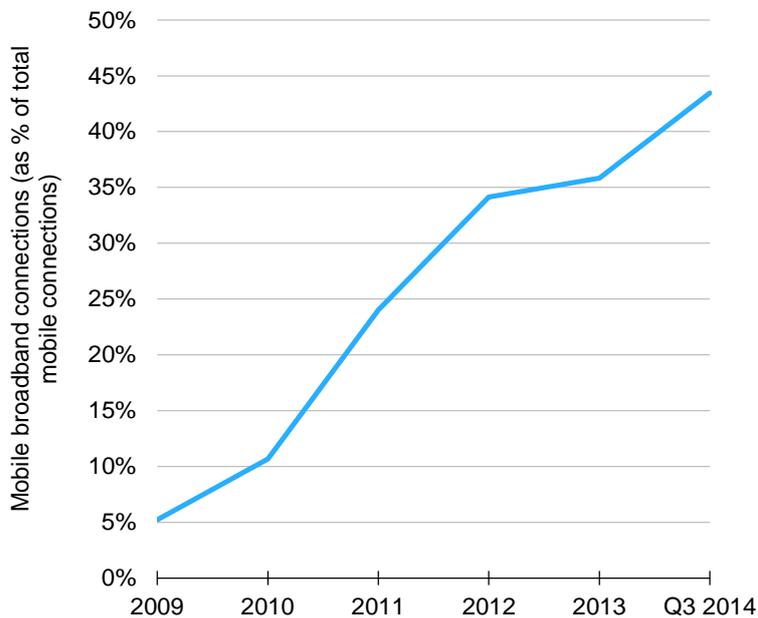
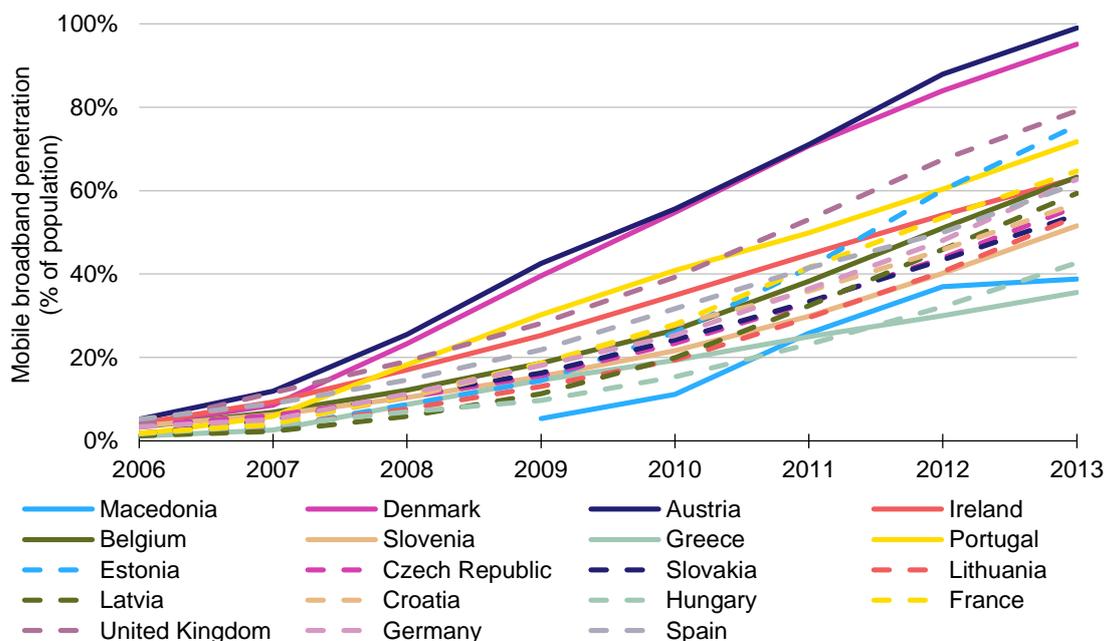


Figure 2.45: Mobile broadband connections as a share of total mobile connections in Macedonia [Source: AEC, operator data, Analysys Mason, 2015]

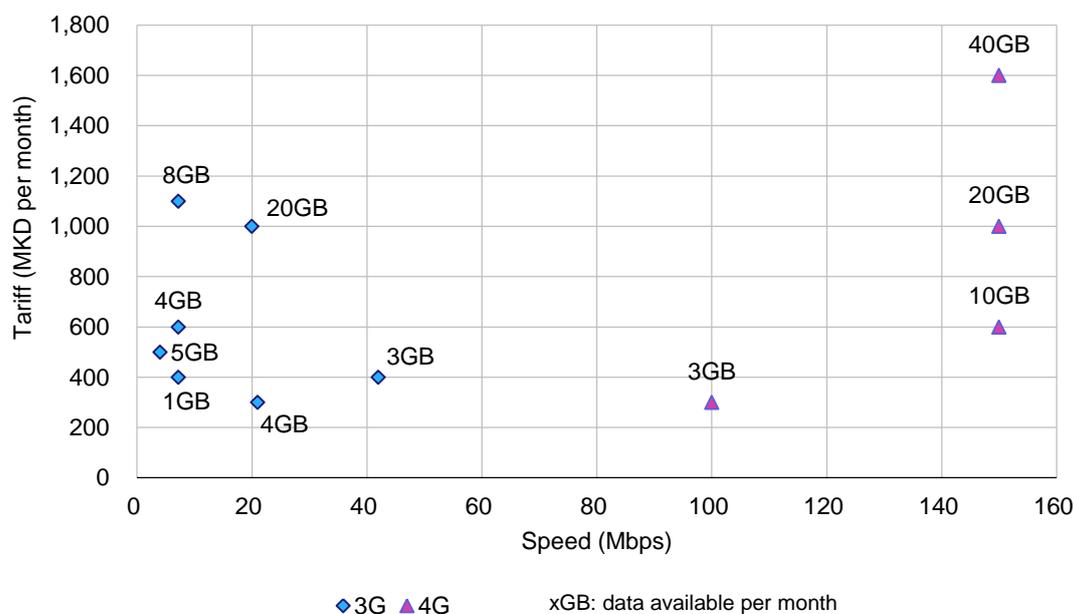
At 40% of the population in 2013, mobile broadband penetration in Macedonia is at the lower end of European benchmarks, as shown below in Figure 2.46. In Europe, mobile broadband penetration levels typically range between 50% and 100%.

Figure 2.46: Benchmark of mobile broadband penetration [Source: AEC, operator data, Analysys Mason, 2015]



Data-only mobile broadband plans on 4G are available in Macedonia since 2014. These plans include high-speed broadband access and the cheapest offer is priced at c.MKD300 per month for 3GB of data. It should be noted that this offer is comparable to the cheapest 3G mobile broadband offer on the market, but with a speed five times higher. As can be seen in Figure 2.47 below, 4G mobile broadband offers are very competitive compared to 3G offers, which may encourage subscribers to eventually migrate from 3G to 4G offers as 4G coverage increases and 4G handsets become more affordable.

Figure 2.47: Prices of a selection of mobile broadband offers currently available in Macedonia [Source: Operator websites, Analysys Mason, 2015]



2.5.3 Factors impacting the development of Macedonia's broadband market

We outline below the main factors, as highlighted by the main Macedonian operators that had been impacting positively or negatively high-speed broadband development.

Factors having a positive impact on the development of the high-speed broadband market

- Increased broadband access speed for the same price which promote high speed broadband to consumers.
- The AEC reduced spectrum annual fees that Macedonian operators are required to pay for their spectrum licences, which has allowed operators to free up cash for investment in network deployment.

Factors having a negative impact on the development of the high-speed broadband market

- The process for obtaining the required permits for network deployment is overly complex.
- There is a lack of information on the current underground networks, which has a negative impact on the speed of roll-out and also reduces the incentives for operators to share their networks.

- The current level of wholesale prices is perceived as a barrier for the entry of alternative operators in the market.
- There is uncertainty among operators over the regulation of next-generation networks (NGN).
- There is a lack of investment support from the government and national/regional authorities.
- There is a lack of control of illegal networks, which enhances disloyal competition.
- The lack of regulation of OTT providers, which are increasingly capturing operators' revenue.

Recommendations as to how the Macedonian high-speed broadband market may be further developed (as highlighted by the main broadband operators)

- Extend the existing regulation on bitstream access to also include high-speed broadband access.
- Include broadband access as a universal service obligation (USO).
- Reduce the VAT on telecoms products from 18% to 5.5%.
- Develop public–private partnerships and create incentives for public investment in high-speed broadband networks.
- Promote infrastructure sharing within the telecoms sector and with other sectors, such as the railway sector, highways sector, etc.
- Develop a geographical regulatory approach in order to promote investment in broadband in rural and remote areas.
- Promote the creation of Macedonian content, online payment and the e-society to enhance the value of the Internet to Macedonian consumers.

3 Assessment of broadband demand in Macedonia

This section provides an assessment of broadband demand in Macedonia. It is laid out as follows:

- Section 3.1 presents the definition of broadband and high-speed broadband
- Section 3.2 presents the methodology used to forecast the take-up of broadband in Macedonia
- Section 3.3 provides an assessment of the evolution of broadband take-up
- Section 3.4 provides an assessment of the evolution of broadband revenue.

3.1 Broadband definition

The definition of broadband can vary widely across countries and operators. The main definitions we have identified during our desk research are summarised below:

*EC*⁴ An Internet connection enabling a download speed of at least **144kbit/s**. As of January 2014, it is estimated that the speed of the vast majority of fixed broadband lines in the EU is 2Mbit/s or above.

OECD Fixed (wired) and wireless broadband includes DSL, cable, fibre, satellite, terrestrial fixed wireless and terrestrial mobile wireless with download speeds greater than **256kbit/s**.

*ITU World Telecommunication/ ICT Indicators (WTI)*⁵ Total fixed (wired) broadband Internet subscriptions refers to subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, **256kbit/s**. This can include, for example, cable modem, DSL, fibre-to-the-home (FTTH) / building (FTTB) and other fixed (wired) broadband subscriptions.

In the context of this project, we have adopted the EC definition, i.e., an Internet connection enabling a download speed of at least 144kbit/s, and have assumed that the number of broadband subscribers published by the Macedonian operators and the AEC are in line with this definition.

Figure 3.1 below provides the headline and real download and upload speeds for different wired technologies. It should be noted that the real speed depends on several parameters including network design (e.g. contention ratios) and can vary across operators and countries.

⁴ Source: Implementation of the EU regulatory framework for electronic communications — July 2014

⁵ See https://www.itu.int/ITU-D/ict/material/TelecomICT_Indicators_Definition_March2010_for_web.pdf

Figure 3.1: Headline and real download and upload speeds by wired technology [Source: Analysys Mason, ITU, DegroupTest, CableLabs]

Technology	Headline download speed (Mbit/s)	Real download speed (Mbit/s)	Headline upload speed (Mbit/s)	Real upload speed (Mbit/s)
ADSL/ADSL2+	Up to 8Mbit/s (ADSL) Up to 24Mbit/s (ADSL2+)	Depends heavily on line length	Up to 1Mbit/s (ADSL) Up to 3Mbit/s (ADSL2+)	Depends heavily on line length
Cable	Up to 38Mbit/s (DOCSIS2) Up to 160Mbit/s (DOCSIS3)	Some studies (e.g. by Ofcom) have shown cable to deliver ~80% of the headline speed	Up to 27Mbit/s (DOCSIS2) Up to 120Mbit/s (DOCSIS3)	Some studies (e.g. by Ofcom) have shown cable to deliver ~80% of the headline speed
FTTC/VDSL	Up to 100Mbit/s	Speed declines heavily with distance. In the UK, BT provides packages of 80Mbit/s and users are getting ~70Mbit/s	–	Speed declines heavily with distance. In the UK, BT provides packages of 20Mbit/s and users are getting ~15Mbit/s
Fibre (FTTH)	Up to 1000Mbit/s (limited only by the networking equipment)	Limited data available – expect much better performance than copper	Up to 1000Mbit/s (limited only by the networking equipment)	Limited data available – expect much better performance than copper

For wireless technologies, their relative headline and real download speed is shown in the table below.

Figure 3.2: Headline and real download and upload speed by wireless technology [Source: Analysys Mason, CDG, WiMAX Forum, Ericsson, ABI research, Qualcomm]

Technology	Headline download speed (Mbit/s)	Real download speed (Mbit/s)	Headline upload speed (Mbit/s)	Real upload speed (Mbit/s)
EDGE	Up to 296kbit/s	≈ 100kbit/s	Up to 296kbit/s	≈ 100kbit/s
W-CDMA (UMTS)	Up to 384kbit/s	≈ 140kbit/s	Up to 384kbit/s	≈ 100kbit/s
HSPA	Up to 14.4Mbit/s	≈ 2–3Mbit/s	Up to 5.8Mbit/s	< 700kbit/s
HSPA+	Up to 42Mbit/s	≈ 4–6Mbit/s	Up to 11.5Mbit/s	≈ 1–2Mbit/s
LTE	Up to 100Mbit/s	≈ 10–20Mbit/s	Up to 50Mbit/s	≈ 5–10Mbit/s

We considered that the following technologies therefore constitute broadband services: DSL, cable, WiMAX, LAN, satellite, FTTC, FTTH, HSPA, HSPA+ and LTE.

Within the context of this study, and in line with the EC, we will consider the following technologies as being capable of delivering high-speed broadband: cable DOCSIS 3, FTTC, FTTH and LTE. These technologies can typically deliver speeds above 30Mbit/s, which is consistent with the EC definition of high-speed broadband services.

We note that in the context of this study, mobile broadband subscribers include mobile data connections via USB modems, datacards, MiFi routers or embedded modules, as well as handset access and use of handsets as a modem.

3.2 Forecasting tools methodology

Two forecasting tools have been developed to inform our assessment of the impact of different drivers on the take-up of broadband in Macedonia. These models are:

- a fixed broadband⁶ and fixed high-speed broadband forecasting model
- a mobile and mobile broadband forecasting model.

A common feature of these two forecasting tools is that they depend on an econometric analysis of a dataset that pools time-series and cross-sectional data from 29 countries (the full list of countries is presented in Annex C of this report) to identify and quantify the impact of different drivers on the demand for fixed high-speed broadband and mobile broadband. The purpose of the econometric analysis is twofold:

- it helps to identify demand drivers that are to be incorporated into the forecasting model
- it is used to estimate the value of the parameters that determine the size of the impact of the demand drivers on a change in the demand for broadband; the values of these parameters are a crucial input to the forecasting tools.

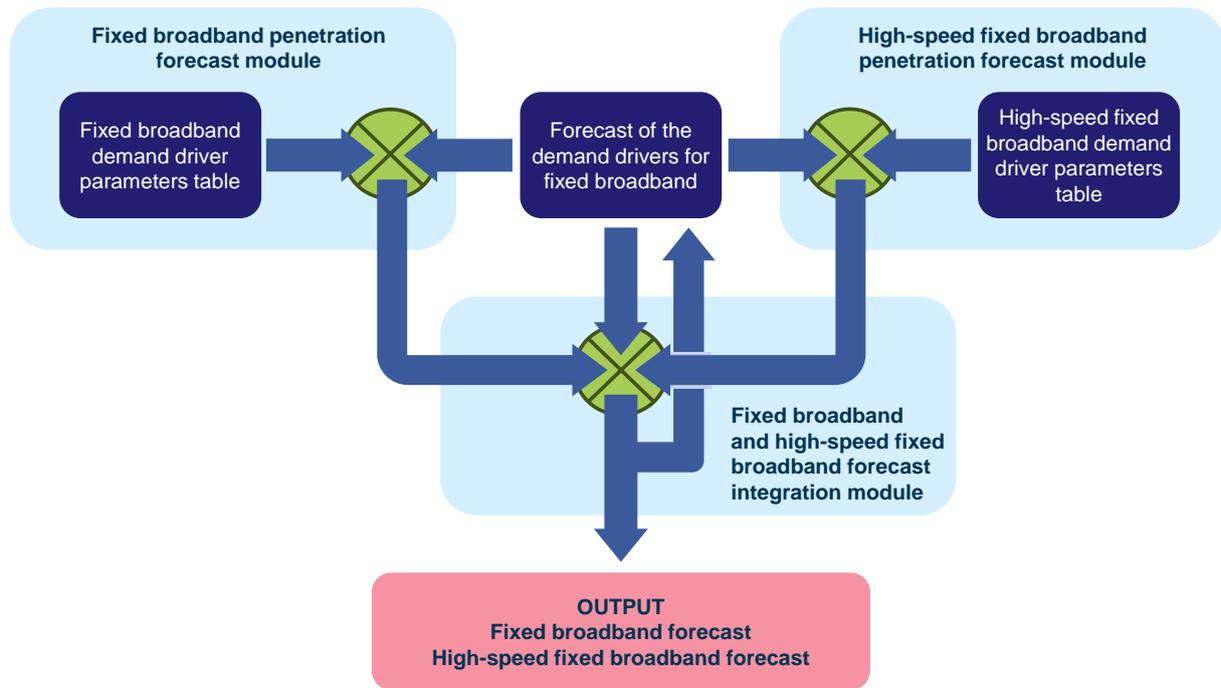
The econometric analysis that underpins the forecasting tools is described in Annex A. The structure and operation of these tools are described in the following sections.

⁶ Fixed broadband represents the total number of broadband connections including basic and high-speed broadband.

3.2.1 Fixed broadband forecast model

Figure 3.3 presents the key elements of the fixed broadband forecasting model, and the flow of information between these elements.

Figure 3.3: Fixed broadband forecasting model [Source: Analysys Mason, 2015]



The first step is to enter the relevant data inputs in the forecasting model, as shown in the figure above. These are:

- fixed broadband demand drivers forecast (including basic and high-speed broadband)
- fixed broadband demand driver parameters table
- high-speed fixed broadband demand driver parameters table.

This data is initially processed in the:

- fixed broadband penetration forecast module
- high-speed fixed broadband penetration forecast module.

The outputs of these two modules, along with the data provided in the fixed broadband demand drivers forecast, are then combined in the broadband forecast integration module to produce the model outputs:

- high-speed fixed broadband forecast
- fixed broadband forecast.

These outputs consist of the yearly forecasts of demand for fixed broadband and high-speed fixed broadband between 2015 and 2023.⁷ High-speed fixed broadband refers to an Internet connection that is capable of supporting download speeds of above 30Mbit/s, which is enabled by fixed-line access networks, while fixed broadband is the sum of the demand for high-speed fixed broadband and basic fixed broadband services.

These outputs are then fed back into the model. This reflects the fact that a factor that affects the demand for broadband in a given year is taken into account in the following year, and therefore the broadband penetration in year n has an effect on the broadband penetration in year $n+1$.

We describe in turn the three modules in which the fixed broadband forecast model is divided.

Fixed broadband penetration forecast module

This module takes the demand drivers and parameter values to forecast the penetration of fixed broadband as a percentage of the total number of households in Macedonia. The forecast is calculated using a logistic function, as illustrated in Figure 3.4 below for a single demand driver; one of the reasons for using the logistic function is that it models a dynamic process for the take-up of broadband.

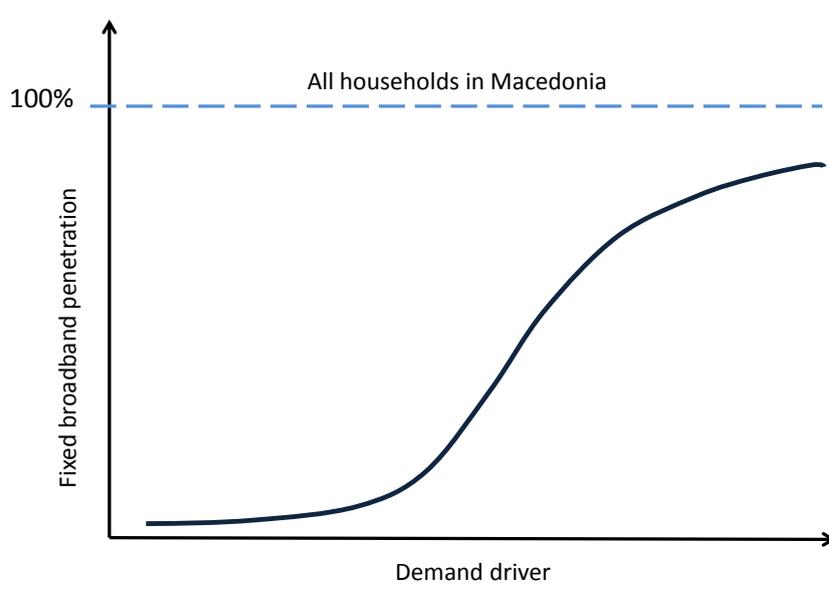


Figure 3.4: Example of logistic function used to forecast fixed broadband penetration [Source: Analysys Mason, 2015]

The figure above shows that the logistic function is S-shaped, which represents the lifecycle of the services:

- Following the launch of the broadband service, the rate of take-up of the service may be low as a small number of ‘early adopters’ acquire the service. This is represented by the flat section on the left hand of the curve.

⁷

It should be noted that forecasts for 2014 were estimated based on the partial data provided (between 6 and 10 months depending on the type of data and operator).

- Broadband take-up then increases and accelerates as the broadband service becomes popular and the majority of consumers acquire it. This is the steep, central section of the curve.
- The rate of take-up of the broadband service then slows as demand becomes saturated, and there are only a small number of ‘laggards’ left to acquire the service. This is represented by the flattening out at the right-hand end of the logistic curve, as nearly all households have acquired a broadband service.

An important feature, therefore, of the logistic function is that it places a floor under, and a cap on, the level of broadband penetration. This means that the model cannot forecast unrealistic levels of fixed broadband penetration, such as a penetration that is less than zero (or the previous year penetration), nor a level of fixed broadband penetration that is greater than 100% of households in Macedonia.

Figure 3.4 illustrates the logistic function for a single demand driver. The fixed broadband forecast module includes 12 demand drivers, and uses the following logistics equation to calculate demand as a proportion of households:

$$P(x_1, x_2, \dots, x_k) = \frac{1}{1 + e^{-(a + b_1x_1 + b_2x_2 + \dots + b_kx_k)}}$$

Where:

- $P(x_1 \dots x_k)$ is the proportion of all households, in this case, that acquire fixed broadband, which is a function of the demand drivers represented by the variables $x_1 \dots x_k$
- the number of variables, which in this case is $k=13$, is greater than the number of demand drivers (12) because one of the demand drivers is a function of two variables
- the function e is the exponential function
- $b_1 \dots b_k$ are the model parameters, which are estimated using econometric analysis, which is described in Annex D
- a is the model constant.

The presentation of these different drivers $x_1 \dots x_k$ are presented in Section 3.2.2

High-speed fixed broadband penetration forecast module

This module takes the demand driver data and parameter values to forecast the penetration of high-speed fixed broadband as a percentage of households in Macedonia within a high-speed fixed broadband coverage area. As for the fixed broadband module discussed above, the forecast is calculated using a logistic function, as illustrated in Figure 3.5 for a single demand driver.

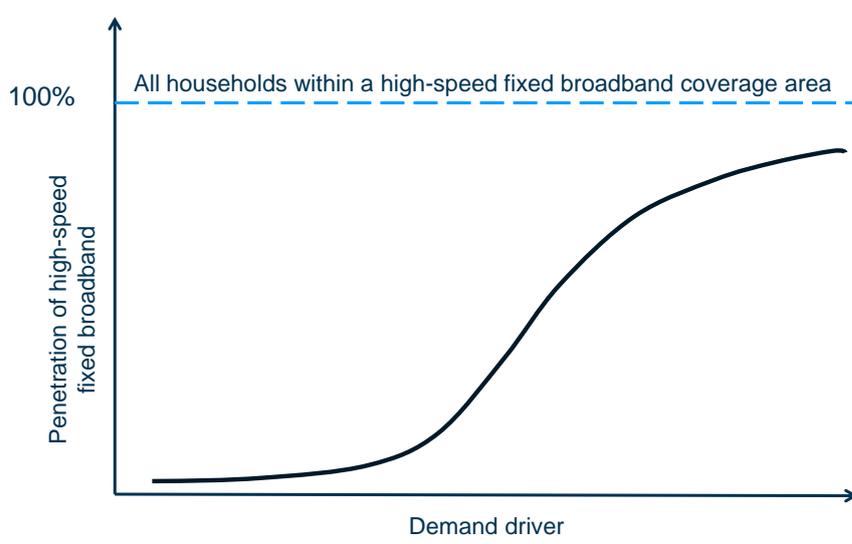


Figure 3.5: Example of logistic function used to forecast high-speed fixed broadband penetration [Source: Analysys Mason, 2015]

A difference between this logistic function and the one for the fixed broadband module described above is that the fixed broadband module puts a cap on demand so that it is less than the number of households in Macedonia, whereas the high-speed fixed broadband module puts a limit on demand so that it is less than the number of households that are within a high-speed fixed broadband coverage area. Other differences between these two modules include differences in the demand drivers and differences in the values of the main parameters.

Fixed broadband and high-speed fixed broadband forecast integration module

This module takes the percentage calculated by the fixed broadband penetration module along with the total number of households in Macedonia to calculate the demand for fixed broadband. It also takes the percentage calculated by the high-speed fixed broadband penetration module along with the number of households within a high-speed fixed broadband coverage area within Macedonia to calculate the demand for high-speed fixed broadband. The final output of the model is also fed back into the demand drivers forecast. This feedback loop represents the fact that demand for a particular year is also a factor or a demand driver that affects the level of demand in the following year.

3.2.2 Demand drivers for fixed broadband and high-speed fixed broadband

The demand drivers represent those factors or variables that have been found to influence the take-up of fixed broadband services.

Criteria for demand driver selection

We have used three criteria for selecting a demand driver in the forecasting model:

- the economic rationale for including the demand driver
- the historical availability and forecast time series data, and
- the significance of the demand driver in explaining demand for fixed broadband services as identified in the econometric analysis of demand for fixed broadband.

Regarding the first criterion listed above, it is important that there is an economic rationale for including the demand driver in the model. For instance, economic theory, along with other econometric analyses of broadband demand, indicates that consumer income and the access price of broadband should be included in the model. Furthermore, on the supply side an important factor that will affect demand will be the extent of network coverage. However, including spurious variables in the model (such as, say, the level of ‘rainfall’) just because an econometric analysis using historical data may suggest there is a correlation between the variable and the demand for broadband raises a question of confidence in the model as a forecasting tool.

With respect to the second criterion identified above, as the purpose of the model is to forecast the demand for fixed broadband in Macedonia ten years into the future, it is important that there is:

- historical time series data for a demand driver for each of the countries included in the benchmark, in order to estimate the value of the corresponding model parameter using econometric techniques
- historical time series data for the demand driver for Macedonia, in order to calibrate the forecast model, and
- forecast time series data for the same data set for Macedonia, for the following ten years.

In particular, if historical data is available and forecast data is not, then the data set was not included in the model as it could not be used to forecast broadband. For example, consumer income is a demand driver that was included in the model. Two options were considered for measuring consumer income: (i) GDP per capita, and (ii) gross national income (GNI) per capita. Even though both measures of income have been used in other econometric studies of the historical demand for broadband, the fact the World Bank does not publish forecasts of GNI by country, particularly for Macedonia, means that GNI could not be used in the fixed broadband forecasting model. The World Bank, however, does publish forecasts of GDP by country from 2015 to 2024, particularly for Macedonia. In this case, therefore, GDP per capita was used as a measure of consumer income.

The third and final criterion listed above is discussed in more detail in Annex C.3.1. The key point here is that a factor that was considered in the selection of a demand driver was the result of econometric analysis and high correlation with the output forecast. In particular, it was important that the parameter estimates were consistent with economic theory and other studies. For instance, the parameter estimate for price implied that demand for broadband would increase (decrease) with a decrease (increase) in price, or that the parameter estimate implied that the demand for broadband would increase (decrease) with an increase (decrease) in GDP per capita.

Fixed broadband demand drivers

The demand drivers represented by the variables $x_1 \dots x_k$ included in the model are summarised in the table on the following page.

Figure 3.6: Demand drivers represented by the variables $x_1 \dots x_k$ included in the model [Source: Analysys Mason, 2015]

Variable	Description
Number of households in Macedonia	<ul style="list-style-type: none"> This determines the upper-bound of fixed broadband connections, where the total number of fixed broadband connections is the sum of basic fixed broadband and high-speed fixed broadband connections This upper-bound of fixed broadband connections will increase over time as the number of households increases
Penetration of fixed broadband and high-speed fixed broadband in previous years	<ul style="list-style-type: none"> A feature of the structure of the forecasting model is that it uses the information about the level of fixed broadband and high-speed fixed broadband penetration in the previous year in order to forecast demand for fixed broadband and high-speed broadband in the next year
Proportion of households covered by a high-speed fixed broadband network	<ul style="list-style-type: none"> This is the proportion of households with access to a high-speed fixed broadband network The result of this percentage and the number of households in Macedonia is the upper-bound of the number of high-speed fixed broadband connections The upper-bound of the high-speed fixed broadband connections will increase as the coverage of the high-speed broadband network increases
Availability of high-speed broadband network	<ul style="list-style-type: none"> This is a 'dummy variable' included in the model that is set to '1' if a high-speed fixed broadband network is available to provide services, and '0' if it is not In the case of the forecasting model for Macedonia, this is set to '1' as high-speed fixed broadband services have been available in Macedonia since 2011
Fixed broadband ARPU	<ul style="list-style-type: none"> This is a measure of the average of the prices of basic fixed broadband and high-speed fixed broadband services ARPU is the monthly average revenue per user
High-speed fixed broadband ARPU	<ul style="list-style-type: none"> This is the ARPU of high-speed fixed broadband services This is a measure of the price of high-speed fixed broadband services
Proportion of households that are urban	<ul style="list-style-type: none"> This is the proportion of all households that are within an urban area
Proportion of the population that is urban	<ul style="list-style-type: none"> This is the proportion of total population that live within an urban area
Population per household	<ul style="list-style-type: none"> This is the average number of people living in a household
GDP per household	<ul style="list-style-type: none"> This is a measure of the average income per household
Consumer spending per household	<ul style="list-style-type: none"> This is a measure of the average consumer expenditure per household
Proportion of the population with medium or high Internet skills	<ul style="list-style-type: none"> This is a measure of the level of Internet skills over the population
Proportion of the population that has never used the Internet	<ul style="list-style-type: none"> This is a measure of the extent of Internet use over the population
Availability of LLU	<ul style="list-style-type: none"> This is a 'dummy variable' included in the model that is set to '1' if regulated LLU is available, and '0' if it is not In the case of the forecasting model for Macedonia this is set to '1' as LLU has been available in Macedonia since 2005
Years since the introduction of LLU	<ul style="list-style-type: none"> This is a 'dummy variable' included in the model that counts the number of years since regulated LLU was introduced into the market In the case of the forecasting model for Macedonia, this variable increases one unit every year since LLU was introduced in 2005, so that at the start of the forecast period in 2015 its value is 10, and its value is 18 at the end of the forecast period (2023)

Fixed broadband demand driver parameters

The value of the demand driver parameters $b_1 \dots b_k$ determines the magnitude of the impact of the demand driver on the demand for broadband. In the case of the fixed broadband forecast, the estimate of the value of the parameters associated with the demand drivers listed above, as determined by the econometric analysis described in Annex A and utilised within the forecasting model, are presented in Figure 3.7.

Figure 3.7: Demand driver parameters $b_1 \dots b_k$ for the fixed broadband forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter value
Fixed broadband penetration in the previous year	2.1881
Fixed broadband ARPU	-0.0026455
High-speed fixed broadband ARPU	-0.00041488
Proportion of households covered by a high-speed fixed broadband network	0.28015
Availability of high-speed fixed broadband networks	0.086332
Proportion of households that are urban	-8.8142
Proportion of the population that is urban	9.8475
Population per household	0.92725
GDP per household	1.3211E-06
Consumer spending per household	0.000011431
Proportion of the population with medium or high Internet skills	0.35671
Proportion of the population that has never used the Internet	-0.48895
Years since the introduction of LLU	0.014261

The inferences that can be directly drawn, by simply observing the above parameter values, regarding the magnitude of the impact of a change in the value of the demand driver on the total demand for fixed broadband are limited. This is because the forecasting model at its core is based on a logistic functional form, as described above, which means that the parameter values are used initially to forecast the ‘logit’ of the demand for broadband, where, for this particular module, the logit is the logarithm of ratio of the proportion of households with fixed broadband over the proportion of households without fixed broadband. As explained in Annex A, the logistic function is transformed into a logit function in order to assist with the estimation of the demand driver parameters.

However, the sign on the parameter values (i.e. whether the parameter value has a positive or negative sign) indicates whether an increase, say, in a particular demand driver will either increase or decrease the demand for fixed broadband. For instance, the negative sign on the parameter value for the ‘proportion of the population that has never used the Internet’ implies that a decrease in the proportion of the population that has never used the Internet will result in an increase in the demand for fixed broadband. However, care needs to be taken when interpreting the direction of causation. That is, the negative sign could also be explained by an increase in the penetration of fixed broadband resulting in a decrease in the proportion of the population that has never used the Internet.

High-speed fixed broadband demand driver parameters

As already noted, the value of the demand driver parameters $b_1 \dots b_k$ determines the magnitude of the impact of the demand driver on the demand for broadband. In the case of the high-speed fixed broadband forecast, the estimate of the value of the parameters associated with the demand drivers listed above, as determined by the econometric analysis described in Annex A and utilised within the forecasting model are presented in Figure 3.8.

Figure 3.8: Demand driver parameters $b_1 \dots b_k$ for the high-speed fixed broadband forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter value
Fixed broadband penetration in the previous year	4.1339
Fixed broadband ARPU	-0.0063899
High-speed fixed broadband ARPU	-0.0063899
Proportion of households covered by a high-speed fixed broadband network	0.20879
Availability of high-speed fixed broadband networks	-2.5576
Proportion of households that are urban	-15.895
Proportion of the population that is urban	52.926
Population per household	4.1614E-06
GDP per household	0.000033949
Consumer spending per household	0.68444
Proportion of the population with medium or high Internet skills	-1.8833
Proportion of the population that has never used the Internet	2.6506
Years since the introduction of LLU	-0.12218

Furthermore, as noted above, the inferences that can be directly drawn regarding the impact of the demand driver on the demand for broadband, by simply observing the above parameter values, are limited. This is because the forecast model at its core is based on a logistic functional form, which means that the parameter values are used initially to forecast the 'logit' of the demand for high-speed fixed broadband. However, also as noted above, the sign on the parameter values (i.e. whether the parameter value has a positive or negative sign) indicates whether an increase, say, in a particular demand driver will either increase or decrease the demand for high-speed fixed broadband.

A point to note regarding the values of the parameters listed in Figure 3.8 above is that the parameters for the fixed broadband ARPU and the high-speed fixed broadband ARPU are the same – i.e. they are both – 0.0063899. As indicated in Annex A, the value –0.0063899 is the value of the fixed broadband ARPU parameter, whereas the estimated value of the high-speed fixed broadband parameter is 0.02427.

The reason why the value of –0.0063899 is used for the high-speed fixed broadband parameter in the forecasting model, and not the estimate of 0.02427, is because the parameter estimate for the high-speed fixed broadband ARPU is positive, whereas the ARPU in the model is intended to act as a proxy for the access price. That is, as ARPU is a proxy for the price of broadband access, economic theory

and supporting empirical evidence indicates that an increase (decrease) in the access price would result in a decrease (increase) in demand for broadband. This implies that the sign of the ARPU parameter should be negative.

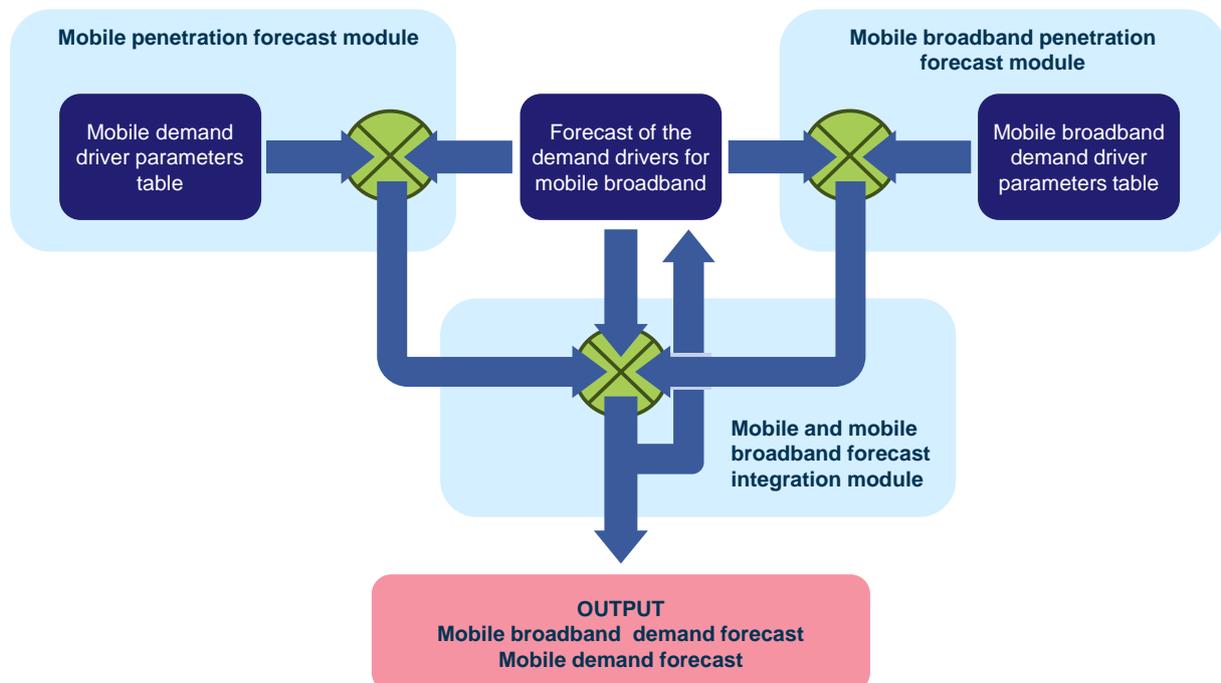
However, the revenue included in the calculation of ARPU for high-speed fixed broadband services includes not only broadband access revenue, but also revenue earned from value-added services and bundles. This would explain the positive value of the econometric estimate of 0.02427, which implies that the penetration of high-speed fixed broadband and its ARPU are positively correlated. That is, it suggests that the demand for high-speed fixed broadband has increased with the ARPU because the ARPU captures revenue from a range of value-added services, where these value-added services have increased over time.

This suggests that the estimated value of high-speed fixed broadband ARPU is not a suitable proxy for the access price of high-speed fixed broadband. The challenge, therefore, is to identify an appropriate proxy for the access price of high-speed fixed broadband. In this case, it seems that the fixed broadband ARPU is a reasonable alternative, given that its negative sign is consistent with economic theory and it is estimated using the available data set. This assumes that the change in the fixed broadband ARPU parallels the change in the access price for fixed broadband.

3.2.3 Mobile broadband forecasting model

Figure 3.9 presents that the key elements of the mobile broadband forecast model, and the flow of information between these elements.

Figure 3.9: Mobile broadband forecasting model [Source: Analysys Mason, 2015]



Comparing this diagram with the corresponding diagram for the fixed broadband forecasting model (see Figure 3.3) indicates that the general flow and organisation of both models are similar, even though the details differ. The mobile broadband forecast starts with the data that enters the model in three areas, which are highlighted in the above figure and reproduced below:

- mobile demand drivers forecast
- mobile demand driver parameters table, and
- mobile broadband demand driver parameters table.

This data is initially processed in the:

- mobile penetration forecast module, and
- mobile broadband penetration forecast module.

The outputs of these two modules, along with the data provided in the mobile demand drivers forecast, are then combined in the mobile broadband forecast integration module to produce the model outputs:

- mobile broadband demand forecast
- mobile demand forecast.

These outputs consist of the yearly forecasts of demand for total mobile services and mobile broadband services, over the 2015–2023 period. The demand forecast for mobile broadband is the primary forecast of these two, whereas the forecast of total mobile demand serves as cross-check and reference point.

The mobile broadband forecasting model consists of three modules, which are described in turn below.

Mobile penetration forecast module

This module takes the demand drivers data and parameter values to forecast mobile penetration as a percentage of 1.5 times the total population in Macedonia (as the penetrations registered in other countries were all below 150%). The forecast is calculated using a logistic function, as illustrated in Figure 3.10 for a single demand driver.

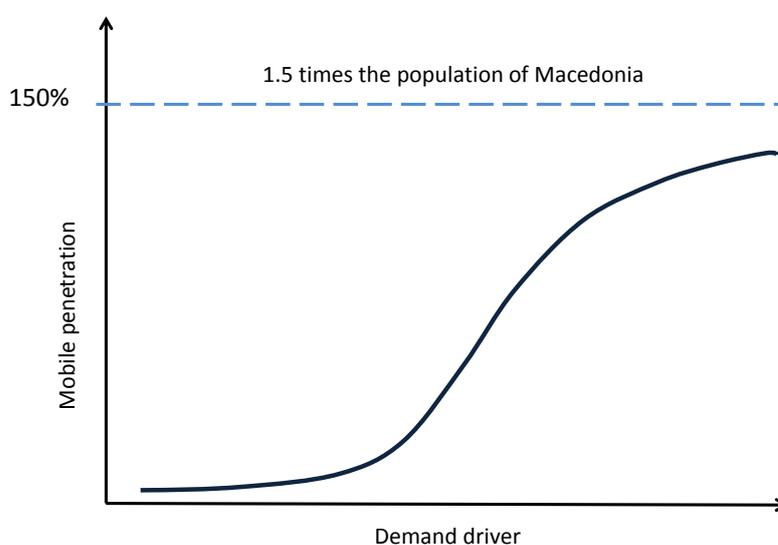


Figure 3.10: Example of logistic function used to forecast mobile penetration [Source: Analysys Mason, 2015]

In this case, the mobile demand is capped at 1.5 times the size of the population in Macedonia. The cap on the number of mobile devices is greater than the size of the population to reflect the fact that customers may own multiple SIM cards. For instance, the number of mobile devices currently in the market is 1.13 times the size of the population in Macedonia.

Furthermore, six demand drivers have been included in the logistic function, similar to the one describe for the fixed broadband penetration forecast, to explain the penetration of mobile in Macedonia.

Mobile broadband penetration forecast module

This module takes the demand drivers data and parameter values to forecast the penetration of mobile broadband as a percentage of the population in Macedonia. The forecast is calculated using a logistic function, as illustrated in Figure 3.11 for a single demand driver.

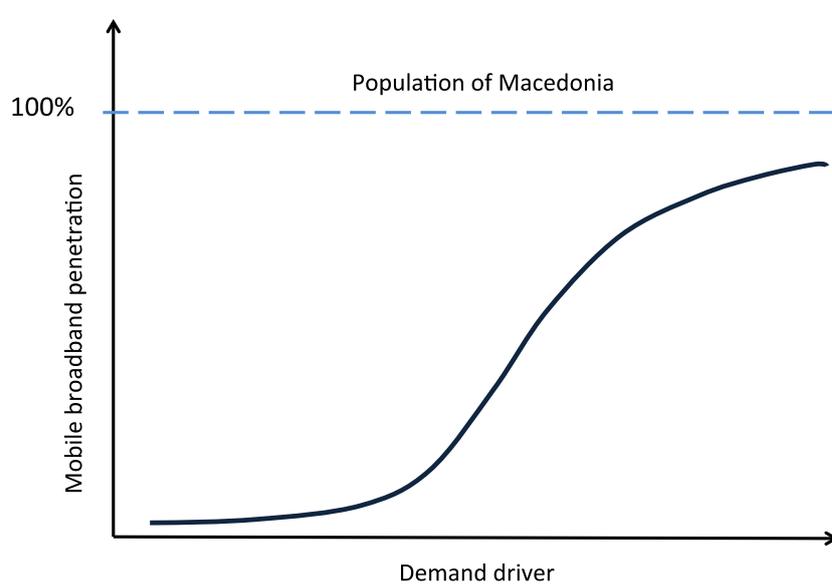


Figure 3.11: Example of logistic function used to forecast mobile broadband penetration [Source: Analysys Mason, 2015]

The mobile broadband demand is capped by the population size. The population size is expected to cap the number of mobile broadband subscribers because subscribers are unlikely to acquire multiple SIM cards for mobile broadband services as they generally do for mobile subscriptions.

Furthermore, eight demand drivers have been included in the logistic function, similar to the one describe in the fixed broadband module, to explain the penetration of mobile broadband in Macedonia.

Mobile and mobile broadband forecast integration module

This module takes the percentage calculated by the mobile penetration module along with the 1.5 times the population size in Macedonia to calculate the mobile demand forecast. It also takes the percentage calculated by the mobile broadband penetration module along with the population size to calculate the mobile broadband demand forecast. The final output of the model is also fed back into the demand drivers forecast. This feedback loop represents the fact that demand for a particular year is also a factor or a demand driver that affects the level of demand in the following year.

3.2.4 Mobile and mobile broadband demand drivers

The demand drivers represent those factors or variables that have been found to influence the take-up of mobile services and in particular mobile broadband services.

Criteria for demand driver selection

The general criteria for selecting these demand drivers are the same as those discussed above in relation to fixed broadband. These are:

- the economic rationale for including the demand driver
- the historical availability and forecast time series data, and
- the significance of the demand driver in explaining demand for mobile and mobile broadband services, as identified in the econometric analysis of mobile broadband demand.

Mobile demand drivers

The demand drivers included in the model are listed in the table below.

Figure 3.12: Demand drivers included in the model [Source: Analysys Mason, 2015]

Variable	Description
Size of the Macedonian population	<ul style="list-style-type: none"> • This is the upper-bound of the total number of mobile broadband connections, and the upper-bound for mobile subscribers is 1.5 times the size of the Macedonian population
Penetration of mobile broadband and mobile services in the previous year	<ul style="list-style-type: none"> • A feature of the structure of the forecasting model is that it uses information about the level of mobile and mobile broadband penetration in the previous year, in order to forecast demand for mobile and mobile broadband penetration in the next year
Mobile ARPU	<ul style="list-style-type: none"> • This is a measure of the average of the prices of mobile voice and broadband services
Mobile broadband ARPU	<ul style="list-style-type: none"> • This is the ARPU of mobile broadband services only (i.e. data-only devices), which is used to measure the price of mobile broadband
Proportion of population that is urban	<ul style="list-style-type: none"> • This is the proportion of all population that live in urban areas
GDP per capita	<ul style="list-style-type: none"> • This is a measure of the average income per capita
Consumer spending per capita	<ul style="list-style-type: none"> • This is the average consumer expenditure per capita
Proportion of the population with medium or high Internet skills	<ul style="list-style-type: none"> • This is a measure of the level of Internet skills among the population
Proportion of the population that has never used the Internet	<ul style="list-style-type: none"> • This is a measure of the extent of internet use among the population

Mobile demand driver parameters

The value of these parameters determines the magnitude of the impact of the demand driver on the demand for mobile subscriptions. In the case of the mobile forecast, the estimate of the value of the parameters associated with the demand drivers listed above, as determined by the econometric analysis described in Annex A and utilised in the forecasting model, are presented in Figure 3.13 below.

Figure 3.13: Demand driver parameters for mobile forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter value
Mobile penetration in the previous year	3.0178
Mobile ARPU	-0.0066904
Mobile broadband ARPU	0.00093377
Proportion of the population that is urban	0.56439
GDP per capita	0.000001149
Consumer spending per capita	0.000024685

Reiterating the point made above in relation to the fixed demand driver parameter estimates, the inferences that can be directly drawn regarding the impact of the demand driver on mobile demand, by simply observing the above parameter values, are limited. This is because the forecasting model at its core is based on a logistic functional form, which means that the parameter values are used initially to forecast the ‘logit’ of the demand for mobile services. However, as also noted above, the sign on the parameter values (i.e. whether the parameter value has a positive or negative sign) indicates whether an increase, say, in a particular demand driver will either increase a decrease the demand for mobile broadband.

Mobile broadband demand driver parameters

The value of these demand driver parameters determines the magnitude of the impact of the demand driver on the demand for mobile broadband services. In the case of the mobile broadband forecast, the estimate of the value of the parameters associated with the demand drivers listed above, as determined by the econometric analysis described below in Annex A and utilised within the forecasting model, are presented in Figure 3.14 below.

Figure 3.14: Demand driver parameters for the mobile broadband forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter value
Mobile penetration in the previous year	2.2183
Mobile ARPU	-0.043142
Mobile broadband ARPU	-0.020584
Proportion of the population that is urban	18.365
GDP per capita	9.9823E-06
Consumer spending per capita	0.000043985
Proportion of the population with medium or high Internet skills	2.2779
Proportion of the population that has never used the Internet	-1.2764

As already noted above, the inferences that can be directly drawn regarding the impact of the demand driver on the mobile broadband demand, by simply observing the above parameter values, are limited. Again, this is because the forecasting model at its core is based on a logistic functional form, which means that the parameter values are used initially to forecast the ‘logit’ of the demand for mobile services.

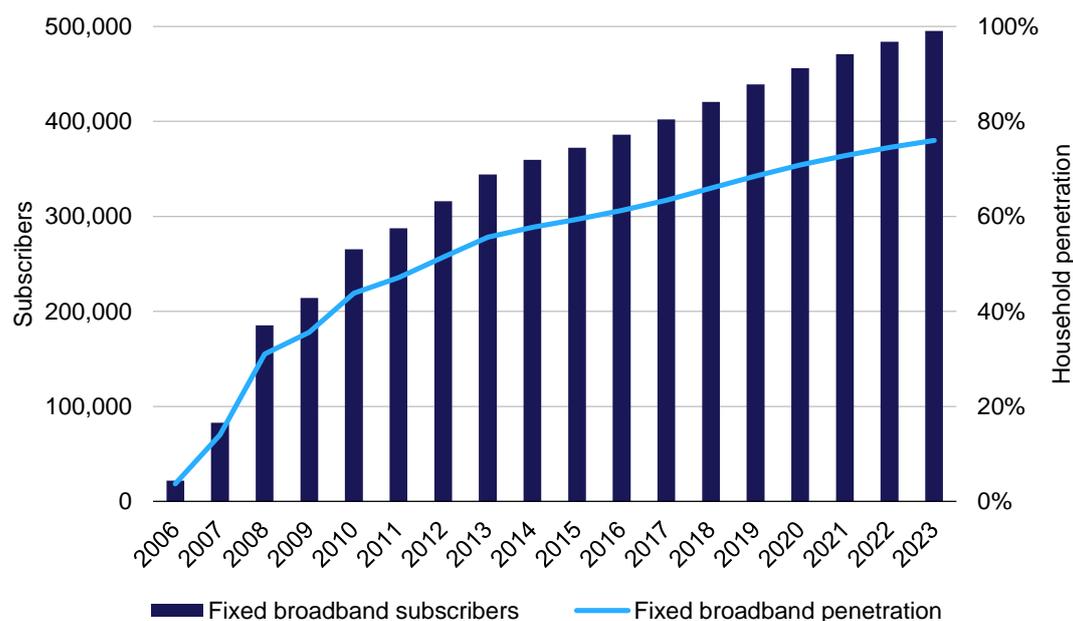
3.3 Broadband take-up

This section presents the results of our econometric analysis of future demand for fixed and mobile broadband services in Macedonia. The validity of these results has been cross-checked against a bottom-up model, which was built on the basis of extensive data on the market⁸ regarding coverage, penetration and revenues for various technologies. Finally, both our assumptions underlying the bottom-up demand model and the results of the econometric analysis have been benchmarked against 18 European countries.

3.3.1 Fixed broadband subscribers

The number of fixed broadband subscriptions in Macedonia is estimated to increase from c.344 000 in 2013 (56% of households) to c.496 000 in 2023 (76% of households).⁹ This represents a 44% increase in number of subscribers, which is due to a moderate increase in the number of households and an increase in the share of covered households taking up a subscription. The historical and forecast evolution of fixed broadband subscribers in Macedonia is presented in Figure 3.15 below.

Figure 3.15: Evolution of fixed broadband subscribers and penetration in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]



⁸ Provided by the AEC and the main Macedonian operators.

⁹ These figures include business connections.

Figure 3.16 and Figure 3.17 below show how fixed broadband penetration in Macedonia compares with the penetration levels currently observed in other European countries. As can be seen in the following figures, Macedonia is at the lower end of Eastern European countries and significantly behind the Western European countries including the benchmark. By 2023, we estimate that fixed broadband penetration in Macedonia will be higher than the current levels observed in all Eastern European countries and in some countries in Western Europe.

Figure 3.16: Benchmark of fixed broadband penetration, 2013 [Source: Analysys Mason, 2015]

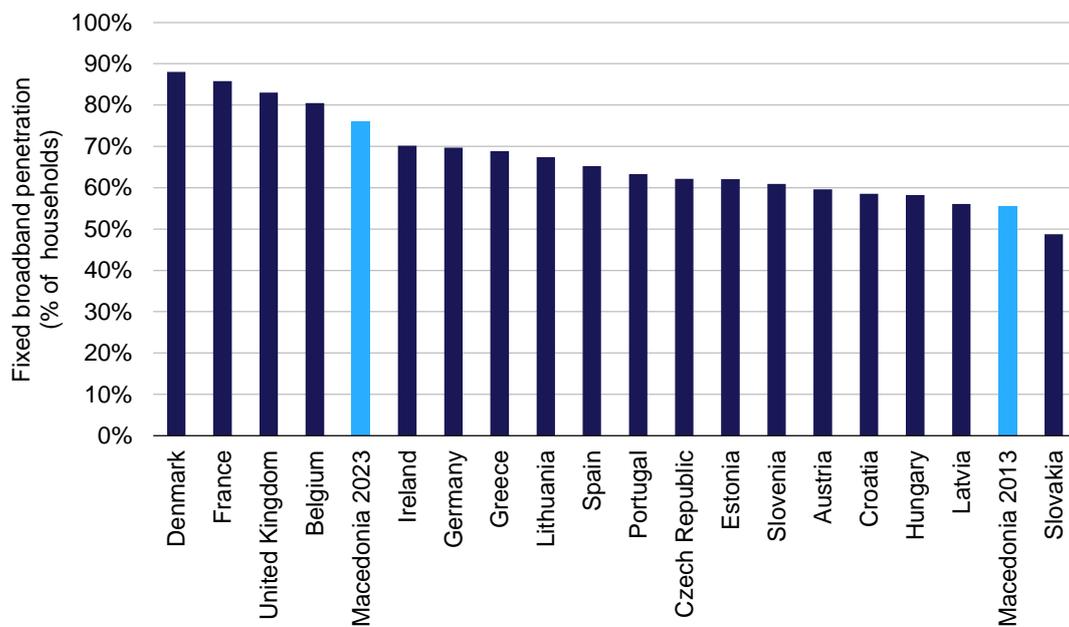
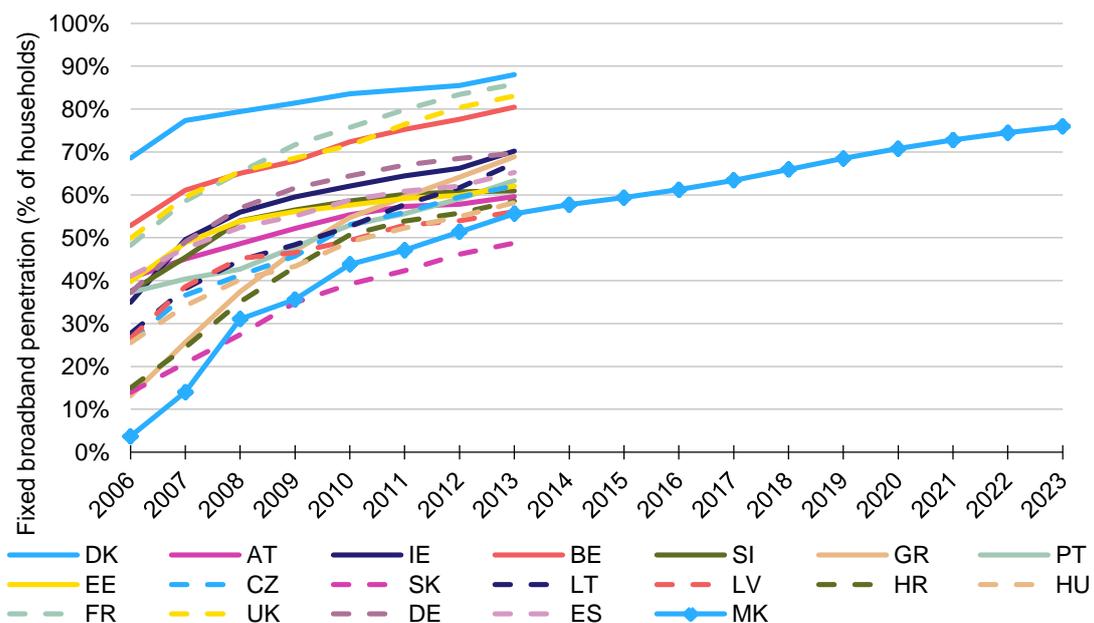


Figure 3.17: Evolution of fixed broadband penetration in the study countries [Source: Analysys Mason, 2015]



We have checked how our penetration forecasts measure against a number of potentially limiting factors for fixed broadband penetration, as illustrated in Figure 3.18. We believe that this level of penetration is reasonable as a forward-looking view based on the high literacy rate in Macedonia, the fact that electricity is widely available throughout the country, the forecasted increase in the percentage of households having Internet-capable PC and that the poverty rate is lower than our forecasts.

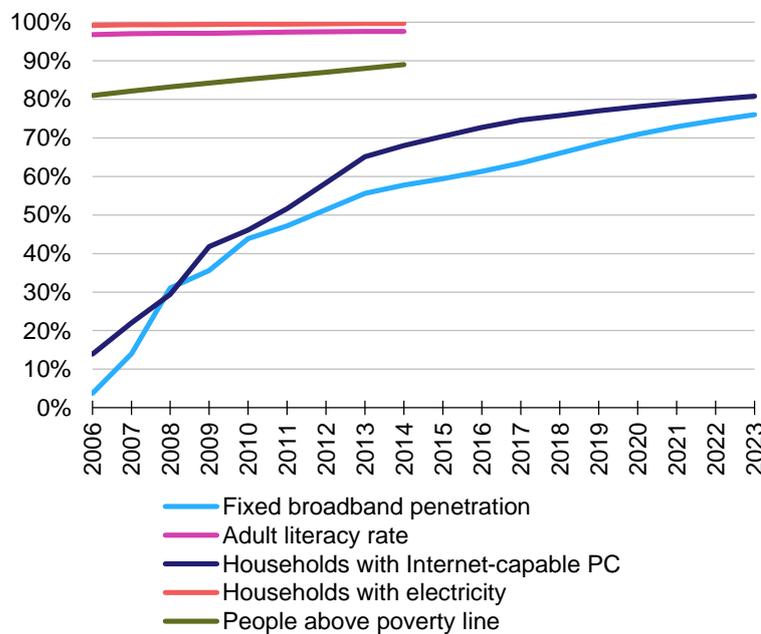


Figure 3.18: Evolution of factors that may limit fixed broadband penetration in Macedonia [Source: Analysys Mason, Euromonitor, 2015]

Two other metrics correlated with broadband and high-speed broadband penetration, and which are included within the Digital Agenda for Europe (DAE), were used in the econometric analysis: the share of population who has never used the Internet, and the share of the population who has medium or high Internet skills.¹⁰ Figure 3.19 and Figure 3.20 below show how Macedonia compares with benchmarks for these metrics.

Macedonia is currently one of the European countries with the largest share of the population who has never used the Internet (estimated at 33% in 2014). We estimate that by 2023 this figure will have declined to 20%, bringing Macedonia closer to the Western European average. Typically, this requires a specific approach to education for two main segments: young students at schools and elderly people who are not comfortable with technology and innovation.

¹⁰ Citation from the Digital Agenda for Europe: "The indicator counts individuals having ever carried out at least 3 of the following 6 activities: using a search engine to find information, sending e-mails with attached files, posting messages to chatrooms, newsgroups or an online discussion forum, using the internet to make telephone calls, using peer-to-peer file sharing for exchanging movies or music, creating a webpage."

and 50%. We estimate that by 2023 the share of the Macedonian population with medium or high Internet skills is estimated to rise to c.60%, close to the values observed for the Eastern European countries currently at the high end of the benchmark.

Figure 3.21: Benchmark of the share of people with medium or high Internet skills, 2013 [Source: Analysys Mason, DAE 2015]

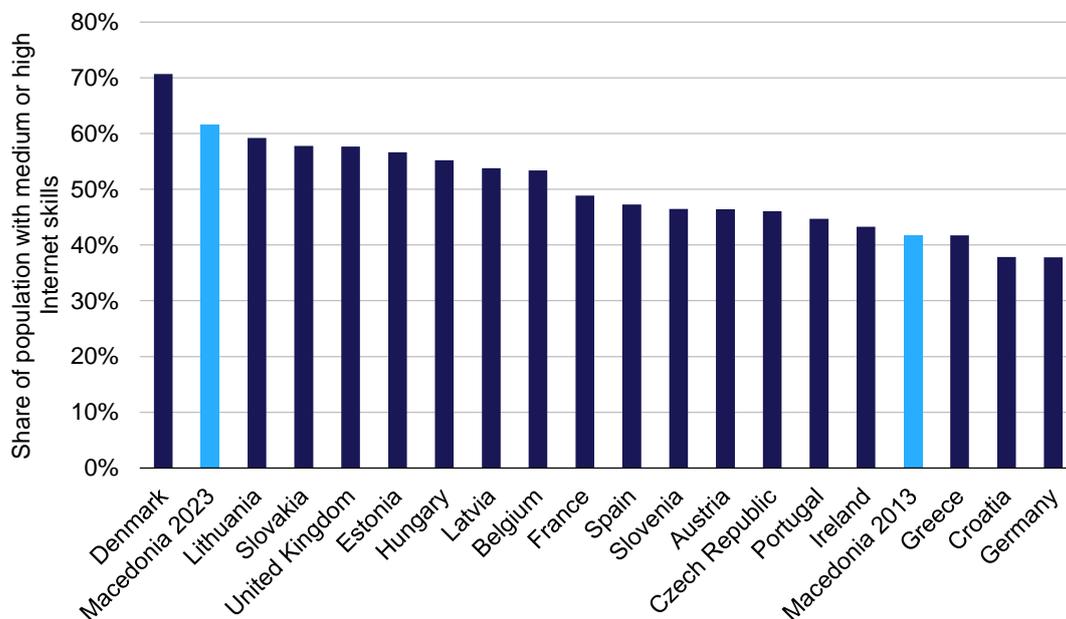
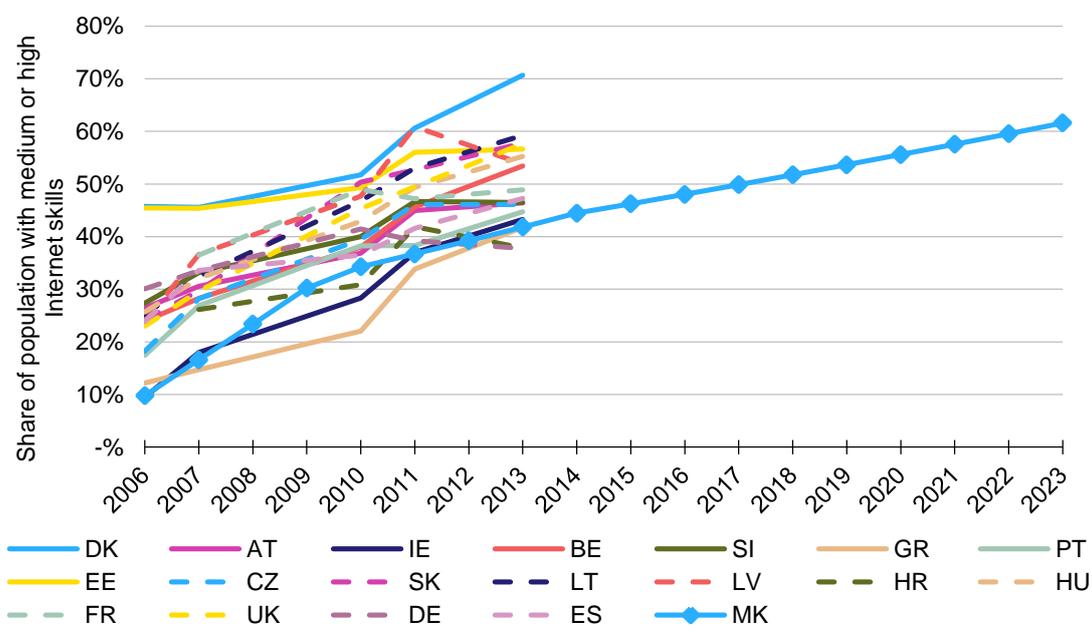


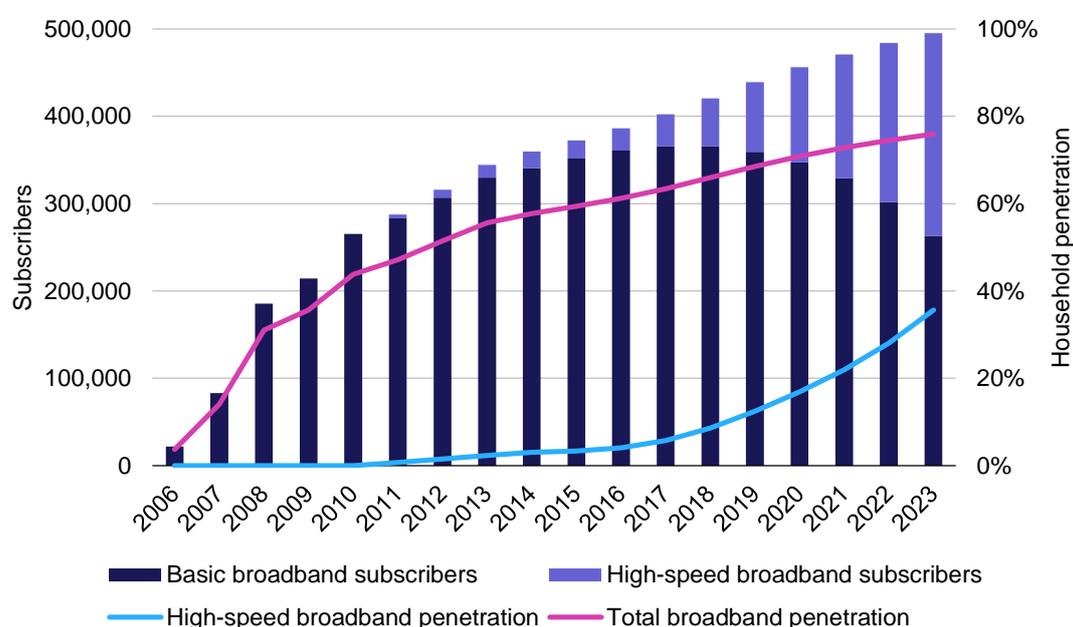
Figure 3.22: Evolution of the share of people with medium or high Internet skills in the study countries [Source: Analysys Mason, DAE, 2015]



Fixed broadband in Macedonia is currently provided through a number of technologies (mostly DSL, coaxial cable, LAN, FWA and FTTH). At the end of 2013, there were 344 000 fixed broadband subscribers in Macedonia. Of these, we estimate that c.15 000 have opted for a high-speed broadband connection (FTTH or DOCSIS3.0), against c.330 000 basic broadband connections.

The penetration of high-speed broadband is expected to gradually increase from 3% of households in 2014 to 12% in 2019 and 36% in 2023, as shown in the figure below. This growth will be mainly supported by operators deploying FTTH in viable areas (with take-up gradually increasing) and by cable operators progressively upgrading their networks to DOCSIS3 and higher versions of this standard (which are capable of supporting higher broadband speeds).

Figure 3.23: Evolution of basic fixed broadband and high-speed broadband subscribers and penetration in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]



Compared to European benchmarks, Macedonia is currently significantly below almost all Western and Eastern European countries, where penetration levels typically range between 10% and 30% of households. We estimate that by 2023 the penetration of high-speed broadband in Macedonia will exceed the levels currently observed in Lithuania, Latvia or Portugal (c.30% of households). This represents a significant but realistic increase because of the relatively large current footprint of cable operators (whose networks have been or will be upgraded to DOCSIS3.0) and due to the ambitious FTTH rollout plans of other Macedonian operators (in particular the incumbent Makedonski Telekom).

Figure 3.24: Benchmark of high-speed fixed broadband penetration, 2013 [Source: Analysys Mason, DAE, 2015]

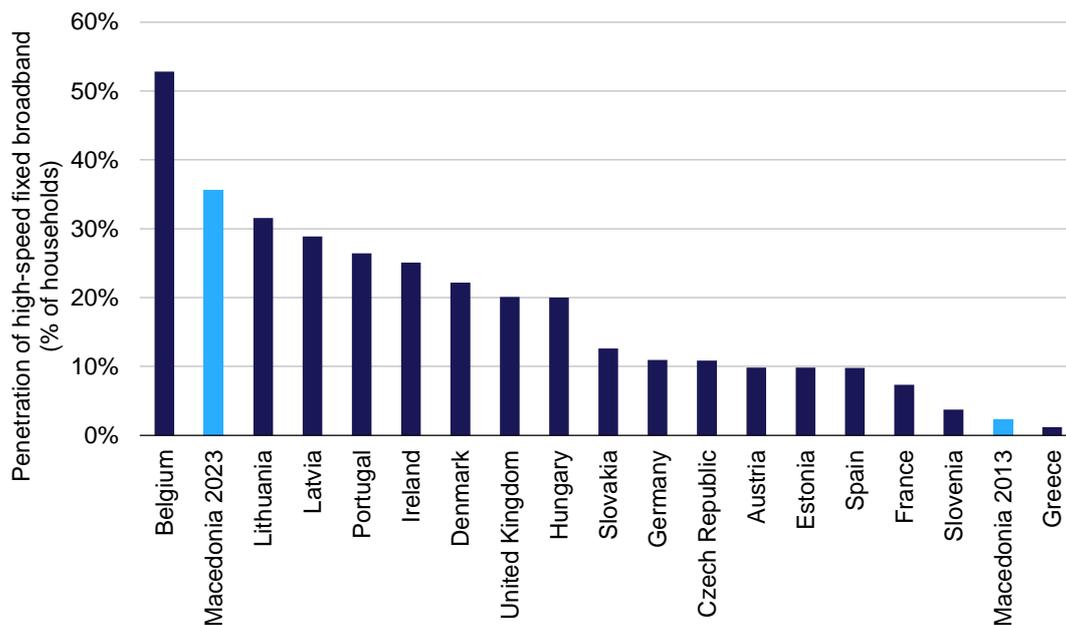


Figure 3.25: Evolution of the penetration of high-speed fixed broadband in the study countries [Source: Analysys Mason, DAE, 2015]

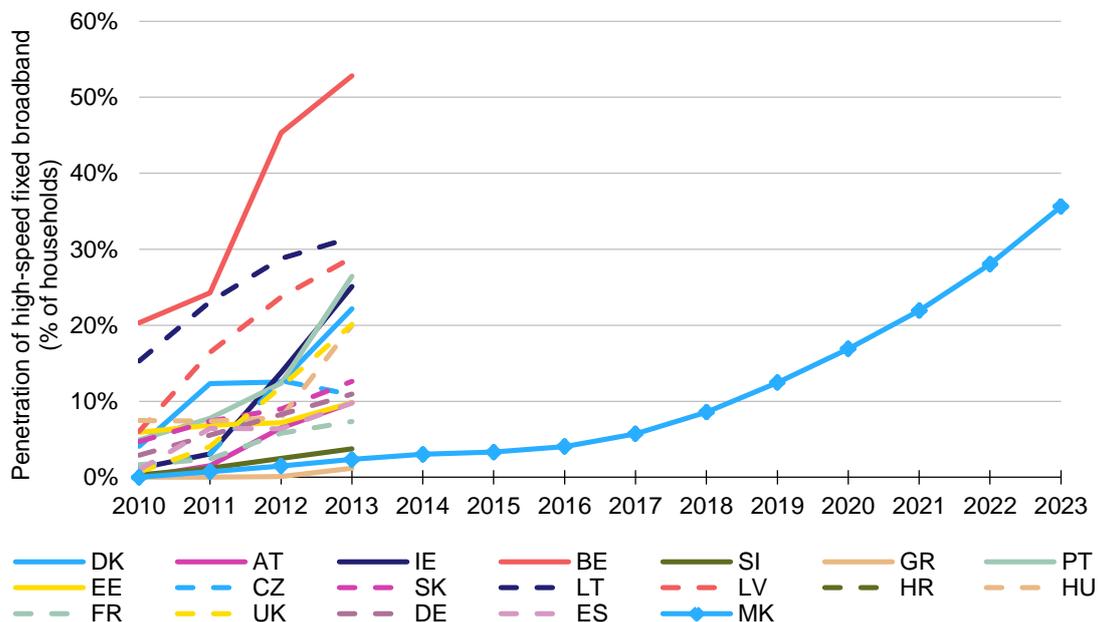


Figure 3.26 and Figure 3.27 show the number of high-speed fixed broadband subscriptions as a share of total fixed broadband subscriptions in Macedonia and in the benchmarked countries. We estimate that high-speed broadband subscriptions will continue to represent less than 10% of all broadband subscriptions in Macedonia until 2018, significantly below the current levels observed in most of the countries included in the benchmark. Thereafter, the share of fixed broadband connections in Macedonia is expected to increase

at a faster rate, accounting for nearly 50% of all broadband connections in 2023, which is similar to the levels currently observed in Belgium, Latvia, Lithuania and Portugal.

Figure 3.26: Benchmark of high-speed broadband subscriptions as a share of total fixed broadband subscriptions, 2013 [Source: Analysys Mason, DAE, 2015]

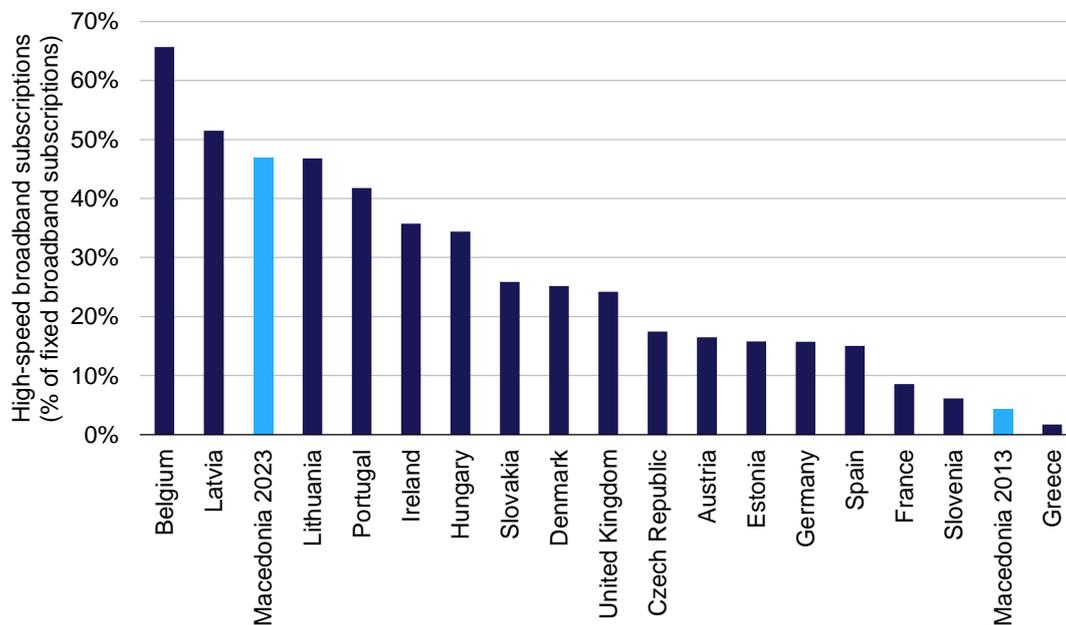
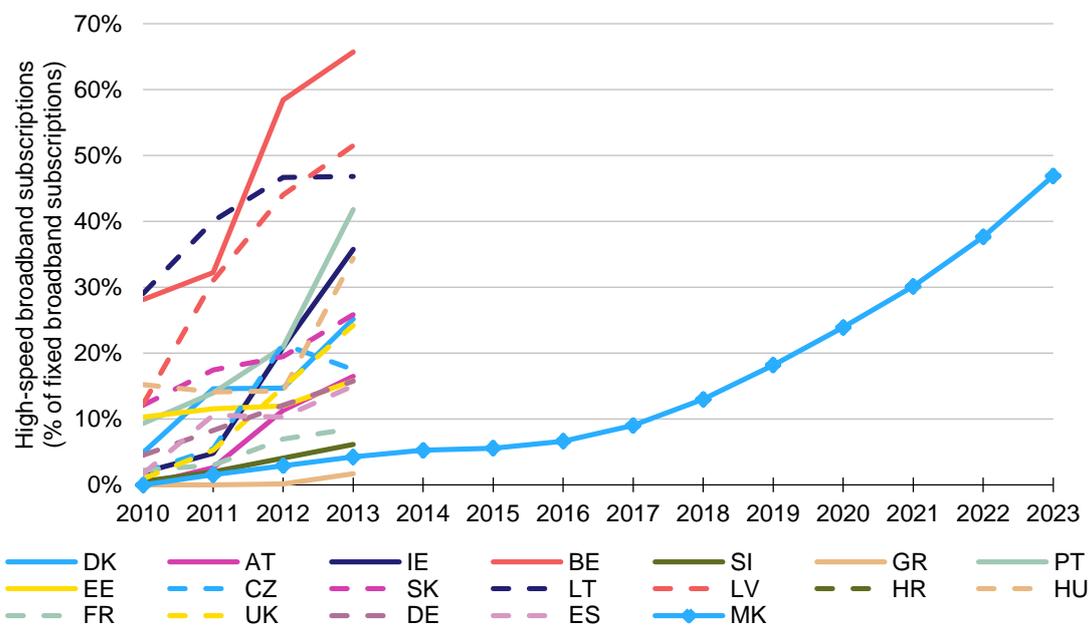


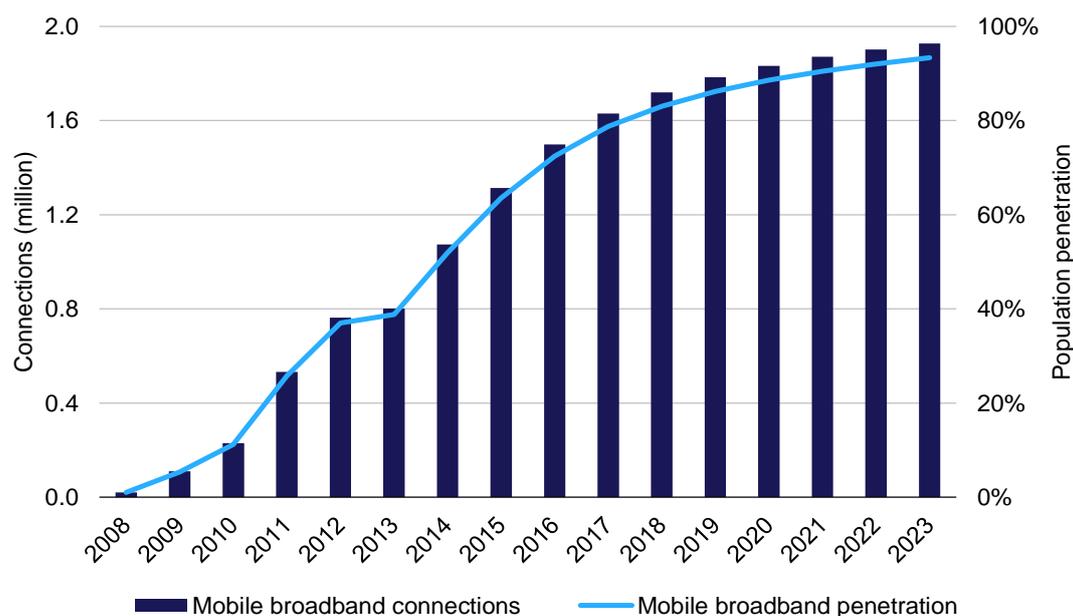
Figure 3.27: Benchmark of the evolution of high-speed fixed broadband subscriptions as a share of total fixed broadband subscriptions [Source: Analysys Mason, DAE, 2015]



3.3.2 Mobile broadband subscribers

The number of mobile broadband subscriptions in Macedonia is estimated to increase from 1.07 million in 2014¹¹ (52% of the population) to 1.93 million in 2023 (94% of the population), shown in Figure 3.28 below. This represents an 80% increase in terms of number of connections, which is principally driven by the expected widespread availability of broadband-capable devices as well as broadband plans including mobile data.

Figure 3.28: Evolution of mobile broadband connections and penetration in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]



Macedonia is the lower end of European benchmarks for this metric, as shown below in Figure 3.29 and Figure 3.30. However, by 2023, mobile broadband penetration in Macedonia is expected to exceed the current levels observed in most of the benchmarked countries; this forecast is reasonable when looking at the strong growth trend in all benchmark countries in the past five years largely due to the proliferation of smartphones.

¹¹ Figure extrapolated based on available data up to Q3 2014

Figure 3.29: Benchmark of mobile broadband penetration, 2013 [Source: Analysys Mason, 2015]

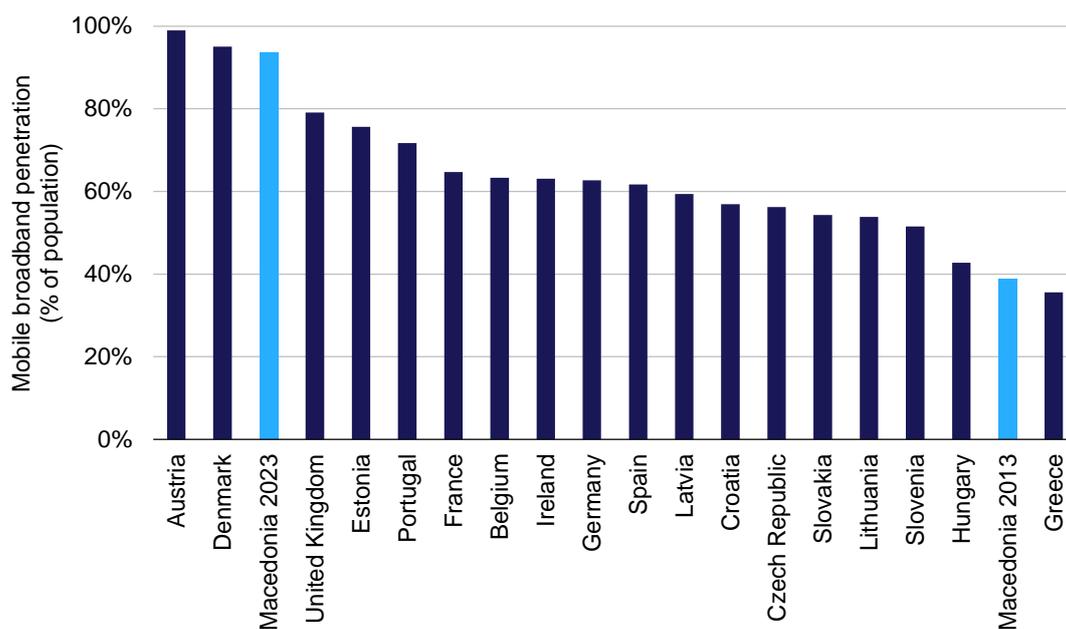
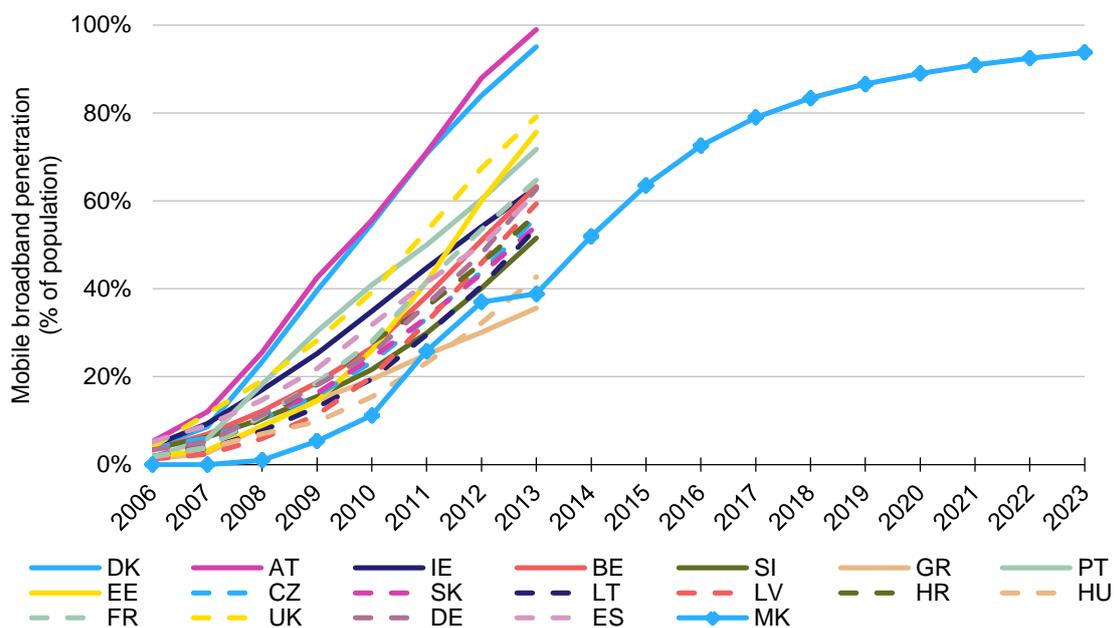
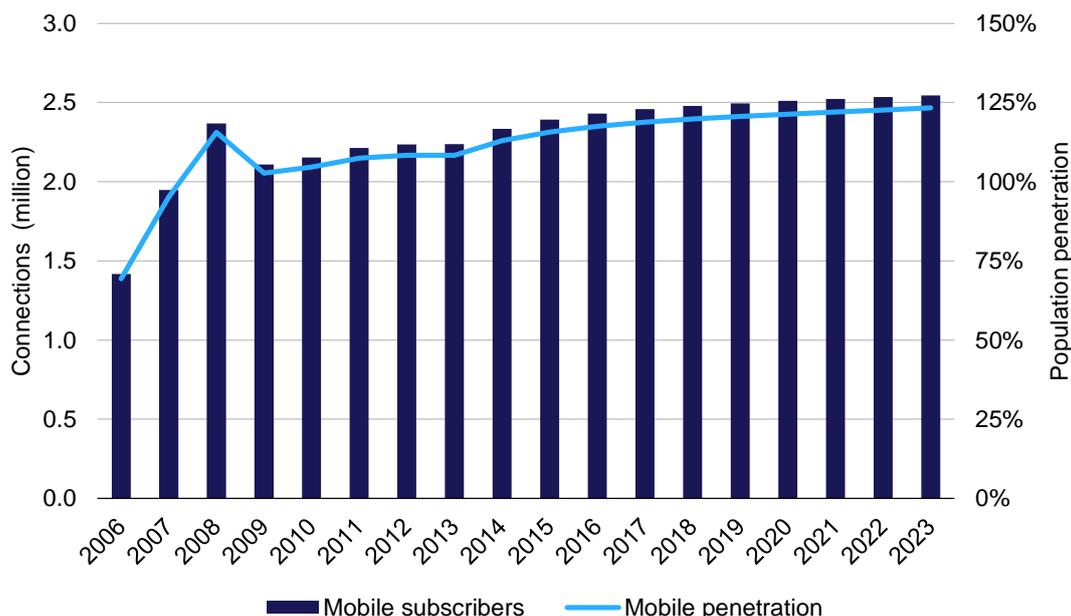


Figure 3.30: Benchmark of the evolution of mobile broadband penetration [Source: Analysys Mason, 2015]



Based on the results of our econometric analysis, the total number of mobile connections in Macedonia is expected to grow from 2.34 million in 2014 (113% population penetration) to EUR2.54 million in 2023 (123% population penetration).

Figure 3.31: Evolution of mobile connections and penetration in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]



Macedonia has the lowest mobile penetration of all European countries included in our benchmark, though it is closely followed by Greece, France and Slovenia (see Figure 3.32 and Figure 3.33 below). We do not expect strong growth in mobile penetration in the period to 2023 in Macedonia (bringing the country towards the lower-middle part of the benchmark), as penetration has been largely stable in past years and prices are already very low.

Figure 3.32: Benchmark of mobile penetration, 2013 [Source: Analysys Mason, 2015]

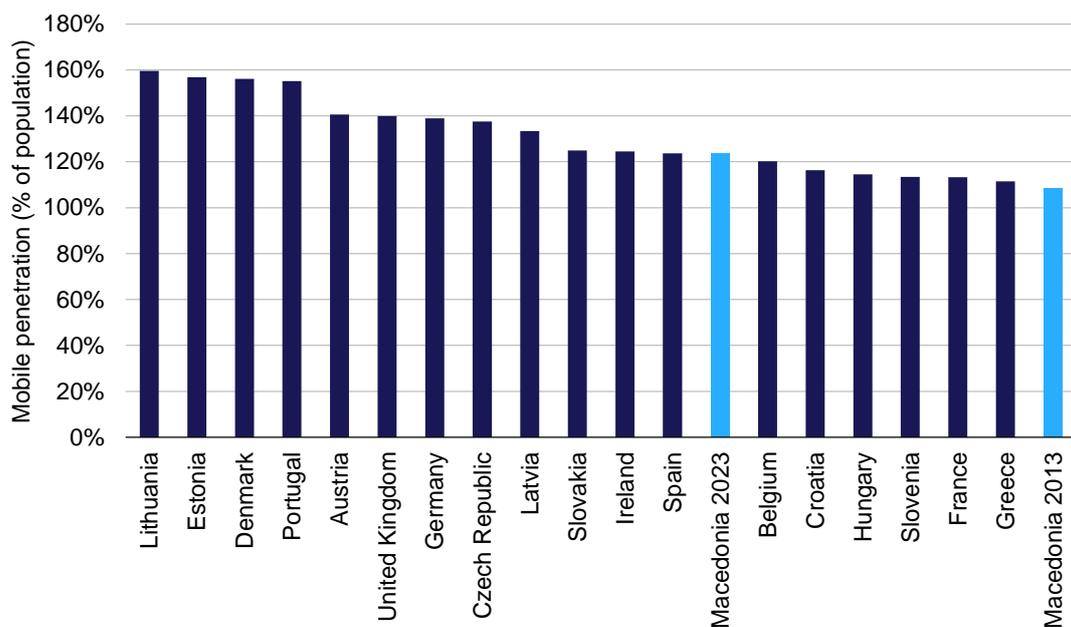
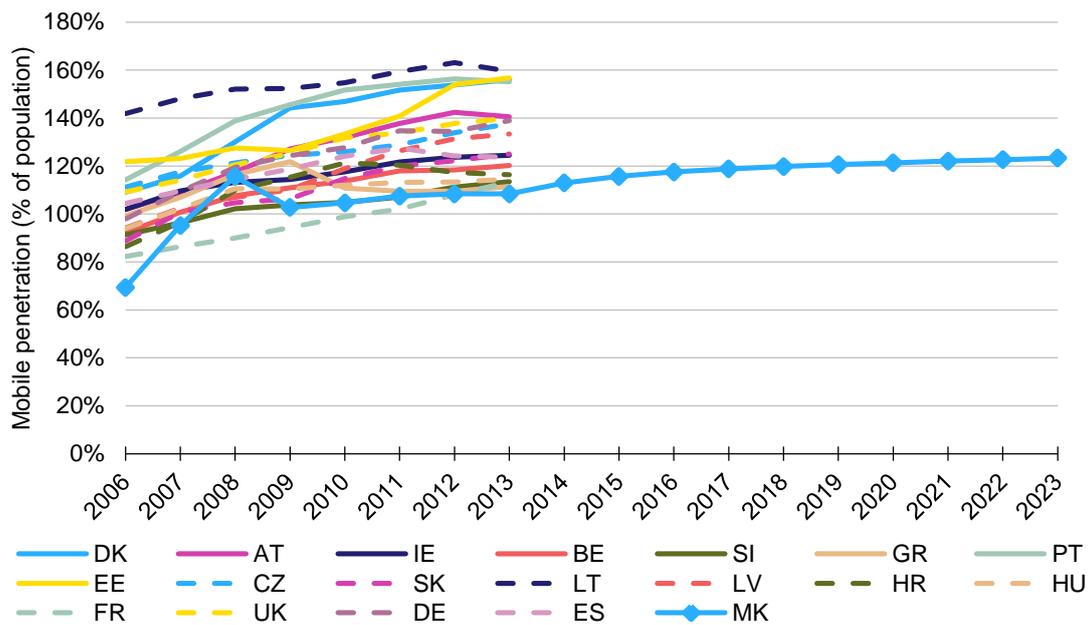


Figure 3.33: Benchmark of the evolution of mobile penetration [Source: Analysys Mason, 2015]



As seen above, the number of mobile connections is not estimated to increase significantly over 2014–23, meaning that the increase in mobile broadband connections is related to an increasing take-up of data services within mobile users (and not to an overall increase in the number of mobile connections).

At 46% in 2014, Macedonia is at the lower end of benchmarks in terms of mobile broadband as a share of total mobile connections. However, over the period to 2023 the share of mobile broadband connections in Macedonia is projected to grow to 76%, exceeding the current levels observed in all the benchmarked countries. It should be noted, however, that by the end of the forecast period mobile broadband connections are expected to account for 100% of all mobile connections in the most developed countries included in the benchmark.

Figure 3.34: Benchmark of mobile broadband connections as a share of total mobile connections, 2013 [Source: Analysys Mason, 2015]

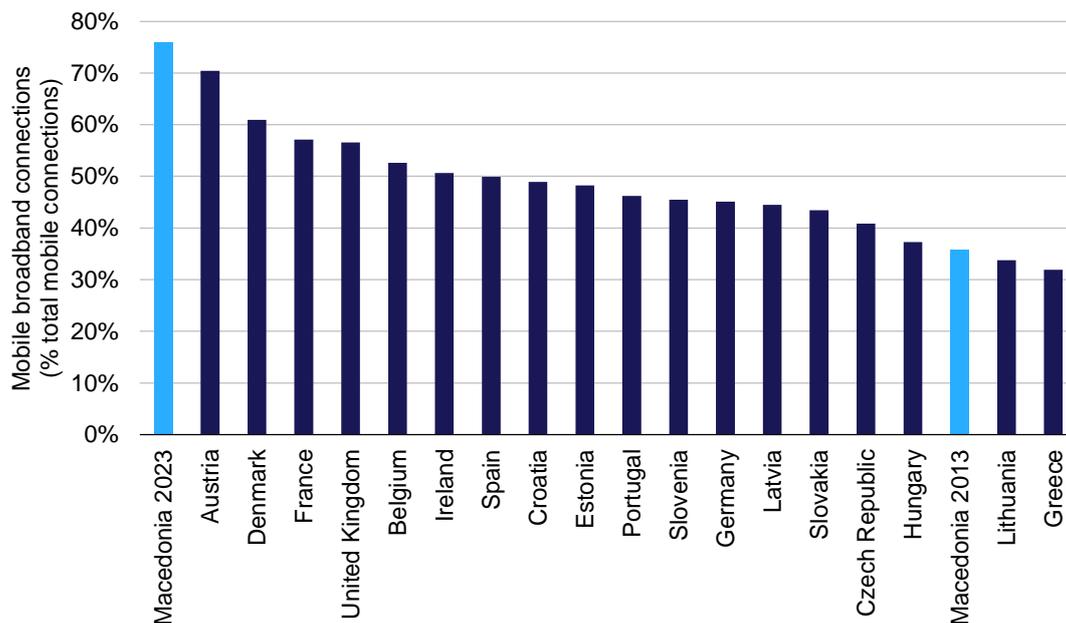
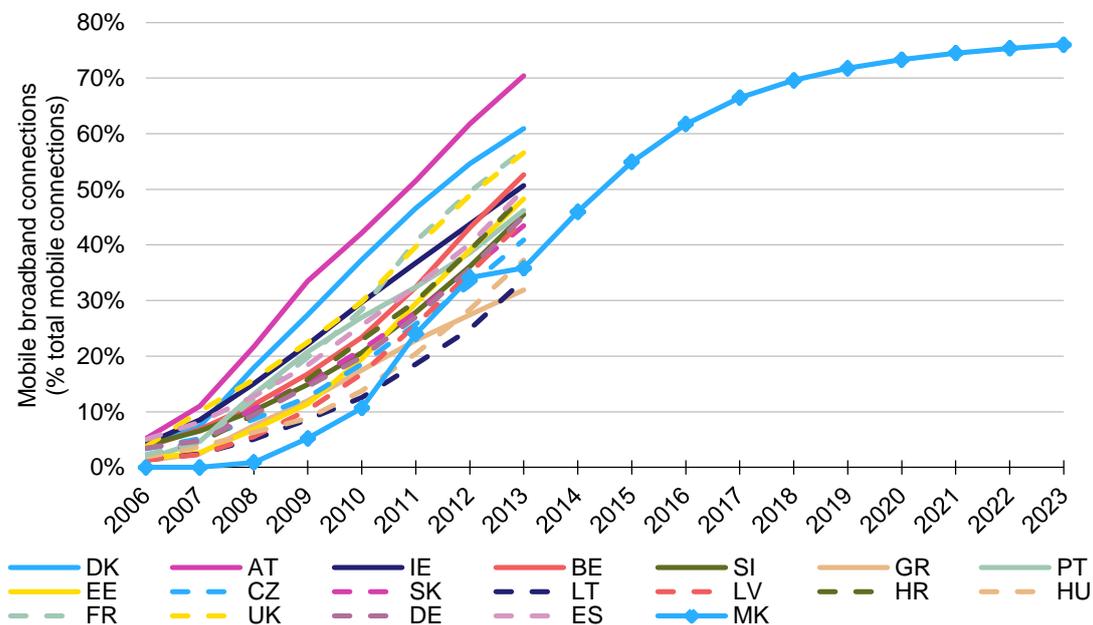


Figure 3.35: Benchmark of the evolution of mobile broadband connections as a share of total mobile connections [Source: Analysys Mason, 2015]



3.4 Broadband revenue

This section presents our analysis of broadband revenue in Macedonia. It is based on:

- our forecast of the evolution of broadband ARPU based on the data provided by the AEC and the Macedonian operators which is used in our econometric analysis
- the outcome of the econometric model in terms of fixed and mobile broadband subscribers.

3.4.1 Fixed broadband revenue

Fixed broadband revenue as reported by the operators and as calculated in our bottom-up model is not limited only to revenue from Internet access, but also includes ancillary services when those are bundled with a broadband subscription. Therefore, if a customer subscribes to a DSL triple-play offer, voice and TV revenue will be included in the reported figures.

As presented in Figure 3.36 below, broadband ARPU has remained relatively flat since 2011 at MKD640 per month (EUR10.4). The ARPU for high-speed broadband is estimated to be MKD910 per month in 2014, which is c. 40% higher than the ARPU for basic broadband.

As the price of basic broadband is already low in Macedonia, we expect basic broadband ARPU to remain flat over the forecast period, in line with the historical trend (see Figure 2.36). The ARPU for high-speed broadband is projected to decline only slightly over the same period due to the general historical stability of prices, which translates into a stronger decrease in real terms as the inflation rate is expected to remain at an average of 2% per annum. By contrast, the ARPU for the total broadband market is forecast to increase to MKD690 by 2023, as the market is expected to gradually shift towards high-speed broadband.

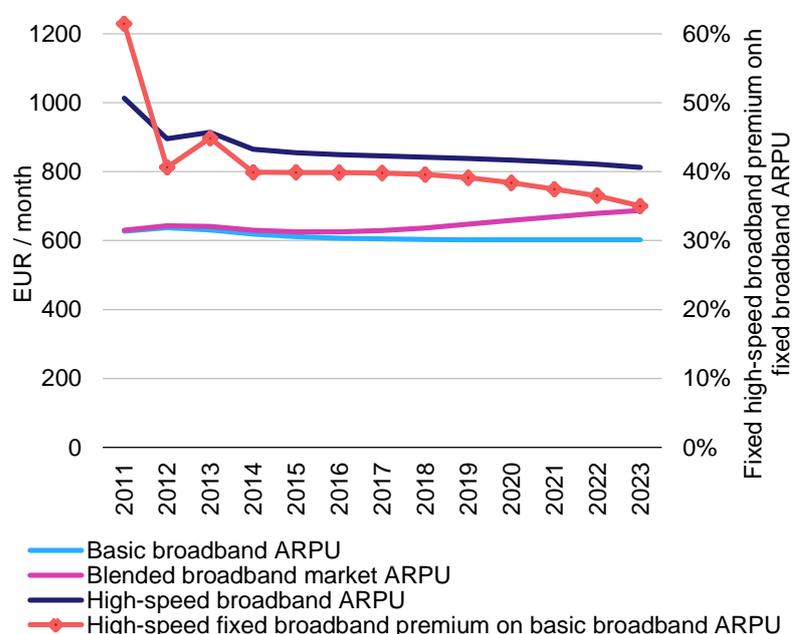


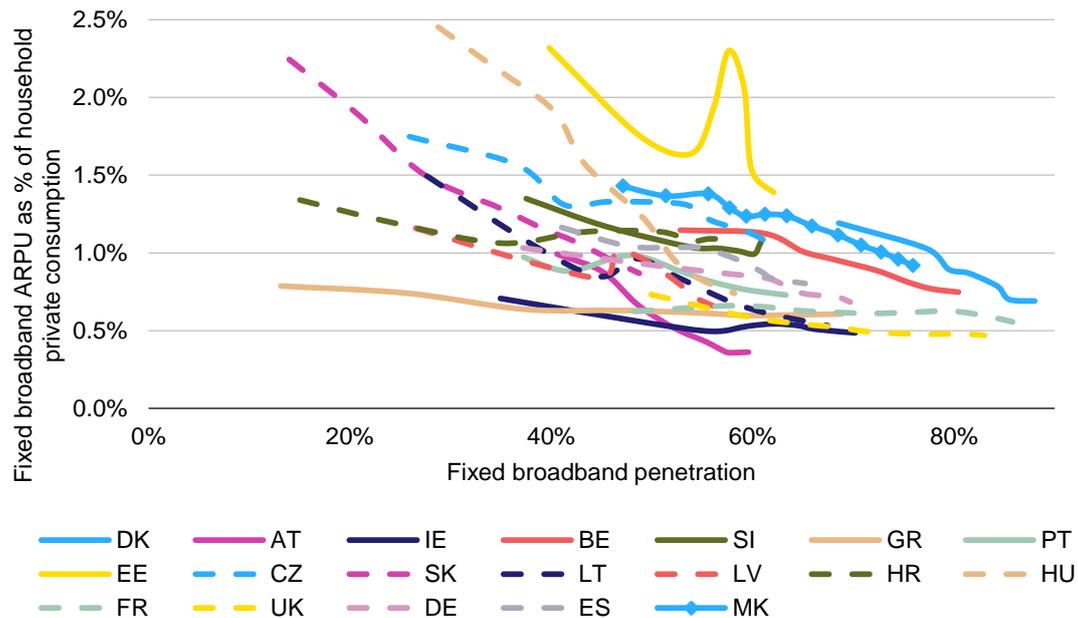
Figure 3.36: Evolution of ARPU of fixed broadband and fixed high-speed broadband services in Macedonia [Source: Analysys Mason, AEC, Operators, 2015]

Broadband ARPU in Macedonia is significantly lower than in most of the benchmarked countries, as shown below in Figure 3.37. Despite this low ARPU, we believe it is reasonable to assume that the weighted broadband ARPU in Macedonia will increase slightly over the period to 2023 (while still decreasing in real terms) because competition in the broadband market is already high, the inflation rate is

Our forecasts of fixed broadband ARPU and penetration are further confirmed by the ‘affordability analysis’ shown in Figure 3.39 below:

- historically, fixed broadband ARPU as a percentage of household private consumption in Macedonia has been at the higher end of benchmarks, at c.60% fixed broadband penetration
- the planned evolution of the ARPU for fixed broadband is in line with the trends observed at that level of penetration.

Figure 3.39: Benchmark of the evolution of fixed broadband ARPU depending on the level of fixed broadband penetration within each country [Source: Analysys Mason, EIU, 2015]



Based on our ARPU and subscriber forecasts, the fixed broadband market in Macedonia is projected to grow from MKD2.5 billion in 2013 to MKD4.0 billion in 2023 (a CAGR of 4.8%, in nominal terms). This growth is expected to be driven principally by a large increase in fixed broadband subscriber numbers (at a CAGR of 3.6% on average) as well as a slight increase in the blended market ARPU (due to the migration towards high-speed broadband). Compared to Macedonia’s GDP, this increase remains modest, as we estimate that the fixed broadband market will represent 0.50% of the country’s GDP in 2023, up from 0.54% in 2013.

High-speed broadband revenue accounted for only c.5% of total broadband revenue in 2013. By the end of the forecast period, 50% of revenue in the broadband market is projected to come from high-speed broadband, as shown below in Figure 3.40.

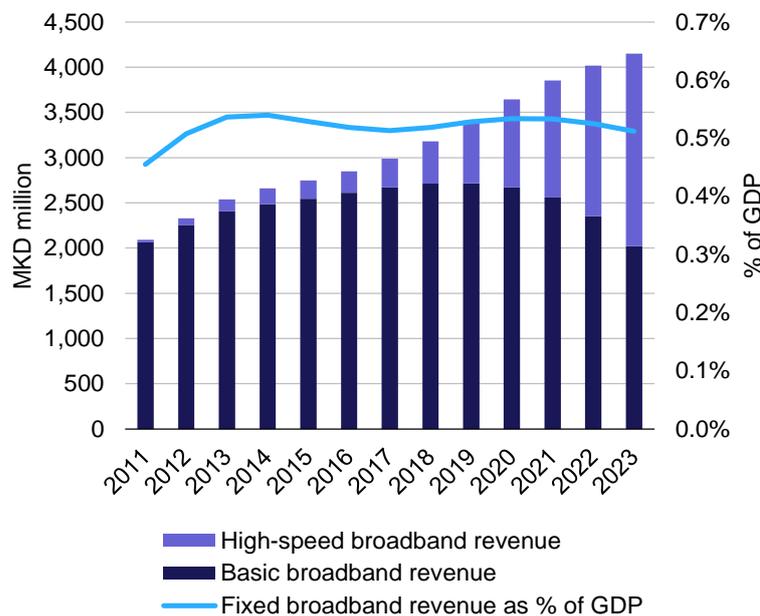


Figure 3.40: Evolution of fixed broadband revenue in Macedonia [Source: Analysys Mason, AEC, operator data, Euromonitor 2015]

3.4.2 Mobile broadband revenue

As of 2014, only 3% of mobile broadband connections in Macedonia are estimated to be data-only connections, i.e. including only a dongle or mobile modem. This means that the large majority of mobile broadband connections are related to a ‘voice + data’ subscription, where voice supports a share of the subscriber’s revenue. It is therefore relatively difficult and not necessarily relevant to isolate ‘pure’ mobile broadband revenue from total mobile revenue. In this section (and in our supply model) we have used total mobile ARPU as a proxy for mobile broadband ARPU, though we have also estimated mobile data-only ARPU.

Figure 3.41 below presents the results of our bottom-up estimates of mobile ARPU and mobile data-only ARPU for Macedonia, based on information from the AEC and operator data. As can be seen in the graphic, mobile ARPU declined from MKD407 per month in 2010 to an estimated MKD311 in 2014. We expect the mobile ARPU to plateau at c.MKD280 by 2018, and thereafter remain broadly stable at this level. Mobile data-only ARPU experienced an even steeper decline between 2010 and 2014, from MKD570 to MKD350, but we expected it to be close to the mobile ARPU in the future.

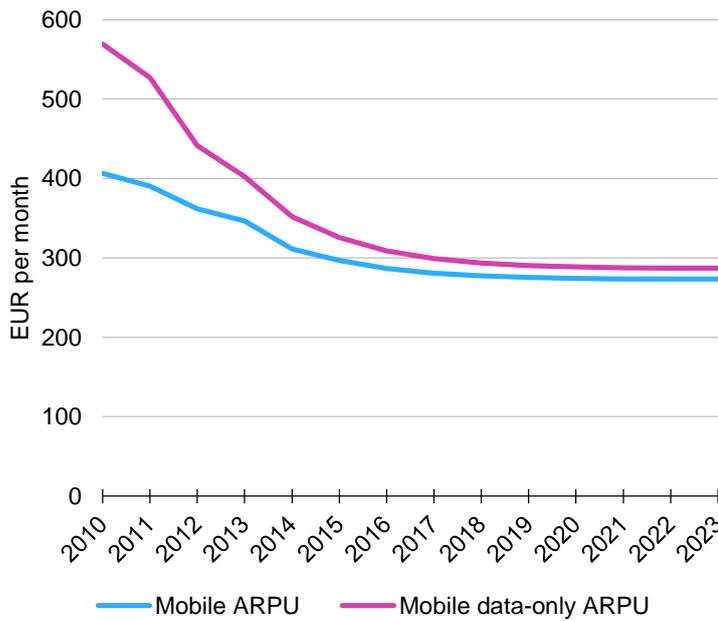


Figure 3.41: Evolution of mobile ARPU and mobile data-only ARPU in Macedonia [Source: Analysys Mason, AEC, operator data, 2015]

In absolute terms, mobile ARPU as a share of private consumption per capita in Macedonia stood at 2.5% in 2013, placing Macedonia at the lower end of European benchmarks; most of the benchmarked countries sit in the range between 1.0% and 1.7%, as shown in the figures below. By the end of the forecast period, mobile ARPU is expected to represent c.1.1% of private consumption per capita in Macedonia, which is in line with the benchmark range.

Figure 3.42: Benchmark of the evolution of mobile ARPU [Source: Analysys Mason, 2015]

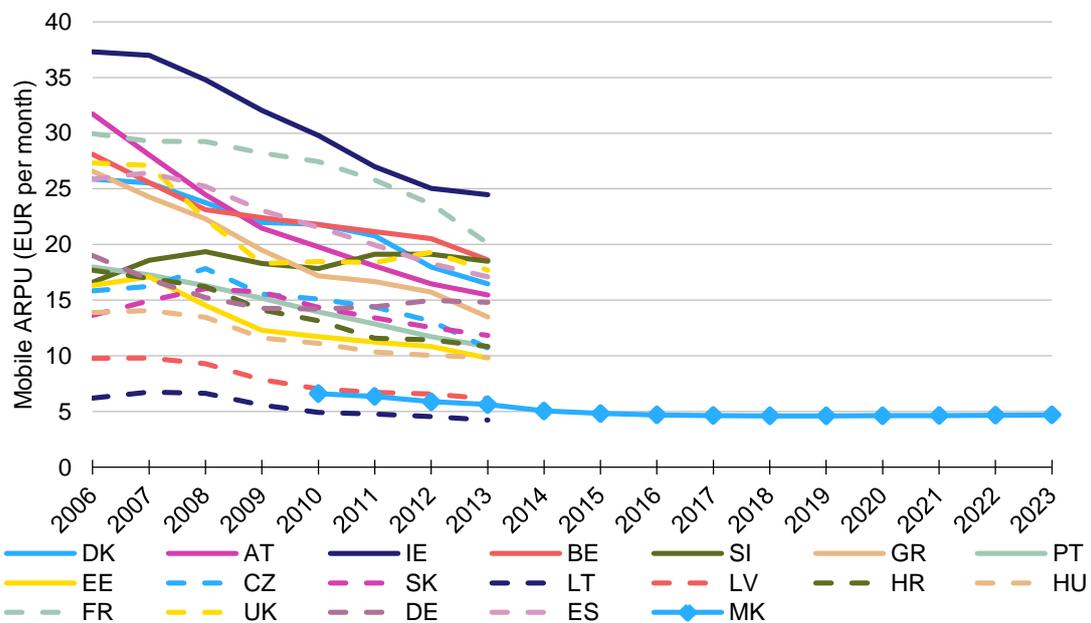


Figure 3.43: Benchmark of the evolution of mobile ARPU as a share of private consumption per capita [Source: Analysys Mason, EIU 2015]

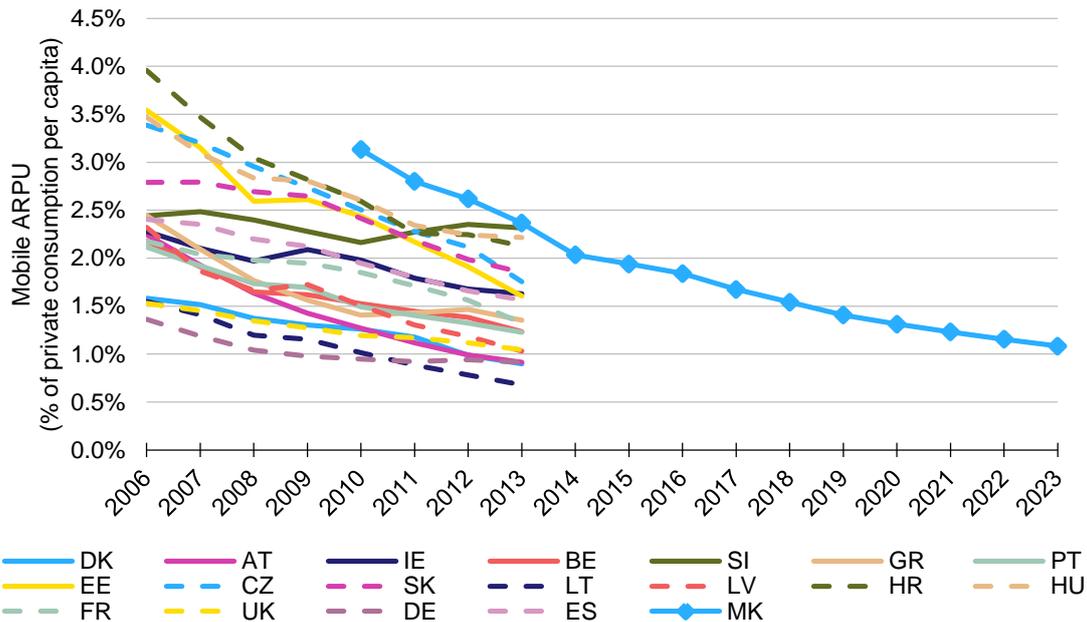
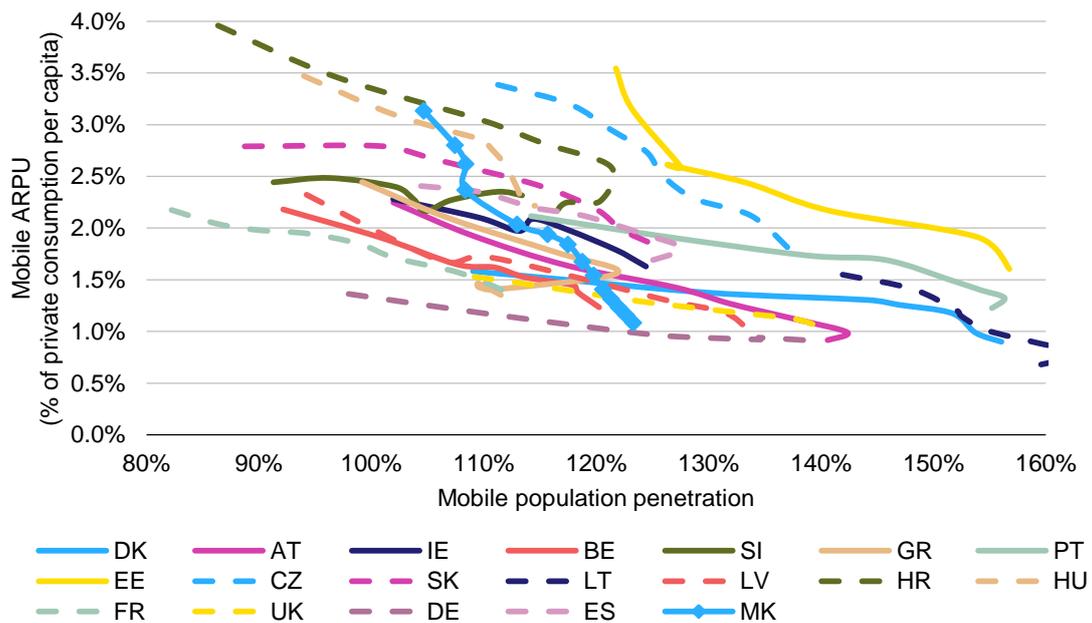


Figure 3.44 presents the results of an affordability analysis for mobile services in Macedonia and in the benchmark countries. Considering that a limited mobile penetration increase is expected in Macedonia (in line with historical trends), the decline in mobile ARPU as a share of private consumption is significantly stronger than in the benchmarked countries. We are therefore confident that our mobile ARPU forecasts for Macedonia are reasonable.

Figure 3.44: Benchmark of the evolution of mobile ARPU depending on the level of mobile penetration within the country [Source: Analysys Mason, 2015]



4 Assessment of broadband supply in Macedonia

This section provides an assessment of broadband market supply in Macedonia. It is laid out as follows:

- Section 4.1 presents the current and announced coverage for high-speed broadband technologies
- Section 4.2 describes the methodology used for the analyses carried out for the different technologies
- Section 4.3 provides an assessment of the commercial viability of broadband coverage for the different technologies
- Section 4.4 presents an assessment of the costs associated with implementing the different technologies

4.1 Current and expected coverage by technology

We have collected information from the main fixed operators in Macedonia regarding population coverage at the municipal, regional and national level for various technologies including LAN, cable, DSL, FWA and FTTH. When two or more operators are present at the same municipality with the same technology, we estimated to what extent their respective networks overlap. This is in particular the case for cable and LAN. For each municipality, the minimum coverage assumes maximum overlap (combined coverage is the maximum among the individual coverage of each operator), while maximum coverage assumes minimum overlap (combined coverage is the sum of the individual coverage of each operator, capped at 100%).

Figure 4.1 below presents the results of our analysis of data from the main operators for c.80 municipalities. For each technology, we present a coverage range as at the end of 2014, taking into account the minimum and maximum overlap between operators. Actual coverage might be slightly higher as we do not have data for all small operators in the market. This is particularly relevant for cable, LAN and FWA technologies.

Figure 4.1: Estimation of fixed broadband network coverage in Macedonia, end of 2014 [Source: Analysys Mason, operator data, 2015]

	DSL	FTTH	Cable	LAN	FWA
Household coverage	>98%	15–20%	40–50%	15–20%	>60%

In a similar process, we also considered overlaps between different technologies at a municipal level, which allowed us to estimate broadband and high-speed broadband coverage at a national level as of the end of 2014:

- fixed broadband technologies currently cover c.99% of Macedonia's households
- high-speed broadband technologies (FTTH + DOCSIS3) currently cover c.20% of Macedonia's households.

As regard future high-speed broadband coverage, some operators indicated their intention to upgrade and expand their fixed networks. On the basis of this information, and assuming operators actually carry out these plans, we estimate that c.60% of Macedonian households can potentially be covered by high-speed

broadband by 2023 in our base case. This increase will be achieved both through cable and LAN operators upgrading their networks to the DOCSIS3.0 standard and through further FTTH deployments.

As far as mobile broadband is concerned, we have not been provided with detailed municipal or regional coverage data, which prevented us from assessing coverage overlap between operators' networks. Figure 4.2 presents our understanding of national mobile coverage by technology.

Figure 4.2: Mobile coverage in Macedonia, end of 2014 [Source: Analysys Mason, Operators, 2015]

	2G	3G	4G
Population coverage	99.9%	>90%	>40%

With regard to future plans for high-speed mobile broadband coverage, operators have indicated that they intend to cover between 80% and 99% of the population with LTE by 2020.

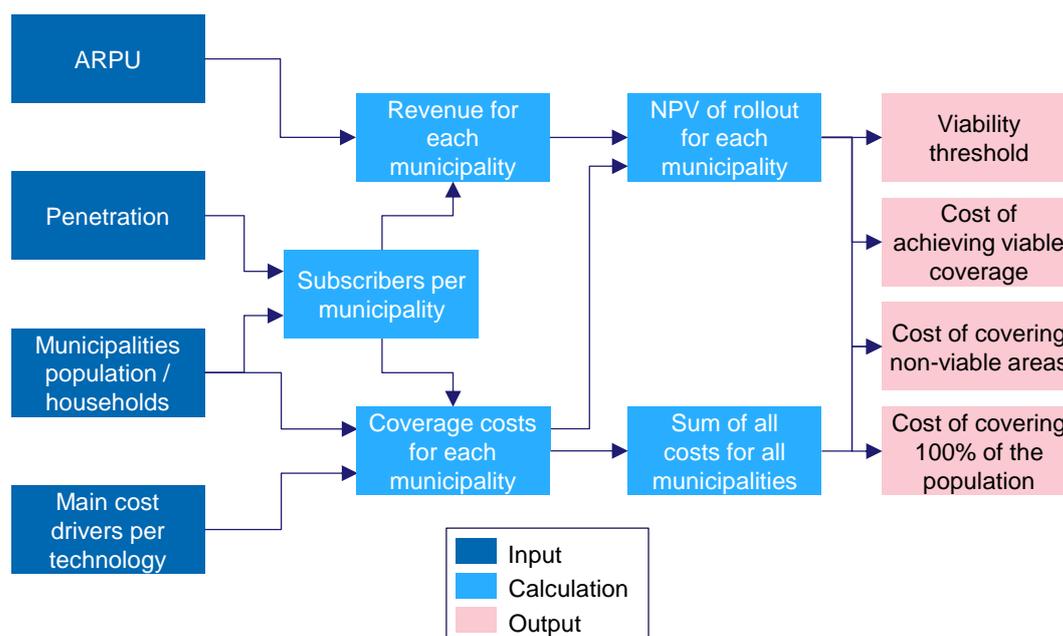
4.2 Description of the methodology used to assess future coverage of high-speed technologies

We have developed a bottom-up 'supply' model for three technologies (FTTH, LTE and DOCSIS3.0) to estimate the following outputs across each technology:

- the total cost of supplying high-speed broadband
- the level of coverage which is commercially viable
- the total cost of supplying high-speed broadband for any percentage of the population
- the level of potential public subsidies required to increase the coverage of high-speed broadband for non-viable areas.

The overall approach followed in the development of the supply model (for each high-speed technology modelled) is illustrated in Figure 4.3 below.

Figure 4.3: High-level methodology used in the supply model [Source: Analysys Mason, 2015]



4.2.1 Commercial viability

The costs of deploying and operating a broadband network for each technology are a function of population density in a given area. As a general rule, the lower the population density, the higher the cost per person or household.¹²

The commercial viability of broadband coverage is defined as the maximum population coverage that could economically (profitability) be achieved¹³ for each broadband technology (i.e. excluding public intervention or public funds) taking into account the demand and supply assumptions as described later in this section.

The commercial viability of high-speed broadband technologies has been assessed at a municipal level. For each municipality out of c.80 municipalities, we estimate whether a technology is viable or not by calculating the net present value (NPV) of a roll-out in this municipality over the 2015–2023 period. The NPV is calculated on the basis of:

- capex required for the high-speed network roll-out in the municipality (FTTH, DOCSIS3 or LTE)
- annual revenue based on the number of subscribers taking up the high-speed broadband service (depending on a number of factors)
- annual operating costs (opex) to account for network operation and maintenance, as well as commercial operations
- annual cash flows (revenue less opex and capex), discounted at an annual rate of 12% to account for the operator's expected return on capital invested.

The NPV is the sum of the discounted cash flows over 2015–2023, to which a terminal value is added calculated using the perpetuity methodology.¹⁴

Therefore, the NPV includes all costs and revenue that will stem from the deployment of a high-speed broadband network in the municipality. If the NPV is positive for a given high-speed technology, it means that the roll-out is commercially viable and operators can be expected to deploy this technology in this municipality. The commercial viability of coverage at the national level for FTTH, DOCSIS3.0 and LTE is then calculated by replicating this analysis for all municipalities in Macedonia.

The remainder of this section presents the methodology followed to estimate capex, revenue and opex in the supply model.

¹² This may not always be true. For instance, in the case of wireless technologies, in areas of very high population density it is necessary to increase the capacity of the network to satisfy the increasing demand for bandwidth. Thus, it may be more expensive to cover the higher-density areas than those areas with lower densities. However, outside very densely populated areas, the rule applies.

¹³ We define an area to be commercially viable whenever the NPV of this area is positive, as described later in this section.

¹⁴ The terminal value (TV) is included as telecoms networks hold a value beyond the ten-year period that we modelled here.

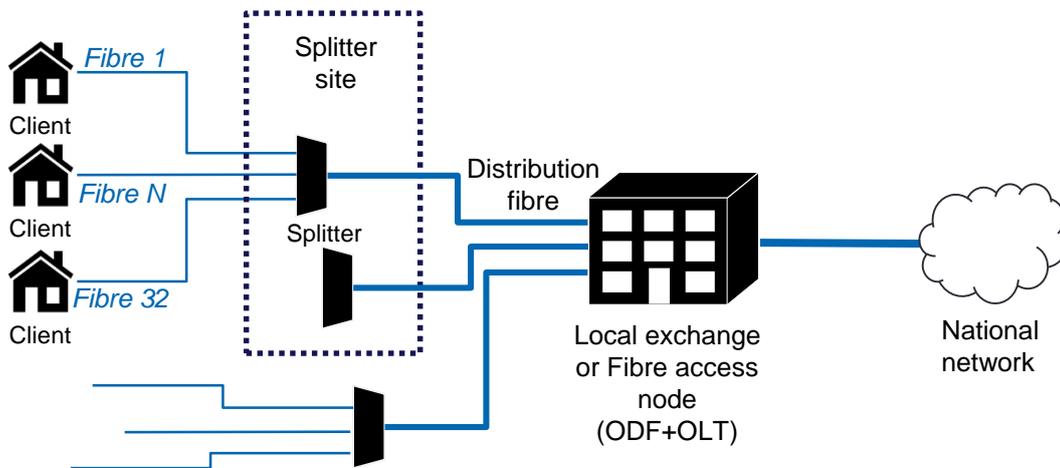
FTTH capex

The model assumes that roll-out in a given municipality starts in 2015, and 100% household coverage is achieved over three years.

Figure 4.4 illustrates the FTTH network topology that has been modelled. In line with the information provided by Macedonian operators, we assumed that the FTTH network follows the GPON architecture, with one level of splitter between the local exchange and the client premises.

At this stage, we have not considered the fact that FTTH may have already been deployed in a given municipality, as the model calculates the full cost of roll-out, not only the cost that would be incurred from the current ‘real life’ situation.

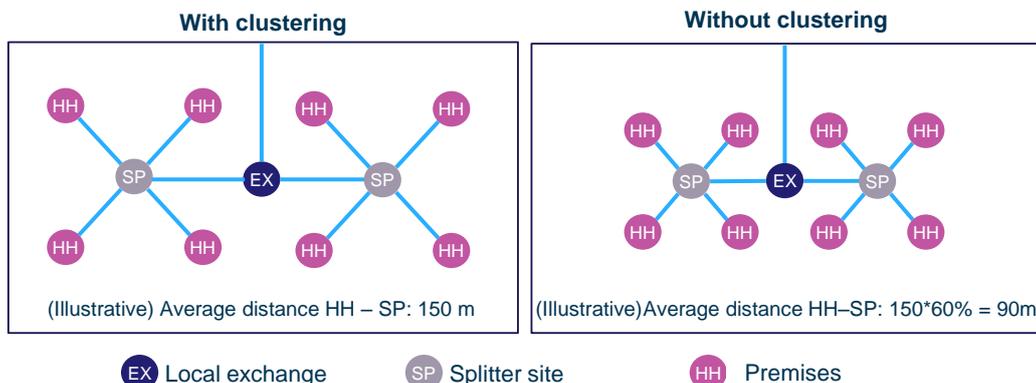
Figure 4.4: Topology of the FTTH network modelled [Source: Analysys Mason, 2015]



To calculate the cost of an FTTH network, we have derived a relationship between population density (which depends on the municipality) and the line lengths between nodes. In particular, assuming premises and splitter sites are homogeneously distributed over a municipality area, we have calculated the average distance between an exchange and a splitter site, and between a splitter site and premises.

However, we have also applied a ‘clustering factor’ to each of the segments, based on previous experience on real line lengths (*versus* areas) in several countries. These clustering factors account for the fact that people tend to cluster together within an area, rather than being spread out evenly. This concept is illustrated in Figure 4.5 below.

Figure 4.5: Derivation of line length from population density with and without clustering [Source: Analysys Mason, 2015]



The figures above show the impact of the clustering factors in the context of an FTTH deployment, although the concept applies equally to DOCSIS3.0. The clustering factors reduce the distance between nodes by a set amount compared to the calculation based on homogeneous distribution of premises. Therefore, the calculated average distance between the home (H) and the splitter site (SP) is reduced according to a first factor, while the calculated average distance between the SP and the local exchange (EX) is reduced according to a second factor.

It should be noted that, in the absence of information regarding the geographical distribution of households within each municipality, we have assumed based on previous similar assignments that 30% of the area of suburban municipalities and 40% of the area of rural municipalities were uninhabited, and therefore did not need to be covered. Municipalities were considered as suburban if their population density as of 2013 was comprised between 110 and 250 inhabitants per square kilometre, and they were considered as rural if their population density was lower than 110 inhabitants. In this case, the rural population represents around 40% of the total population (which is in line with the split of urban and rural population at national level).

Figure 4.6 below lists the main dimensioning and unit capex assumptions that were used for the modelling of the FTTH network based on operator inputs and benchmarks from similar countries.

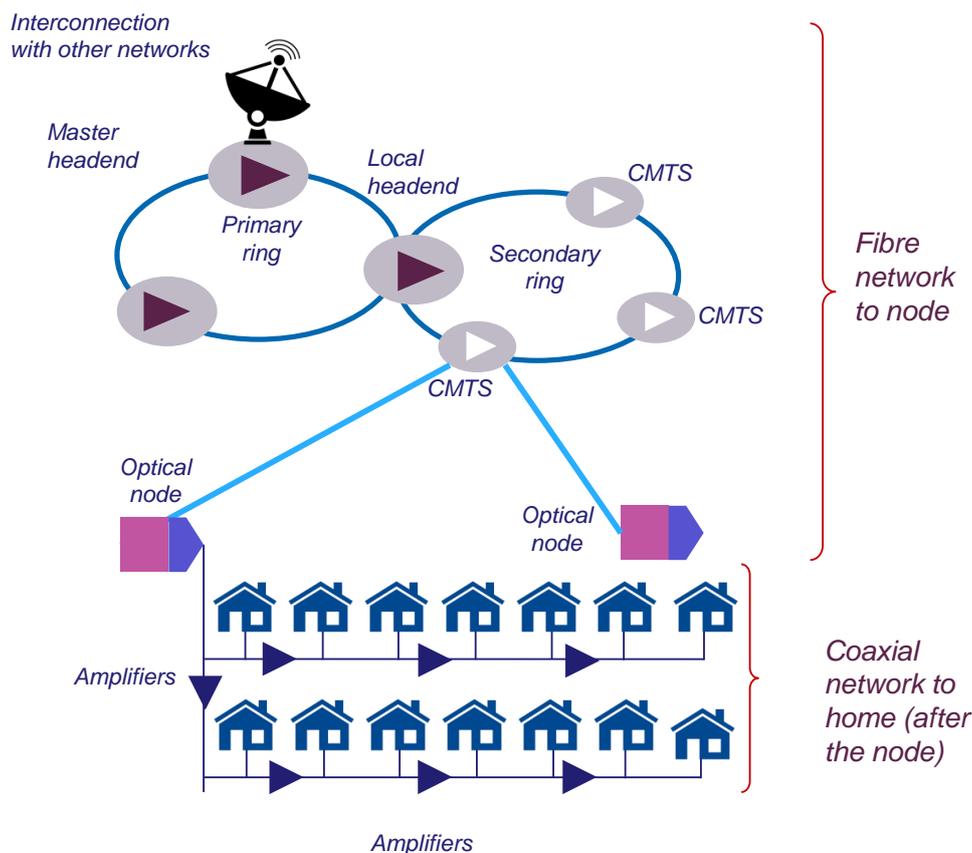
Figure 4.6: Dimensioning and cost assumptions for FTTH modelling [Source: Analysys Mason, operator data, 2015]

Item	Dimensioning assumption	Unit capex assumption	Comment
Local exchange	5000 premises per local exchange	No civil work costs	Reuse of existing local exchanges
Optical distribution frame (ODF)	2000 premises per ODF	MKD250 000	Distributed over several municipalities if needed
Optical line terminal (OLT)	128 fibre (splitters) per OLT	MKD4 000 000	Distributed over several municipalities if needed
Fibre dig cost	Between the exchange and a splitter: <ul style="list-style-type: none"> • 0% share of aerial links and 100% share of ducts • 75% of ducts can be reused Between a splitter and premises: <ul style="list-style-type: none"> • 35% share of aerial links and 65% share of ducts • 70% of ducts can be reused 	MKD400 per metre	Clustering factor also taken into account
Fibre install cost	–	MKD20 per metre	Same as fibre dig
Fibre cost	–	MKD65 per metre	Same as fibre dig
Splitter site	Maximum of 10 splitters per site	MKD150 000	–
Splitter	32 premises per splitter	MKD6000	–
Customer premises equipment (CPE)	1 per gross additional subscriber	MKD6000	–
Connection cost	1 per gross additional subscriber	MKD2000	–

DOCSIS3.0 capex

Figure 4.7 presents the topology of a typical cable network based on DOCSIS3.0. It is composed of fibre up to an optical node, which is connected to end-user premises with a coaxial cable. DOCSIS3.0 uses a wider spectrum band than DOCSIS2.0, as well as a different technology, but there are no major topological differences between a DOCSIS2.0 and a DOCSIS3.0 network. The main difference is that the optical node will typically be much closer to the end user in a DOCSIS3.0 network, so that clients are able to benefit from high-speed broadband services. A DOCSIS3.0 network is therefore composed of a longer fibre length, and additionally requires equipment upgrades.

Figure 4.7: Topology of a typical DOCSIS3.0 network [Source: Analysys Mason, 2015]



In the context of this study, we believe it is unrealistic to expect operators to roll out coaxial cable to premises that are not currently connected to any cable network.¹⁵ Therefore, when assessing the viability of cable at a municipal level, we did not calculate the cost of covering 100% of the municipality, but only the cost of upgrading the existing cable network to DOCSIS3.0 for all previously connected premises. As an exception to this rule, an operator indicated its intention to upgrade its LAN to DOCSIS3.0. We assumed this modification could be carried out with costs similar to the ones incurred to upgrade a cable network to DOCSIS3.0, and included this LAN footprint into the final DOCSIS3.0 coverage.

¹⁵ It would be extremely costly and less efficient than directly rolling out FTTH.

Based on information received from the Macedonian operators, we assumed that all current cable networks were already digital.¹⁶ Therefore, the DOCSIS3.0 roll-out is a network upgrade that requires:

- the acquisition of a new CMTS (Cable Modem Termination System) at the local head-end
- the installation of optical nodes
- the roll-out of fibre between the local head-end and optical nodes
- the installation of new amplifiers and taps
- the acquisition of new CPEs.

Figure 4.8 below lists the main dimensioning and unit capex assumptions that were used for the modelling of the DOCSIS3.0 network based on operator inputs and benchmarks from similar countries.

Figure 4.8: Dimensioning and cost assumptions for the modelling of the DOCSIS3.0 network [Source: Analysys Mason, operator data, 2015]

Item	Dimensioning assumption	Unit capex assumption	Comment
CMTS	10 000 premises per CMTS	MKD13 000 000	Distributed over several municipalities if needed
Optical node	300 premises per optical node	MKD50 000 + MKD10 000 for civil work	–
Fibre dig cost	0% share of aerial and 100% share of ducts 70% duct reuse between the head-end and optical nodes	MKD400 per metre	Clustering factor also taken into account
Fibre install cost	–	MKD20 per metre	Same as fibre dig
Fibre cost	–	MKD65 per metre	Same as fibre dig
Amplifiers	6 amplifiers per optical node	MKD18 000	–
Taps	1 per gross additional subscriber	MKD500	–
CPE	1 per gross additional subscriber	MKD4000	–
Connection costs	1 per gross additional subscriber	MKD2500	–

Our DOCSIS3.0 modelling assumes that no fibre currently exists beyond the local head-end, so that optical nodes will need to be installed and fibered. This might be a conservative assumption depending on the current situation of cable networks in Macedonia.

¹⁶ The major cable operators indicated that their whole footprint is already digital.

LTE capex

With the exception of some core network upgrades, an LTE network can largely be rolled out as an overlay to an existing 2G or 3G mobile network such as the ones operated in Macedonia. We assumed the LTE roll-out to be carried out as follows:

- Based on 800MHz spectrum, the average cell coverage radius is estimated to be 1km for the urban geotype, 2.5km for suburban and 6km for rural based on operator data and comparable assignments we have undertaken in the past.
- For a given municipality, we calculated the minimal area coverage that can be achieved on the basis of existing mobile sites.
- If this covered area represents less than 50% of the municipality's total area, we assumed new physical sites would need to be built to reach that threshold.¹⁷
- We then assumed that 4G would be gradually rolled out to all pre-existing 2G and 3G sites of the municipality over three years. The fact that LTE may have been deployed before 2015 in the municipality is not considered at this stage, as the model needs to calculate the full cost of roll-out, not only the cost that would be incurred starting from the current 'real life' situation.
- Every year, the model compares the capacity offered by the LTE sites, and the capacity required by LTE subscribers. If the capacity of the sites is insufficient, new physical sites are rolled out to meet the demand. Figure 4.9 below presents the historical and forecast evolution of monthly data usage per mobile broadband subscriber in Macedonia, based on data provided by Macedonian mobile operators.

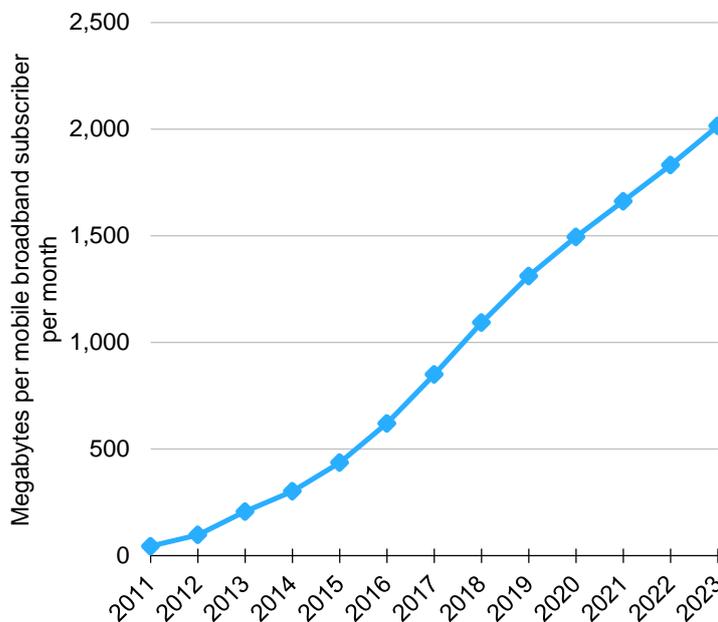


Figure 4.9: Evolution of average data usage of mobile broadband subscribers in Macedonia [Source: Analysys Mason, operator data, 2015]

¹⁷

Considering that 2G coverage based on the 900MHz band is close to 100% of the population, it is likely that the existing number of sites by municipality would be enough to cover all the population of a municipality with LTE using the 800MHz band. However, we assumed that a minimal 50% area coverage for each municipality would be a reasonable target for operators willing to provide good service to clients (not only in inhabited areas).

Figure 4.10 below lists the main dimensioning and unit capex assumptions that were used for the modelling of the LTE network.

Figure 4.10: Dimensioning and cost assumptions for the modelling of the LTE network [Source: Analysys Mason, operator data, 2015]

Item	Dimensioning assumption	Unit capex assumption	Comment
Dimensioning factors			
Busy-hour days per month	20	–	–
Busy-hour data traffic	12% of busy-day traffic	–	–
Sectors per site	2.8	–	Reflects average existing situation in the market
Spectral efficiency of LTE	1.87 bits per Hz	–	Used to calculate the capacity of a site
4G spectrum used	2x10MHz of 800MHz + 2x15MHz of 1800MHz	–	–
Loading factor for site capacity	50%	–	Takes into account the fact that population is not distributed homogeneously
Building a new 4G site			
Rooftop physical site	75% of urban sites 50% of suburban sites 10% of rural sites	MKD800 000	Only if new site build is required
Tower physical site	25% of urban sites 50% of suburban sites 90% of rural sites	MKD3 500 000	Only if new site build is required
4G antenna	1 per sector	MKD60 000	–
4G eNodeB	1 per site	MKD1 000 000	–
Microwave backhaul	25% of urban sites 60% of suburban sites 85% of rural sites	MKD250 000	Only if new site build is required
Fibre backhaul	75% of urban sites 40% of suburban sites 15% of rural sites	MKD600 000	Only if new site build is required
Upgrading an existing site to add 4G			
Civil work to add 4G to an existing site	1 per site upgrade	MKD130 000	–
Base station upgrade	1 per site upgrade	MKD500 000	–
Adding a second 4G spectrum band to a 4G site	1 per site upgrade	MKD100 000	–
Upgrading backhaul	1 per site upgrade	MKD100 000	–

Revenue

Annual revenue from high-speed broadband services is calculated at municipality level on the basis of ARPU and number of subscribers. Figure 4.11 below presents the assumptions that have been made in this regard for FTTH, DOCSIS3.0 and LTE.

Figure 4.11: Revenue assumptions made in the supply model [Source: Analysys Mason, 2015]

Technology	ARPU assumptions	Subscriber assumptions
FTTH	<ul style="list-style-type: none"> Retail FTTH ARPU is the fixed high-speed broadband ARPU as forecast for the Macedonian market in the bottom-up demand model Wholesale ARPU is assumed to be 40% of the retail ARPU on the basis of current wholesale DSL ARPU 75% of the connection costs are billed to the client on the basis of current commercial conditions in Macedonia CPE is free for retail clients, as we understand it is the case in Macedonia 	<p>FTTH subscribers are calculated on the basis of:</p> <ul style="list-style-type: none"> high-speed broadband take-up (from the econometric analysis) FTTH coverage (assumed at 100% over three years) number of households in the municipality discount depending on the presence of cable in the municipality¹⁸ <p>Wholesale subscribers are estimated to represent 15% of FTTH subscribers (based on data for DSL in Macedonia)</p>
DOCSIS3.0	<ul style="list-style-type: none"> Retail ARPU is the fixed high-speed broadband ARPU forecast for the Macedonian market in the bottom-up demand model There are no wholesale clients 75% of the connection costs are billed to the client on the basis of current commercial conditions in Macedonia CPE is free for retail clients, as we understand it is the case in Macedonia 	<p>DOCSIS3.0 subscribers are calculated on the basis of:</p> <ul style="list-style-type: none"> cable take-up in the covered area as estimated at a national level in the bottom-up demand model estimated share of cable users that subscribe to DOCSIS3.0 DOCSIS3.0 coverage (assumed at 100% over three years) number of households in the municipality
LTE	<ul style="list-style-type: none"> Retail ARPU is a share of the mobile ARPU we forecast for the market. This share represents an estimate of the value that data holds for mobile broadband subscribers, which is expected to increase rapidly over time There are no wholesale clients 	<p>LTE subscribers are calculated on the basis of:</p> <ul style="list-style-type: none"> mobile broadband penetration market share of the operator modelled – we run the analysis on the basis of the largest operator in the market by using a 45% market share population in the municipality estimated share of mobile broadband users that subscribe to LTE, which is expected to increase rapidly as 4G handsets become more affordable and data usage becomes more attractive to consumers

¹⁸ If the municipality is covered (even partially) by a cable network, it means that in the medium term the high-speed broadband subscribers will be distributed between FTTH and DOCSIS3.0 in the municipality (so that the FTTH take-up will be lower than the high-speed broadband take-up).

Opex

Figure 4.12 presents the assumptions that were made to estimate operational costs in the supply model based on operator inputs and benchmarks from similar countries.

Figure 4.12: Opex assumptions made in the supply model [Source: Analysys Mason, 2015]

Item	Opex assumption
Civil work maintenance (ducts)	0.5% of cumulative capex annually
Tower and rooftop maintenance	1% of cumulative capex annually
Passive equipment maintenance (fibre, taps)	0.5% of cumulative capex annually
Fixed active equipment maintenance (ODF, OLT, CMTS, optical nodes)	1% of cumulative capex annually
Mobile active equipment (antenna, eNodeB)	4% of cumulative capex annually
Backhaul	2% of cumulative capex annually
CPE	3% of cumulative capex annually
Commercial costs and other costs	30% of recurring revenue

4.2.2 Different cost types

The supply model can calculate several cost types for each high-speed technology, as presented in Figure 4.3:

- **'100% costs'** – The costs associated with covering 100% of the population, independently of what is commercially viable. The population coverage would exceed the commercially viable coverage (calculated on the basis of the NPV analysis described above).
- **'Viable costs'** – The costs associated with achieving a commercially viable coverage (at municipality level). These costs are likely to be close to a maximum of what private operators may invest in the future. The commercially viable coverage is derived from our NPV analysis and will result in partial population coverage.
- **'Unviable costs'** – The difference between the costs for achieving 100% population coverage (or a given population coverage target) and the commercially viable cost. These costs are needed to cover the commercially unviable areas and those areas may require public funding.

For these three costs, we also estimated the share of these costs that were already spent by Macedonian operators to deploy their current high-speed networks. In particular, if operators currently cover some parts of a municipality which is estimated as non-viable as a whole (which is possible considering that municipalities constitute a fairly detailed but not extremely granular breakdown of the country), we are able to exclude already spent costs from the unviable costs.

It should also be noted that the costs of deploying a fixed broadband network are calculated for the roll-out of a single network for any given technology:

- we assume that only one FTTH network will be rolled out at the national level, and will be used on a wholesale basis by other operators
- we assume that if two cable networks overlap in a given municipality, only one will be upgraded to DOCSIS3.0 in overlapped areas, as this would be enough to increase the coverage of fast broadband networks and achieve coverage objectives.

For LTE, we assessed the viability of a deployment carried out by the incumbent operator, with its corresponding market share. Other operators will deploy LTE networks, but might obtain a lower (or higher) viability threshold at the national level.

4.3 Assessment of commercially viable coverage by high-speed broadband technology

Figure 4.13 illustrates the current coverage and headline speed of the different broadband technologies available in Macedonia.

Figure 4.13: Coverage of broadband networks in Macedonia [Source: Analysys Mason, operator data, 2015]

Technology	Population / household coverage (2014)	Maximum commercial speed offered	Comments
ADSL	>98%	12Mbit/s	DSL broadband is delivered using the existing copper network. In our assessment we assume no further investments in the existing copper network as it is unlikely to be extended further
FTTH	15–20%	1000Mbit/s	FTTH is currently deployed by Makedonski Telekom in the most populated municipalities
FTTC	0%	Not applicable	FTTC is currently not deployed in Macedonia. In the absence of street cabinets in the country, we believe FTTC will not represent a significant share of the deployments in the future (though VDSL at the central office could be considered)
WiMAX / FWA	>60%	10Mbit/s	We are not aware of plans to further extend FWA coverage in Macedonia
Cable	40–50% for total cable <5% for DOCSIS3.0	25Mbit/s in DOCSIS2.0 150Mbit/s in DOCSIS3.0	It is unlikely that operators will extend the footprint of their cable networks (with the exception of operators planning to upgrade their LAN network to DOCSIS3.0). However, operators have started upgrading, and will continue to upgrade, their cable networks to DOCSIS3.0
HSPA+	>90%	42Mbit/s	For some operators the maximum commercial speed is 21Mbit/s (depending on the use of carrier aggregation)
LTE	>40%	150Mbit/s	LTE is currently being rolled out in the country by all three MNOs

The results of our analysis for high-speed broadband technologies are shown in Figure 4.14 below. For FTTH and LTE, the coverage value is the share of population living in those municipalities where high-speed roll-outs are viable, while in the case of DOCSIS3.0 (which is exclusively based on pre-existing networks) some municipalities might be partially covered.

Figure 4.14: Commercially viable coverage by technology [Source: Analysys Mason, 2015]

Technology	2014 population / household coverage	Commercially viable coverage
FTTH	15–20%	44%
DOCSIS3.0	<5%	51%
LTE	>40%	94%

Figure 4.15 and Figure 4.16 show the evolution of the commercial viability of FTTH and LTE technologies by calculating the NPV per household or per population for each municipality.

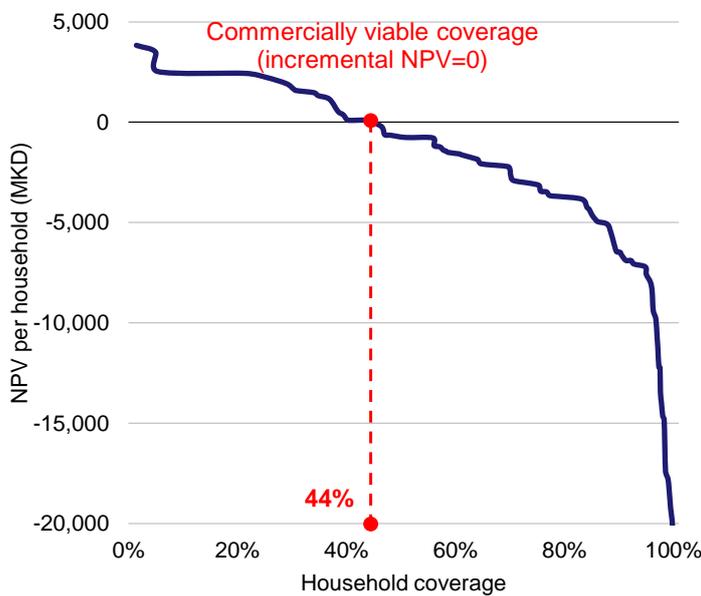


Figure 4.15: Evolution of the NPV per household of FTTH deployments, by municipality [Source: Analysys Mason, 2015]

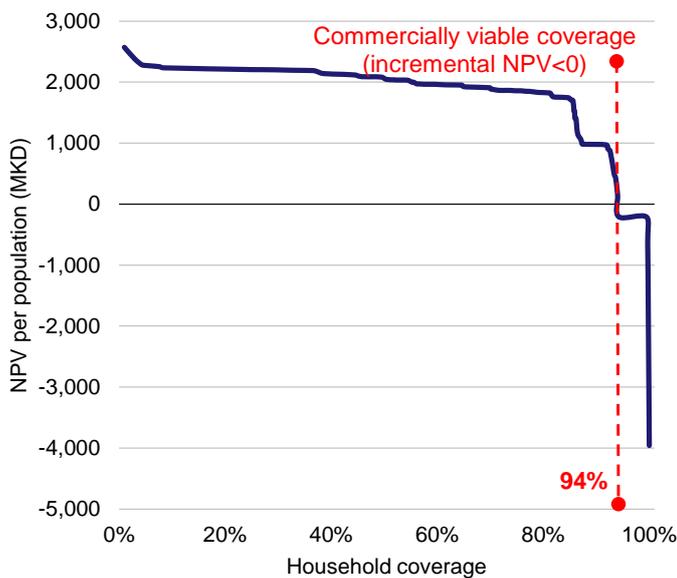


Figure 4.16: Evolution of the NPV per head of population of LTE deployments, by municipality [Source: Analysys Mason, 2015]

Figure 4.17 shows the same calculation for DOCSIS3.0, but the total coverage shown is not that of total households, but only of households within the maximum cable footprint.¹⁹

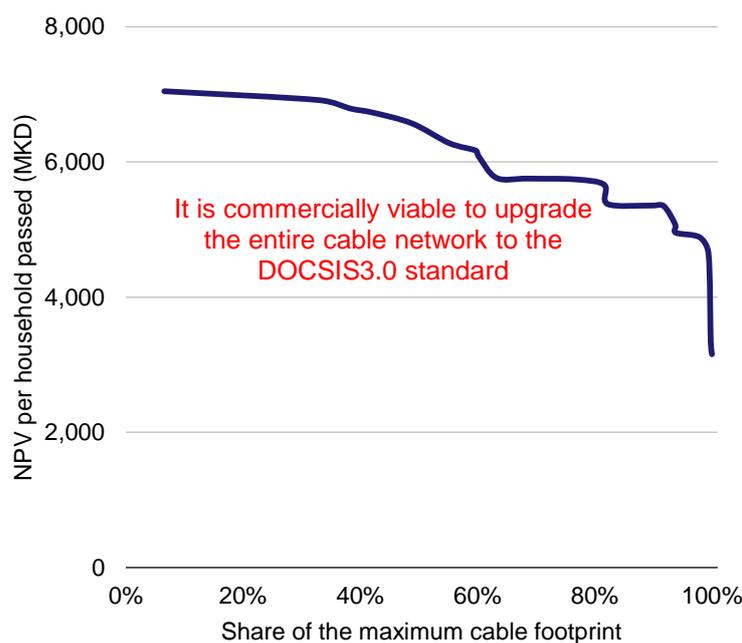


Figure 4.17: Evolution of the NPV per household passed of a DOCSIS3.0 upgrade within the existing cable network footprint [Source: Analysys Mason, 2015]

4.4 Assessment of different cost types for a nationwide roll-out of high-speed broadband technologies

Figure 4.18 below presents the capex required to roll out each technology to its maximum coverage. For FTTH and LTE, it represents 100% of households / population, and for DOCSIS3.0 it represents 51% of the population (maximum cable footprint).²⁰ These costs do not take into account existing deployments for these technologies. Covering all Macedonian households with FTTH would require close to MKD9.6 billion²¹, compared to MKD1.0 billion for LTE (which can heavily reuse existing physical sites for 2G and 3G technologies) and MKD1.9 billion for the upgrade of all cable networks to DOCSIS3.0.²²

¹⁹ Including the LAN coverage of operators which stated their intention to upgrade their LAN to DOCSIS3.0 in the future.

²⁰ Including the LAN coverage of operators which stated their intention to upgrade their LAN to DOCSIS3.0 in the future.

²¹ Costs include CPE and connection costs for clients.

²² In case two cable networks are currently overlapped, we assumed in our modelling that the DOCSIS3.0 upgrade would be carried out only once.

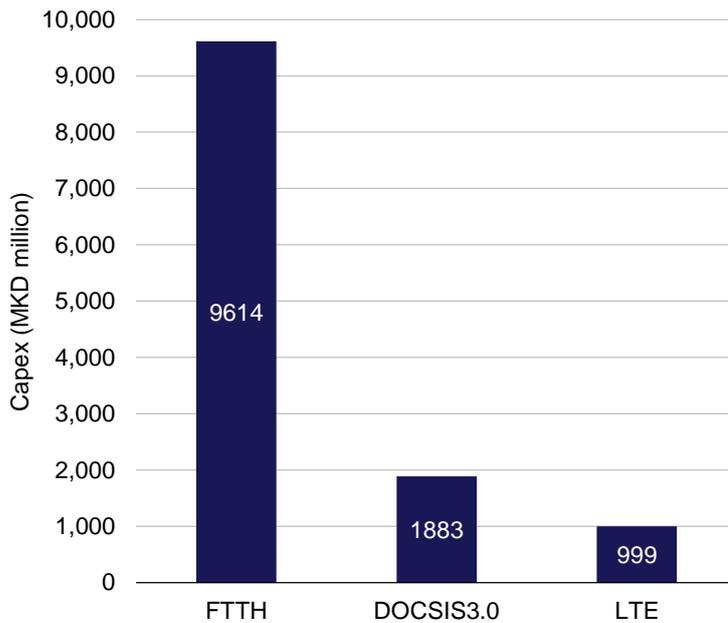


Figure 4.18: Capex required to achieve 100% high-speed broadband coverage [Source: Analysys Mason, 2015]

Note: For DOCSIS3.0 the coverage achieved is equal to the existing footprint of the cable networks in Macedonia

Figure 4.19 shows the breakdown of total coverage capex between viable and unviable costs. In the case of FTTH, MKD6.3 billion capex would be required to cover 56% of the population that is located in unviable areas (66% of the total cost). For LTE, the capex required to cover 6% of the population living in unviable areas would be MKD250 million (25% of the total cost). The roll-out of DOCSIS3.0 is fully viable within the existing coverage area.

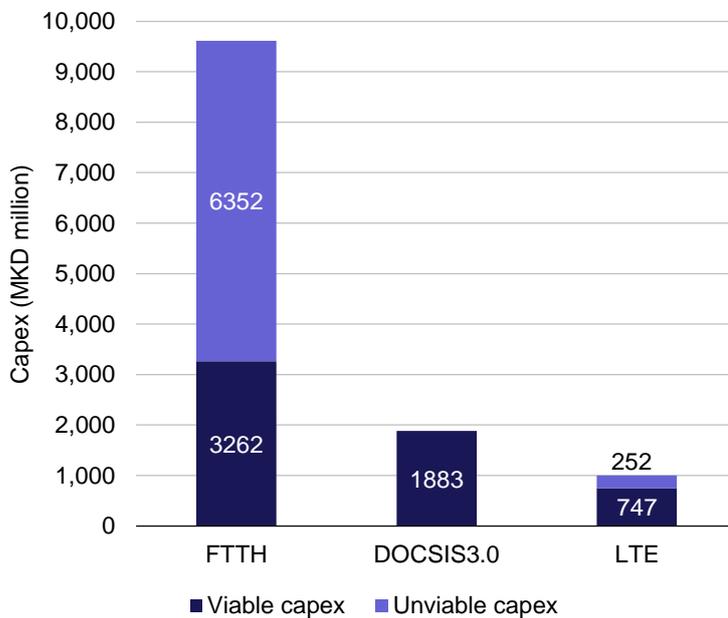


Figure 4.19: Viable and unviable capex required to achieve 100% high-speed broadband coverage [Source: Analysys Mason, 2015]

Note: For DOCSIS3.0 the coverage achieved is equal to the existing footprint of the cable networks in Macedonia

Figure 4.20 and Figure 4.21 show our estimates of the reduction in capex when taking into account existing FTTH and LTE roll-outs. For FTTH, we consider that c.MKD770 million are no longer required in viable municipalities, compared to MKD280 million in non-viable municipalities. It should be noted that our analysis has been performed on a municipality level and therefore the results for a municipality are either ‘viable’ or ‘unviable’. However, in reality some parts of a municipality could be viable and some others could be unviable depending on the density and level of premises concentration within the municipality. Therefore, it is not surprising that operators may have deployed FTTH to cover parts of some municipalities which are considered to be unviable.

For LTE, we estimate that c.MKD110 million are no longer required, most of it in viable municipalities.²³

Figure 4.20: Viable and unviable FTTH capex required when taking into account existing roll-outs [Source: Analysys Mason, 2015]

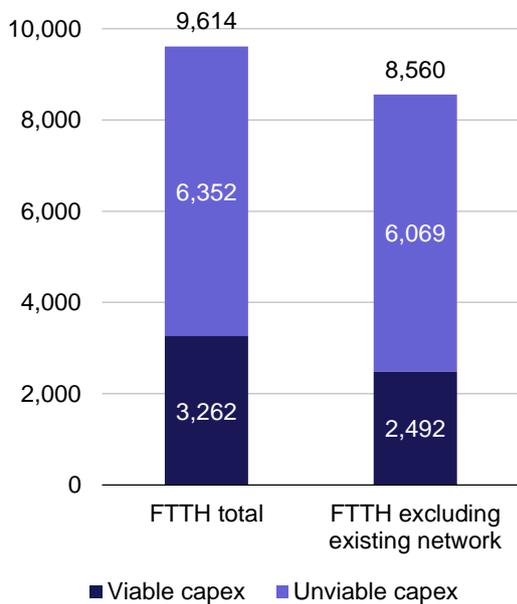
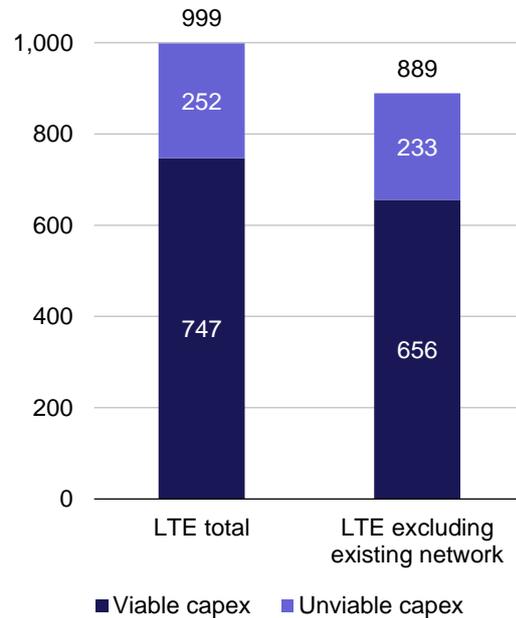


Figure 4.21: Viable and unviable LTE capex required when taking into account existing roll-outs [Source: Analysys Mason, 2015]



For FTTH, as shown in Figure 4.22 below, in the most profitable areas the cost per household increases from MKD7000 to as much as MKD47 000 per household.

²³ Even though more than 40% is estimated to be currently covered with LTE technology, a large proportion of sites still need to be upgraded to 4G, including in municipalities where some 4G sites are currently operated, in order to provide high-speed quality broadband to end users taking into account the expected growth of traffic.

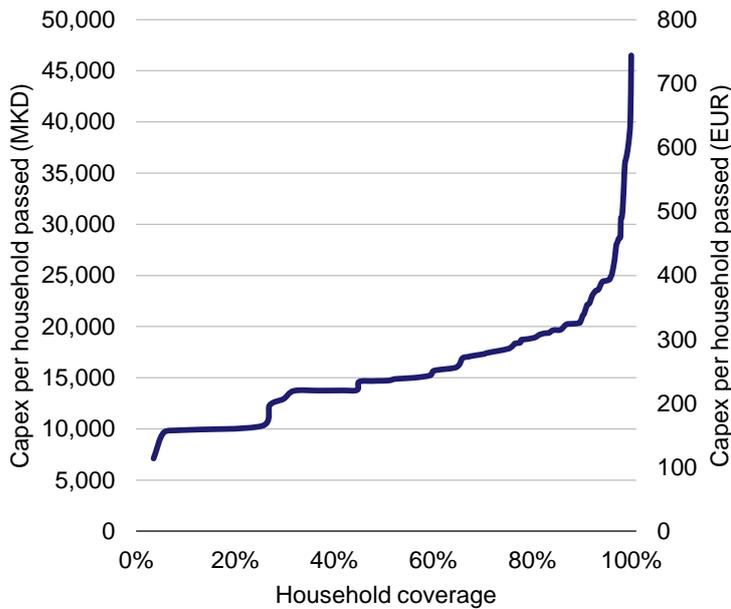


Figure 4.22: Evolution of the capex per household passed with FTTH [Source: Analysys Mason, 2015]

For LTE, 87% of the population can be covered with less than MKD1000 per inhabitant (increasing to MKD5000 in the less viable municipalities); this is shown in Figure 4.23 below.

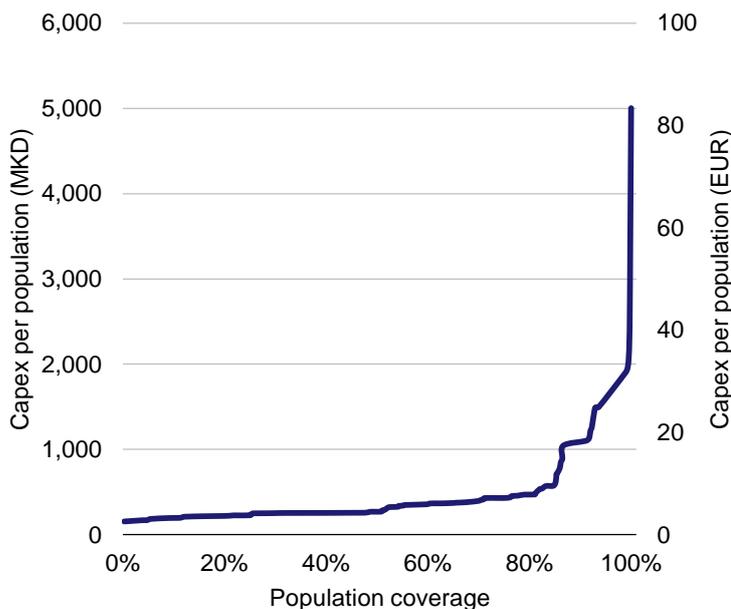


Figure 4.23: Evolution of the capex per population covered with LTE [Source: Analysys Mason, 2015]

For cable, in Figure 4.24 we do not present household coverage but the share of the maximum cable footprint that is upgraded to DOCSIS3.0. In most cable areas, the cost to upgrade the network to DOCSIS3.0 ranges from MKD5000 and MKD7000 per household; in the less viable areas, it can be as high as MKD8500 per household.

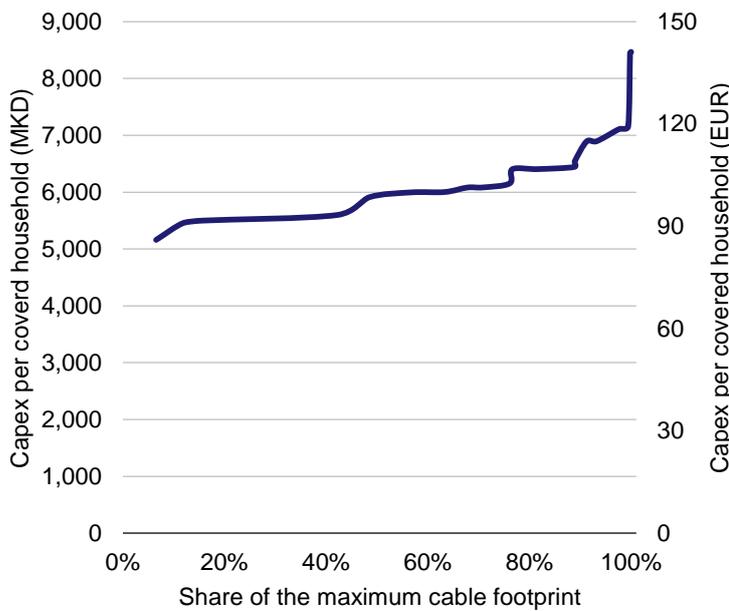
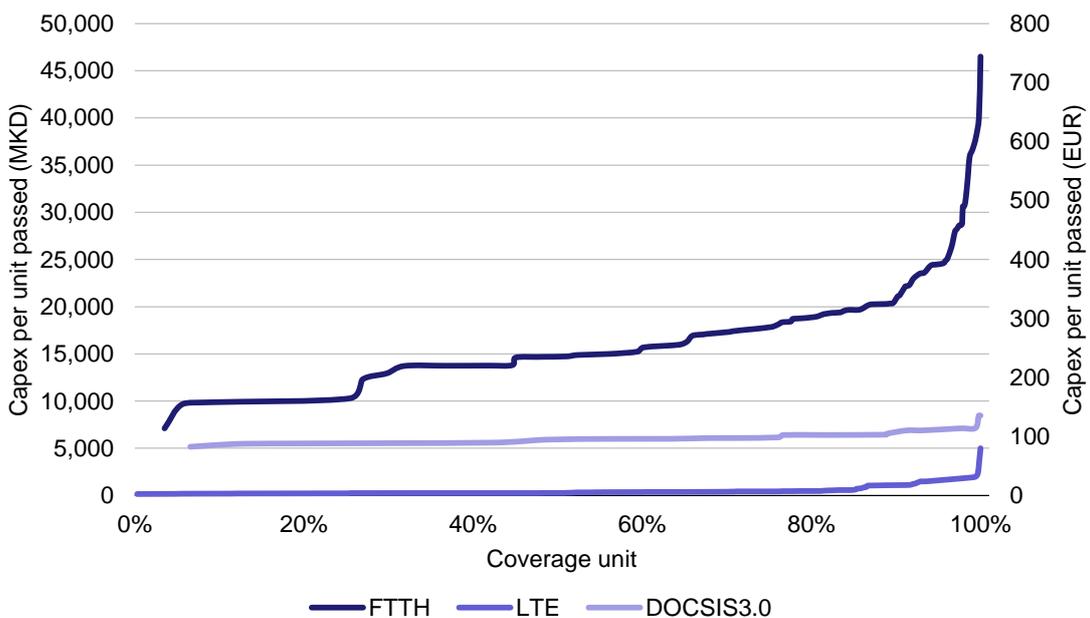


Figure 4.24: Evolution of the capex per household upgraded to DOCSIS3.0 [Source: Analysys Mason, 2015]

Figure 4.25 shows the evolution of the cost per unit passed for FTTH, LTE and DOCSIS3.0 as coverage increases; it includes the costs that might have already been spent on existing roll-outs. The figure shows that capex varies widely by technology, which can be explained by the following three factors:

- LTE roll-out mostly requires light hardware upgrade on existing physical sites
- DOCSIS3.0 deployment consists mostly of equipment upgrade and some fibre roll-out
- FTTH requires a full infrastructure roll-out.

Figure 4.25: Evolution of the deployment capex per unit passed for each of the three high-speed broadband technologies modelled [Source: Analysys Mason, 2015]



5 Main type of measures

We summarise in this section the measures that regulators have implemented or defined in their national broadband plans to promote competition in the broadband market.

As shown in Figure 5.1 below, we have identified three main categories of measures that can be applied to promote the development of the broadband market:

- measures to develop the supply side – i.e. measures aimed at increasing the availability of broadband to end users
- measures to develop the demand side – i.e. measures aimed at increasing the interest of citizens for broadband services and foster take-up
- general measures aimed at adapting the regulatory and policy framework of the country to support broadband development.

Supply-side and demand-side measures have been further divided into two categories, as detailed in the following sub-sections.

The remainder of this section presents and details measures that have been adopted or that have been included in national broadband plans in other European countries under the main categories identified.

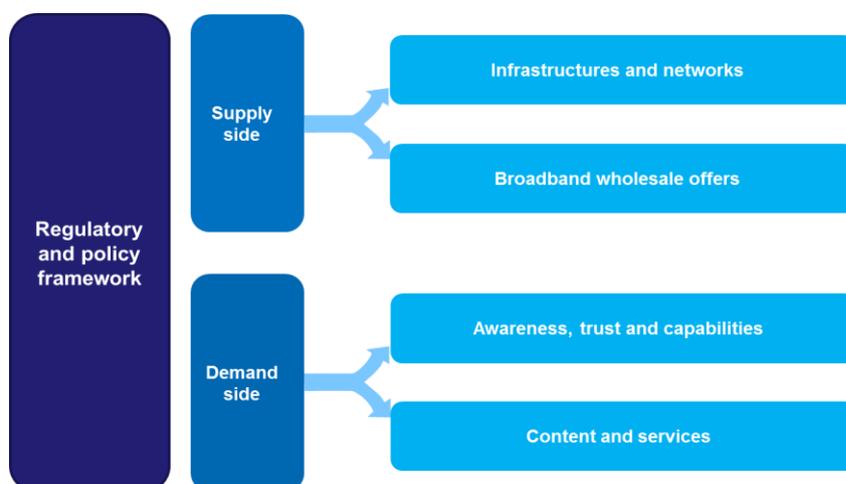


Figure 5.1: Main types of measures to promote the demand and supply of broadband networks [Source: Analysys Mason, 2015]

5.1.1 Regulatory and policy framework

A first, generic step in the promotion of broadband in a country is to ensure a clear regulatory and policy framework is put in place. This helps policymakers and legislators to:

- articulate their targets and key priority areas
- identify sectors where public actions are needed and set aside public funding if required
- provide stakeholders of the ICT sector with a clear, long-term plan, and a stable and foreseeable legal and operational environment, which is key to attract investors.

In particular, public authorities aim to create a more favourable environment for broadband development by focusing on:

- streamlining administrative processes and facilitating interactions between operators and public authorities, for example by
 - defining a national, unique process to allow deployment of networks on publicly owned infrastructure (right of way)
 - reducing or suppressing fees for the use of public property
 - simplifying the process to launch a new operator
- ensuring the telecoms market remain competitive, as a healthy competitive market will drive prices down and improve the quality of service, to the ultimate benefit of consumers
- guaranteeing enough powers and independence to the regulator – it is important to ensure that the regulator is able to take the necessary decisions within the legislative framework, that it is in a position to enforce these decisions, that it can arbitrate disputes between operators, and that it is able to function quickly enough to be efficient
- avoiding restriction on subjects such as VoIP, innovation and access, so that end users and companies can continue to benefit from the positive effects of net neutrality.

5.1.2 Supply side

This section presents measures that can be taken to promote the supply of broadband networks and services, and in particular high-speed broadband.

It should be noted that this study focusses mainly on the supply side measures as these are the core of the regulation that can be adopted by National Regulatory Authorities (NRAs), whereas demand-side measures are mainly policies adopted by governments.

The table below summarises the measures taken on the supply side by European countries (most EU countries as well as ‘regional’ countries close to Macedonia) to promote broadband. It should be noted that most of the supply side measures are taken by NRAs in charge of the telecoms sector and are therefore more regulatory than policy measures. As can be seen in the table, all countries regulate wholesale access; other measures are less ubiquitous like access to non-telecoms infrastructure and spectrum trading, though passive sharing of telecoms infrastructure and spectrum assignments towards broadband are currently well spread across Western Europe.

Figure 5.2: Measures to promote the supply of broadband networks and services [Source: EC, national broadband plans, Analysys Mason, 2014]

Country	Sharing of telecoms infrastructure	Co-deployment and co-investment	Access to non-telecoms infrastructure	Spectrum assignment	Spectrum trading	Coverage obligations	Imposition of technical standards	Wholesale and retail markets
Albania	✓	✓						✓
Austria	✓		✓	✓	✓	✓	✓	✓
Belgium		✓		✓	✓	✓		✓
Bulgaria		✓			✓			✓
Cyprus	✓	✓				✓		✓
Czech Republic	✓			✓	✓	✓		✓
Croatia	✓			✓		✓		✓
Denmark	✓	✓		✓	✓			✓
Estonia	✓			✓				✓
Finland	✓	✓		✓		✓	✓	✓
France	✓	✓	✓	✓		✓	✓	✓
Germany	✓		✓	✓		✓	✓	✓
Greece								✓
Hungary				✓				✓
Ireland		✓		✓		✓		✓
Italy	✓			✓				✓
Latvia				✓	✓			✓
Lithuania	✓			✓				✓
Luxembourg	✓	✓	✓					✓
Montenegro	✓	✓			✓			✓
Netherlands				✓	✓			✓

Country	Sharing of telecoms infrastructure	Co-deployment and co-investment	Access to non-telecoms infrastructure	Spectrum assignment	Spectrum trading	Coverage obligations	Imposition of technical standards	Wholesale and retail markets
Norway				✓	✓	✓		✓
Poland	✓	✓	✓			✓	✓	✓
Portugal	✓	✓	✓	✓	✓	✓	✓	✓
Romania		✓	✓	✓				✓
Slovenia	✓	✓	✓	✓	✓			✓
Spain	✓	✓	✓	✓	✓	✓	✓	✓
Sweden	✓	✓		✓		✓	✓	✓
UK	✓	✓	✓	✓	✓	✓	✓	✓

Infrastructure and networks

Sharing of telecoms infrastructure Measures to promote the sharing of existing telecoms infrastructure between different players typically include:

- Compiling a civil infrastructure register indexing location and characteristics of all the existing infrastructure components of communications networks that are suitable for pooling. This facilitates infrastructure sharing (e.g. Germany, Croatia, Albania).
- Mandating the incumbent to provide duct access and pole access to reduce roll-out costs for alternative operators (e.g. UK, Slovenia).

Co-deployment and co-investment Measures to enable co-ordination and joint investment in the roll-out of communications networks, between telecoms operators or with utilities/promoters, typically include:

- Promoting the joint construction of electronic communications networks during the construction of other infrastructure, such as water supply or sewage system (e.g. Slovenia, Croatia).
- Mandating operators to deploy new communication infrastructure to offer the possibility of joint investment to other communications operators (e.g. France).
- Imposing the obligation to set up electronic communication networks in all new dwelling developments (e.g. UK).
- Allowing the development of public–private partnerships for the roll-out of communications networks, especially in areas with lower profitability (e.g. Spain, Slovenia, Albania).
- Providing financial support to upgrade the data transport infrastructure (backbone) in rural and isolated areas where economic space is insufficient (e.g. UK, Germany, Slovenia).
- Implementing a public comprehensive portal with information around the topics of planning, funding and overall business models developed in the area of broadband Internet to assist non-specialist stakeholders, such as local authorities with investment in broadband deployments (e.g. Germany, France).

<i>Access to non-telecoms infrastructure</i>	Measures to allow operators to use non-telecoms civil infrastructure in the deployment of communications networks. For instance, give the NRA legal powers to mandate access to infrastructures (e.g. duct, poles) owned by entities outside the telecoms sector (e.g. public domain, utility sector, railways) (e.g. UK, France, Germany, Romania, Slovenia).
<i>Spectrum assignment</i>	<p>Actions to define a clear and efficient spectrum policy to encourage the development of mobile broadband typically include:</p> <ul style="list-style-type: none"> • Assigning the digital dividend spectrum (the 790–862MHz band) to high-speed broadband mobile communications (e.g. most European countries). • Implementing spectrum refarming measures to allow more advanced technologies to use frequencies already assigned to existing technologies (e.g. Montenegro). • Promoting full technological neutrality in assigning frequencies (e.g. Croatia, Albania).
<i>Spectrum trading</i>	Give the possibility to transfer spectrum rights to improve flexibility and rationality in the use of frequencies (e.g. Montenegro, UK).
<i>Coverage obligations</i>	<p>Use new spectrum licences to increase the availability of broadband networks and services at the national level. Measures typically include:</p> <ul style="list-style-type: none"> • Including coverage obligations in licences for spectrum in low-frequency bands (e.g. 800MHz, 700MHz) to extend broadband coverage to areas where it is not economically viable for operators to provide coverage (e.g. Croatia, France, Germany). • Ensuring actual monitoring and enforcement of coverage obligations is achieved, and if necessary applying less stringent obligations to new entrants so that they are not prevented from operating profitably (e.g. UK). • Implementing geographical regulation (different requirements depending on the region), to adapt licence obligations to the competition conditions in specific areas of the market (e.g. Poland). • Considering the relevance of imposing a universal service obligation on the provision of basic broadband to an operator. The economic cost of this could be covered by a fixed contribution in case of unfair burden to the operator that is in charge of providing services (e.g. Finland, Spain, Sweden).

Imposition of technical standards Eliminate the uncertainty related to the technical specifications of broadband roll-out projects. Measures typically include:

- Defining standards for new dwelling developments to be built with a high-speed broadband connection (e.g. UK).
- Defining standards for deployment of new network elements to be shared by all operators, such as ducts or in-building fibre (e.g. France).

Broadband wholesale offers

Wholesale and retail markets Measures to promote competition and set up an investment scale to allow potential new operators to successfully enter the market. These typically include:

- Mandating access to the communications network of SMP operators at various levels, both passive and active (unbundling of fibre and copper local loop, regional bitstream, national bitstream), to ensure alternative operators are able to choose the adequate level of investment and control on their network (e.g. most European countries).
- Mandating additional products to facilitate network deployment for competitors (e.g. dark fibre products, leased lines, national transport links) (e.g. most European countries).
- Monitoring and enforcing regulatory obligations, and conduct regular and relevant analysis of markets to be able to adapt to changes in the competitive situation (e.g. most European countries).

5.1.3 Demand side

This section presents measures that can be taken on the demand side to promote the use of broadband by citizens. We have identified two categories of measures:

- measures aiming at facilitating the use of broadband to the largest number of citizens possible, by increasing
 - their awareness of the possibilities of ICT
 - their trust in ICT (security, transparency, protection)
 - their capabilities to actually use the new services
- measures aiming at increasing the amount and attractiveness of digital content and services to foster the interest of citizens in ICT.

Awareness, trust and capabilities

Figure 5.3 below summarises the ‘awareness, trust and capabilities’ measures taken to promote demand for broadband in large European countries (France, Germany, UK, Italy, Spain and Poland) as well as ‘regional’ countries close to Macedonia. Among the regional countries, Serbia, Greece and Bosnia do not currently have a national broadband plan in place and so have not been included in the analysis.

The table shows that almost all countries have taken communication measures to promote demand for broadband networks and services. Most have taken actions towards e-inclusion and in favour of trust and security; measures involving broadband mapping and transparency and control are less frequent.

Figure 5.3: Awareness, trust and capabilities measures to promote demand for broadband networks and services [Source: Analysys Mason, 2014]

Country	Broadband mapping	Transparency and control	Communication	Trust and security	e-Inclusion and ICT literacy
Albania			✓	✓	✓
Bulgaria	✓		✓		
Croatia			✓	✓	
France	✓	✓	✓	✓	✓
Germany	✓	✓	✓	✓	✓
Italy	✓		✓	✓	✓
Montenegro			✓	✓	✓
Poland		✓	✓		✓
Romania			✓		✓
Slovenia					
Spain	✓	✓	✓	✓	✓
UK	✓	✓	✓	✓	✓

<i>Broadband mapping</i>	Design a publicly accessible mapping tool to display the availability and speed of retail broadband connections, at a national scale. This would enable the visualization of the current status of broadband services at a certain location including the availability of basic or high-speed broadband, and facilitate the identification of areas where there are market gaps (e.g. Spain, France).
<i>Transparency and control</i>	<p>Set up transparency requirements for stakeholders to enhance information, control and trust for end users as regards broadband. These typically include:</p> <ul style="list-style-type: none"> • setting up transparency requirements for ISPs regarding the speed delivered at the point of sale (e.g. UK, Poland) • giving the possibility for end-users to measure the parameters of the broadband service provided to ensure they correspond to the offer (e.g. Poland) • mandating broadband contracts to be structured in a clear, understandable and accessible manner (e.g. Poland) • setting up legislation and procedures to define the rights of broadband subscribers, and facilitate the processing, handling and resolution of complaints against operators as regards contract and service (e.g. Poland) • publishing an annual monitoring report detailing the measures already implemented, their impact on the ICT sector and the future steps and actions to be taken (e.g. Germany).
<i>Communication</i>	<p>Design marketing campaigns to encourage widespread use of digital services. Measures that may be taken in this regard typically include:</p> <ul style="list-style-type: none"> • undertaking public campaigns to promote the digital economy and raise awareness of the benefits arising from the use of Internet (e.g. Spain, Bulgaria, Poland) • informing users on the possibilities offered by digital television (e.g. many European countries).
<i>Trust and security</i>	<p>Measures to improve security in the use of digital services and increase confidence towards these technologies typically include:</p> <ul style="list-style-type: none"> • creating a commission on radio frequencies and health matters, to increase confidence in environmental safety and in the fact that the use of the radio spectrum will not affect public health (e.g. Spain) • developing services such as e-identification, signature devices and digital identity services to protect identity in the respect of privacy (e.g. Montenegro) • implementing laws to protect consumers and ensure responsible handling, management, storage and control of personal data by any entity (e.g. Albania)

- ensuring appropriate security in the field of electronic transactions (e.g. Spain)
- adapting copyright laws to the digital sphere (e.g. UK, Croatia).

e-inclusion and ICT literacy Measures to foster access to, and use of, ICT content and services to the largest part of the population. These typically include:

- increasing usability and accessibility of services, in line with international web accessibility standards (e.g. Spain, Montenegro, Poland)
- enabling access to groups with special needs and ensure everyone has the opportunities, skills and knowledge to use online services; this could involve support to ICT training and education, both in schools and for adults (e.g. Spain)
- setting up public access points to information, for people disadvantaged geographically, in weak economic conditions, with low digital skills, with limited infrastructures (e.g. Romania, Albania)
- providing subsidies or social tariffs to citizens needing financial support to be able to afford the use of communications services (e.g. Belgium).

Content and services

Figure 5.4 below summarises the ‘content and services’ measures taken to promote demand of broadband networks and services by large European countries (France, Germany, UK, Italy, Spain and Poland), as well as ‘regional’ countries close to Macedonia. Among the regional countries, Serbia, Greece and Bosnia do not currently have a national broadband plan in place and so have not been included in the analysis.

As shown in the table, all countries have taken measures to promote e-education, e-administration and e-health. Most countries have adopted actions to support the industry and foster the creation of quality online content, while measures involving e-justice and e-commerce are less frequent.

Figure 5.4: Content and services measures to promote demand of broadband networks and services [Source: Analysys Mason, 2014]

Country	e-education	e-administration	e-health	Quality online content	Support to the industry	e-commerce	e-justice
Albania	✓	✓	✓	✓	✓		
Bulgaria	✓	✓	✓		✓		
Croatia	✓	✓	✓	✓	✓		
France	✓	✓	✓	✓	✓		✓
Germany	✓	✓	✓	✓	✓		
Italy	✓	✓	✓	✓			✓
Montenegro	✓	✓	✓		✓		
Poland	✓	✓	✓	✓	✓		✓
Romania	✓	✓	✓	✓	✓		
Slovenia	✓	✓	✓				
Spain	✓	✓	✓	✓	✓	✓	✓
UK	✓	✓	✓	✓	✓		

- e-education* Measures to connect schools and universities and develop use of ICT in the educational system across all stakeholders. These typically include:
- creating new educational tools, content and services adapted to the digital world, for students, teachers and parents (e.g. France, Italy, Romania)
 - promoting the digitization of universities and schools, by providing ubiquitous high-speed Internet access and offering connectivity to students (e.g. Italy, Montenegro)
 - increasing the possibilities of academic and professional qualifications in the ICT sector, for example by defining new degrees and qualifications to adapt to the evolution of the digital economy (e.g. Spain, France)
 - introducing digital learning in the classroom, for example with digital interactive blackboards or tablets (e.g. Italy, Poland).
- e-administration* Measures to make the most important administrative services available to all the population to streamline and simplify administrative processes. These typically include:
- creating an online platform to provide the most used public administration services, e.g. tax forms, payment of fines, applications to services, complaints, reports, social security (e.g. most European countries)
 - implementing progressive digitisation of administrative registers and processes, to shorten processes and reduce the paperwork (e.g. Albania)
 - training civil servants (at the national, regional and local level) on the use of digital services (e.g. Poland).
- e-health* Measures to adapt the possibilities offered by broadband access to the health sector and encourage the use of such new services. These typically include:
- implementing the digitization of health services and processes: e-prescriptions, clinical reports with digital signatures, diffusion of electronic prescription cycle, online reservations, online payments, online medical reports and digital sickness certificates (e.g. Spain, Italy)
 - developing a public online portal to provide healthcare information and services (e.g. Montenegro)
 - developing telemedicine services by videoconferencing (e.g. Romania).
- Quality online content* Involvement of the state in actions to develop an offer of quality content online, in order to attract a wide public. Measures typically include:
- offering digital access to cultural content under the responsibility of the state, for example through digitations of national archives, virtual museums visit or online publishing (e.g. France, Poland, Italy)

- supporting financially the creation of digital content of high value, for example content in national language, or audiovisual digital content (e.g. Albania, Spain)
- adopting laws to protect intellectual property online and address the issue of online copyright infringement, to reduce the scope of illegal downloading of Internet content (e.g. Croatia, UK).

Support to the industry

Actions to support ICT businesses to stimulate the development of new and innovative services or products typically include:

- providing funds and/or trainings for companies involved in the digital sector and for companies working on the creation, production and distribution of digital content (e.g. Romania)
- creating ‘digital hubs’ to concentrate enterprises in the digital sector, to stimulate competitiveness and growth (e.g. France)
- setting up a broadband centre of excellence, which would deliver advice and information about broadband development, and make proposals on the implementation of measures (e.g. Germany)
- cutting VAT for products and services in the ICT sector (e.g. Albania).

e-commerce

Measures to develop the use of e-commerce typically include:

- defining standards and certifications for e-commerce (e.g. Spain)
- simplifying the administrative process related to opening an online business (e.g. Spain).

e-justice

Measures to make the judiciary system benefit from the use of ICT services typically include:

- implementing legal guidance and information services online (e.g. Spain)
- allowing citizens to pre-register minor complaints online (e.g. France)
- implementing the digitization of legal case files to reduce paperwork and simplify exchange of information (e.g. Poland).

6 Impact assessment of measures

This section provides an assessment of the main measures that could be considered to promote the development of the Macedonian broadband market. It is laid out as follows:

- Section 6.1 identifies a list of relevant measures that could be considered in the Macedonian context
- Section 6.2 measures the impact of each type of measure identified on a series of key indicators of the market
- Section 6.3 discusses the likely impact of these measures and the potential difficulties in implementing them.

6.1 Identification of relevant measures

6.1.1 Supply side

We present below the measures we have considered as the most relevant under each “supply side” category, as presented in Section 5 above. We also provide an explanation as to why we think some of them are not relevant to the Macedonian context.

Sharing of telecoms infrastructure: A large majority of European countries have taken measures to ease sharing of telecoms infrastructure between operators.

⇒ **relevant to be tested**

In the context of Macedonia, we believe that a measure **stimulating operators to mutualise their mobile network infrastructure** (active as well as passive) would be relevant. This would typically be done in low-density areas and could allow operators to achieve cost savings, and therefore have a positive impact on LTE coverage. Implementation can be relatively complex between operators, especially for active sharing, but there are several examples of MNOs implementing network sharing agreements in Europe.

Co-deployment and co-investment: This category spans a large spectrum of measures that have been taken at a national level in several European countries. We have chosen not to model a measure related to co-deployment and co-investment as:

⇒ **not relevant to be tested**

- we are not aware of alternative operators willing to deploy FTTH networks alongside the incumbent operator, and cable network upgrades to DOCSIS3.0 are not suited for co-investment
- measures involving public financial subsidies for roll-outs require “political” decisions that we are not in a position to comment on
- measures mandating the roll-out of fibre when constructing new premises or other infrastructures are difficult to model without detailed geographical information.

Access to non-telecoms infrastructure:
⇒ **relevant to be tested**

Around half of European countries have taken measures to allow operators to use non-telecoms civil infrastructure (e.g. duct, poles owned by entities such as public domain, utility sector, railways...) in the deployment of communications networks.

In the case of Macedonia, though we do not have information on the potential nature of such non-telecoms infrastructure, we have considered a measure **allowing operators to re-use ducts and poles owned by non-telecoms entities**. This could have a strong impact on the cost of FTTH deployments (as digging to install fibre represents a large part of the roll-out costs), and thus could improve the commercial viability and ultimately the coverage of FTTH networks in the country.

Spectrum assignment:
⇒ **relevant to be tested**

Spectrum for mobile broadband has been attributed in most European countries. Macedonian operators currently hold 800MHz and 1800MHz spectrum for their LTE roll-outs. The 2600MHz band has also been attributed as an LTE spectrum band in most European countries.

We have considered the impact of **attributing 2600MHz spectrum to mobile operators**. This measure would affect the LTE deployment costs, and can be modelled in the context of our analysis.

Spectrum trading:
⇒ **not relevant to be tested**

Around a third of European countries give mobile operators the possibility to transfer spectrum rights to improve flexibility and rationality in the use of frequencies.

The spectrum available in Macedonia is largely sufficient to meet the needs of the three operators currently and in the foreseeable future. We have not considered this measure in our analysis as we believe it would not have a significant impact on the supply of mobile high-speed broadband networks in Macedonia.

Coverage obligations:
⇒ **relevant to be tested**

Coverage obligations are a typical measure implemented in relation with LTE spectrum awards to ensure the highest possible share of the population can benefit from mobile high-speed broadband. As regards fixed broadband, some countries have considered including broadband in the universal service obligation (USO). It is, however, typically limited to basic broadband services as extending such measures to high-speed fixed broadband networks would lead to operators incurring very high costs. For this reason, we have not considered a measure related to coverage obligation for high-speed fixed broadband.

We have, however, chosen to retain a measure **imposing a 100% coverage obligation for LTE** in Macedonia. This measure does not appear overly costly due to the existing footprint of other mobile technologies and could have a direct impact on the availability of high-speed mobile broadband in the country.

Imposition of technical standards:
⇒ **not relevant to be tested**

Some European countries have taken measures to ease the roll-out of fibre networks by defining common technical standards (network topology, technology) to be shared between players.

Given the limited size of the Macedonian market, it is difficult to consider that Macedonia could lead the definition of new technical standards. Main operators belong to international groups and/or are well aware of international standards and best practice. There is therefore no particular reason to believe that Macedonian operators need some guidance at this stage on their technical strategy.

Wholesale and retail markets:
⇒ **relevant to be tested**

All European countries have taken measures to promote competition and new entry in the broadband or high-speed broadband market by mandating access to incumbents' infrastructure, as competition is a key driver of innovation, investment and services take-up.

In the context of this analysis, we have chosen to retain a measure **mandating access to high-speed fixed broadband networks at sustainable prices**. This measure:

- is likely to have a strong impact on the market
- can be effectively implemented by the regulator.

6.1.2 Demand side

We present below the measures we have considered as the most relevant under each 'demand side' category, as presented in Section 5 above. We also provide an explanation as to why we think some of them are not relevant to the Macedonian context.

Broadband mapping:
⇒ **not relevant to be tested**

Some European countries have designed a publicly accessible mapping tool to display the availability and speed of retail broadband connections at a national scale.

Although initiatives of this kind are likely to reinforce awareness of the population (for example, allowing people to realise they are eligible for high-speed broadband services), we believe they would not have an important impact on overall demand for broadband, and have therefore not been retained in our analysis.

Transparency and control:

⇒ **not relevant to be tested**

A few European countries have set up transparency requirements for stakeholders to enhance information control as regards broadband service (typically regarding the nature and quality of the service available to end users, as well as contractual rights and obligations of clients).

Such measures appear interesting in terms of end-user protection, but we believe they could be taken in the more general context of consumer protection law, and would not have a major (and easily quantifiable) impact on the general public demand for broadband or high-speed broadband access. We have therefore not retained them in our analysis.

Communication:

⇒ **relevant to be tested**

Many European countries have designed marketing campaigns to encourage widespread use of digital services.

Considering that more than 30% of the Macedonian population have never used the Internet as of 2014, communication measures could increase the overall demand for broadband and high-speed broadband services. We have therefore retained in our analysis a measure to **undertake public campaigns to promote the digital economy and raise awareness of the benefits arising from the use of Internet.**

Trust and security:

⇒ **not relevant to be tested**

Some European countries have tried to improve security in the use of digital services and increase confidence towards these technologies. Such measures are likely to have a direct or indirect impact on the demand for broadband service. However, their impact on broadband development is hard to quantify. Therefore we have not retained a measure of this type in our analysis.

e-inclusion and ICT literacy:

⇒ **relevant to be tested**

A large part of the European countries considered have taken measures to foster access to and use of ICT content and services to the largest part of the population. These measures are very relevant to demand for broadband and high-speed broadband services as

- they can increase the share of population having used and being able to use the Internet (demand for broadband)
- stimulate the skills of people so that they use a larger array of services online and recognise the value of high-speed broadband.

We have therefore retained three measures in our analysis:

- **ensuring everyone has the opportunities, skills and knowledge to use online services** (e.g. support to ICT training and education, in schools and for adults)

- **setting up public access points to information regarding use of digital services, for people disadvantaged geographically, in weak economic conditions, with low digital skills, with low infrastructure**
- **providing public subsidies or “social tariffs” to low-income population** (typically for fixed broadband access).

These measures can practically be taken by public authorities in Macedonia, and can have an impact on public demand for broadband services.

e-education, e-administration, e-health, e-justice:

⇒ **not relevant to be tested**

A large share of European countries have implemented actions to favour the use of digital services in public-sector areas, such as administration, education, health or justice.

Such types of measures have a breadth of interest for a government, among which significant efficiency gains and costs saving. However, on top of being particularly difficult to quantify, isolating the impact on broadband or high-speed broadband (rather than Internet usage as a whole) can be quite speculative. We have therefore not retained any measures from these categories in our analysis.

Quality online content:

⇒ **relevant to be tested**

Some countries have taken actions to support the development of quality content online to attract a wide public. Such measures appear relevant to stimulate the demand for broadband services as a way to access this digital content.

In the context of our analysis, we have chosen to retain a measure **financially supporting the creation of high-value digital content, for example content in national language, or audiovisual digital content**. This measure could be implemented practically by Macedonia on the basis of the model of legislation existing in European countries, for example through regulation of the public service broadcaster’s role in content creation. We believe that this measure could affect demand for broadband and high-speed broadband services.

Support to the industry:

⇒ **relevant to be tested**

Governments regularly choose to take actions to support ICT businesses to stimulate the development of new and innovative services or products. The support can be financial, but can also be related to ways of enhancing the digital ecosystem as a whole (e.g. simplifying the administrative burden on digital companies).

In the context of our analysis, we have retained a measure **cutting VAT for products and services in the ICT sector**. Such a measure could be justified under the consideration that access to telecoms services represents a ‘necessity’ for citizens, and would make broadband offers more affordable to a part of the population, which would directly increase demand for broadband and high-speed broadband access services.

e-commerce: Few countries have taken steps to develop the use of e-commerce. The development of e-commerce appears beneficial for businesses and the overall economy. However, on top of being particularly difficult to quantify, isolating the impact on broadband or high-speed broadband (rather than Internet usage as a whole) can be quite speculative. Therefore we have not retained measures within this category in the context of our analysis.

⇒ ***not relevant to be tested***

6.1.3 Parameters affected by the measures identified as relevant to be tested

The Digital Agenda for Europe aims at increasing the proportion of the European population that benefits from a high-speed broadband connection. In light of this objective, it identifies two main goals:

- increasing take-up of high-speed broadband within the population that can access it
- increasing coverage of high-speed broadband networks across Europe.

Each of the measures identified previously (and listed in Figure 6.1) aims at fulfilling at least one of these two goals: “supply-side” measures would affect network coverage (broadband or high-speed broadband availability), while “demand-side” measures would affect take-up of broadband or high-speed broadband services (share of the covered population that actually subscribes to a service). Figure 6.1 below describes the impacts that the measures studied aimed to achieve.

It should be noted that we have grouped some relevant demand-side measures under the same measure to be tested, as implementing different measures would impact the same parameter and would potentially lead to the same results.

To conduct the impact assessment of the selected measures, we had to identify the modelling parameters used in the econometric analysis (demand side) and the coverage-viability analysis (supply side) that should be altered to estimate the likely impact of these measures. Figure 6.1 presents the parameters that were used for each measure.

Figure 6.1: Main parameters affected by the measures modelled in our analysis [Source: Analysys Mason, 2015]

Measure	Segment	Main impact	Modelling parameter affected
M1: Mobile network sharing	Mobile broadband	Less capex and opex, resulting in potentially higher coverage/viability	Mobile sites rolled out
M2: Access to non-telecoms infrastructure	High-speed fixed broadband	Fewer civil works and ducts are required for fibre roll-out, reducing roll-out cost and therefore increasing coverage/viability	Share of duct reuse
M3: Spectrum assignment	Mobile broadband	More capacity per mobile site, potentially resulting in fewer roll-out costs and higher coverage/viability	Additional LTE spectrum available

Measure	Segment	Main impact	Modelling parameter affected
M4: Coverage obligation	Mobile broadband	Higher mobile network coverage, at the expense of higher roll-out costs	None specifically – we just assess the cost of going beyond viable coverage areas
M5: Mandating wholesale NGN access at sustainable price	High-speed fixed broadband	Increased competition in the high-speed broadband market, potentially resulting (among other) in lower prices and higher take-up	Fixed high-speed broadband ARPU
M6: Public campaigns to promote digital economy M6: Supporting the creation of high-value digital content	Fixed broadband, high-speed fixed broadband and mobile broadband	More people are willing to use the Internet and are able to do so, potentially resulting in higher take-up of broadband services (these measures are assessed collectively and referred to hereafter as “measures increasing the number of Internet users”)	Share of population having never used the Internet
M7: Ensuring everyone has opportunities, skills and knowledge to use online services M7: Setting up public access points to information regarding use of digital services	Fixed broadband, high-speed fixed broadband and mobile broadband	More people are willing to “go digital” and use the Internet in several aspects of their life, potentially resulting in higher take-up of broadband services (these measures are assessed collectively and referred to hereafter as “measures increasing the Internet skills of the population”)	Share of population with medium or high Internet skills
M8: Providing subsidies or social tariffs to low-income citizens	Fixed broadband and high-speed fixed broadband	More people can afford a broadband connection, resulting in higher take-up	Fixed broadband and fixed high-speed broadband ARPU
M9: Cutting VAT for services in the ICT sector	Fixed broadband, high-speed fixed broadband and mobile broadband	More people can afford a broadband connection, resulting in higher take-up	Fixed broadband and fixed high-speed broadband ARPU Mobile and mobile broadband ARPU

6.2 Impact assessment of the relevant measures identified

This section presents the results of the impact assessment that was carried out for each relevant measure identified. We provide the following three different figures/results for each measure, whenever the measure has an impact on the results:

- the premium on fixed broadband penetration, high-speed fixed broadband penetration and mobile broadband penetration compared to the base case
- the difference of viable high-speed broadband coverage with the base case
- subscriber, penetration and coverage figures for 2019 and 2023 for the base case and the case when the measure is implemented.

6.2.1 Mobile network sharing (M1)

This measure would allow mobile operators to carry out passive or active network sharing in areas they would be interested in. Two operators could share both their physical sites and active equipment, and would be able to jointly operate fewer sites, thus achieving capex and opex savings. For competition reasons, this is often not done at a national level, but typically in areas where roll-out is less profitable (e.g. complicated terrain, low-density area).

Such an operation would likely not only affect the 4G network, but also the 2G and 3G networks of an operator. However, in our modelling we translated this in terms of cost savings as regards LTE deployment only. We assumed for our coverage-viability model that a network sharing agreement would involve 25% of sites (for the two operators) therefore allowing each operator to reduce the number of its 4G sites by 12.5%. The MNO would also achieve related technical opex savings, as there would be fewer sites and reduced equipment roll-out.

Under the base scenario, LTE coverage/deployment is commercially viable at 94% of the population; under our assumptions for this measure the viability for LTE would be 99.5% of the population. The measure does not directly affect mobile broadband penetration as other technologies such as 3G are providing mobile broadband services in Macedonia and are already widespread.

The following figure presents the results of our analysis in the base case and when testing the impact of this measure.

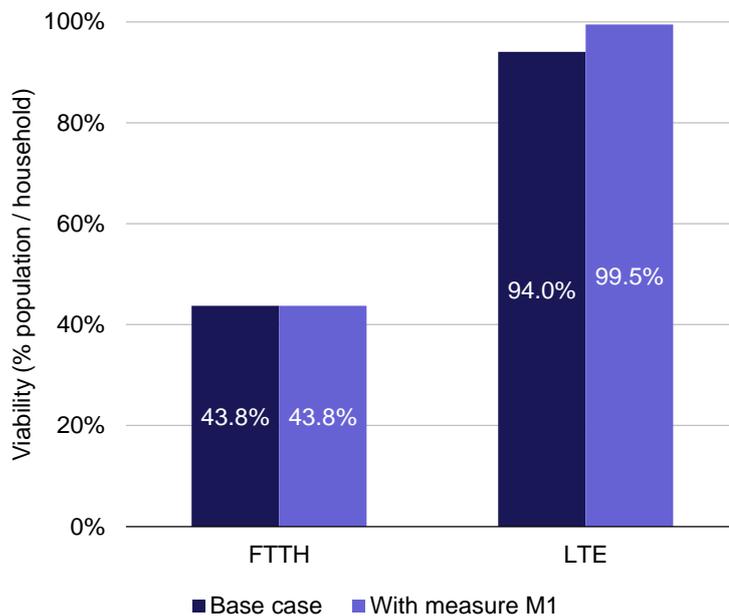


Figure 6.2: Viable coverage of FTTH and LTE technologies in the base case and when assessing the impact of mobile network sharing [Source: Analysys Mason, 2015]

6.2.2 Access to non-telecoms infrastructure (M2)

This measure would allow operators rolling out networks to rent access to the ducts or poles of non-telecoms infrastructure players, which would allow for significant deployment cost savings considering that civil works represent the major part of the costs of rolling out a fixed network.

We assumed for our coverage-viability model that instead of being able to use existing ducts for 75% of the length of its fibre links between the exchange and splitter and 70% of the length of its fibre links between the splitter and the premises, an operator deploying FTTH would be able to use existing ducts for 80% and 75% of the length of its fibre links respectively, resulting in significant cost savings.

Under the base scenario, FTTH coverage/deployment is commercially viable at 44% of the population; under our assumptions for this measure the viability of FTTH would be 48.1% of the population, and there would be circa 40 000 additional high-speed broadband subscribers by 2023.

The following figures present the results of our analysis in the base case and when testing the impact of this measure.

Figure 6.3: Penetration premium of fixed broadband, high-speed fixed broadband and mobile broadband compared to base case when assessing the impact of access to non-telecoms infrastructure [Source: Analysys Mason, 2015]²⁴

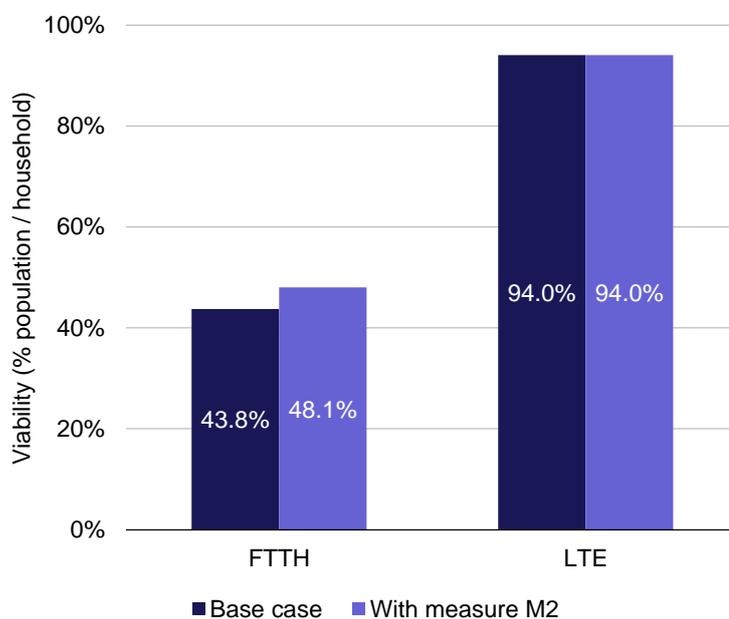
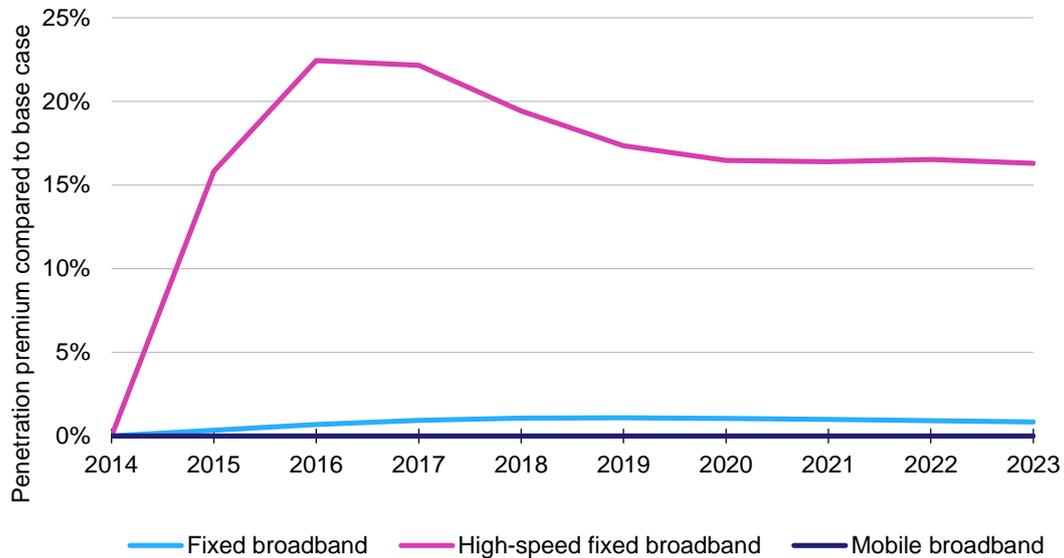


Figure 6.4: Viable coverage of FTTH and LTE technologies in the base case and when assessing the impact of access to non-telecoms infrastructure [Source: Analysys Mason, 2015]

²⁴ It should be noted that this measure has no impact on mobile broadband.

Figure 6.5: Key results of our analysis in the base case and when assessing the impact of access to non-telecoms infrastructure [Source: Analysys Mason, 2015]

	2019 With measure	2019 Base case	2019 evolution	2023 With measure	2023 Base case	2023 evolution
Fixed broadband subscribers / penetration	443 776 / 69%	439 036 / 68%	1.1%	499 440 / 77%	495 266 / 76%	0.8%
High-speed fixed broadband subscribers / penetration	93 661 / 15%	79 823 / 12%	17.3%	270 106 / 41%	232 253 / 36%	16.3%
High-speed fixed broadband coverage	54%	47%	14.5%	65%	58%	12.7%
Mobile broadband subscribers / penetration	1 791 370 / 87%	1 791 370 / 87%	-%	1 935 124 / 94%	1 935 124 / 94%	-%

6.2.3 Spectrum assignment (M3)

Under this measure, operators would be assigned 20MHz duplex of LTE spectrum in the 2600MHz band. This would allow them to offer more capacity per site, which could potentially reduce the number of 4G sites required to address the capacity needs of end users and improve service quality.

In our modelling, we translated this directly in terms of increased capacity per 4G site. In our base case scenario, the existing number of sites (when upgraded to 4G) is enough to address almost all of the capacity required by mobile broadband clients. Therefore, the viability of LTE deployment is not affected by additional spectrum assignments. However, this measure would have a positive impact on mobile operators as they would be able to have more capacity on a specific site and would have to deploy a fewer LTE sites whenever required for network densification. The estimated capex saving achieved with this measure for our modelled operator is circa MKD10 million.

However, in a scenario with higher average data usage per client, it is highly possible that this measure would have a stronger impact and lead to higher cost savings and higher technology viability. Additionally, the 2600MHz spectrum band holds a commercial value for operators as a means to increase headline speed for end users.

6.2.4 Coverage obligation (M4)

This measure would mandate mobile operator to cover 100% of the Macedonian population with LTE technology, a requirement which would need to be added to their 4G licences, if legally possible or to be included in a future attribution of new bands (e.g. 2600MHz, 700MHz).

In our modelled base case, LTE coverage viability is 94% of the population, implying that the remaining 6% would be commercially unviable and therefore may not be covered without public intervention. Implementing a coverage obligation would ensure that all the population has access to high-speed mobile broadband by “forcing” operators to bear additional costs for full LTE coverage.

On the basis of our coverage-viability analysis, we estimate that mandating full national LTE coverage to an operator would result in circa MKD250 million of additional capex. Taking into account additional revenue that would be derived from newly covered population, the NPV of additional coverage costs would decrease by MKD45 million, an amount which would probably not represent an unbearable burden for a Macedonian operator (so that they might actually consider pushing LTE coverage over the unviable areas for commercial or strategic reasons).

6.2.5 Mandating wholesale NGN access at sustainable price (M5)

This measure suggests mandating wholesale access to NGN networks (FTTH or DOCSIS3.0) and ensuring that prices allow competitors to operate profitably on the basis of wholesale offers. Competition is a strong driver of penetration and innovation, and this measure would ensure that the level of competition currently observed in the fixed broadband market also replicated in the high-speed broadband market in the medium and long term. We believe this measure would likely have a positive impact on the demand for high-speed broadband services.

In our modelling, we assumed that this measure would translate into a 15% reduction in long-term high-speed broadband ARPU in the market, which affects the results of our demand-side econometric analysis. We considered this measure would not affect the supply-side modelling, under the assumption that the reduction in ARPU would be compensated by increased operator efficiency (due to competition) and by increased attractiveness of high-speed broadband.

Compared to our base case, this measure would translate into circa 15 000 additional high-speed broadband subscribers by 2023, for the same FTTH viability.

The following figures present the results of our analysis in the base case and when testing the impact of this measure.

Figure 6.6: Penetration premium of fixed broadband, high-speed fixed broadband and mobile broadband compared to base case when assessing the impact of mandating wholesale NGN access [Source: Analysys Mason, 2015]²⁵

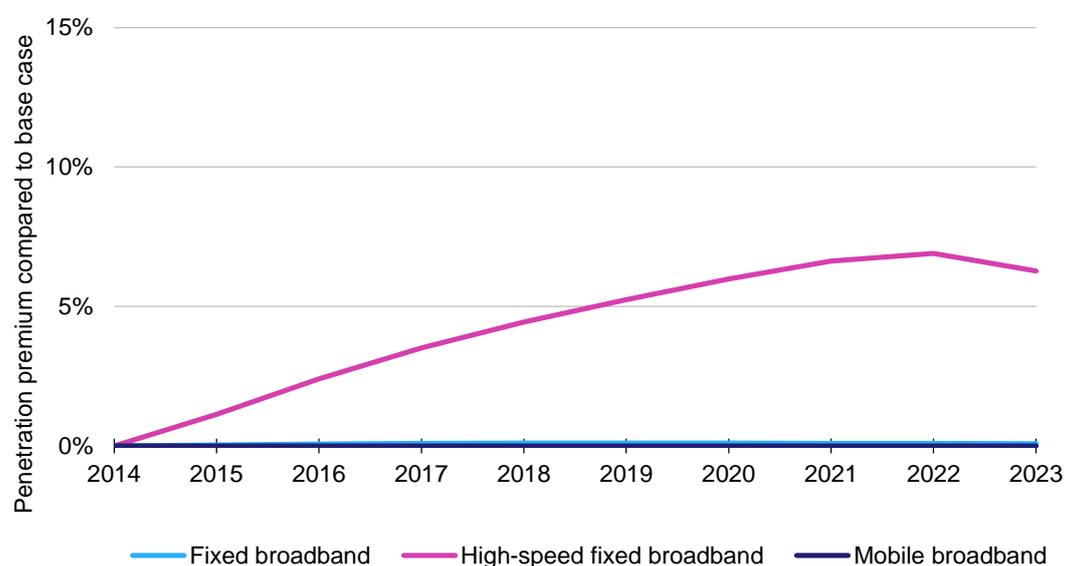


Figure 6.7: Key results of our analysis in the base case and when assessing the impact of mandating wholesale NGN access [Source: Analysys Mason, 2015]

	2019 With measure	2019 Base case	2019 evolution	2023 With measure	2023 Base case	2023 evolution
Fixed broadband subscribers / penetration	439 508 / 69%	439 036 / 68%	0.1%	495 646 / 76%	495 266 / 76%	0.1%
High-speed fixed broadband subscribers / penetration	84 010 / 13%	79 823 / 12%	5.2%	246 830 / 38%	232 253 / 36%	6.3%
High-speed fixed broadband coverage	47%	47%	–%	58%	58%	–%
Mobile broadband subscribers / penetration	1 791 370 / 87%	1 791 370 / 87%	–%	1 935 124 / 94%	1 935 124 / 94%	–%

²⁵

It should be noted that this measure has no impact on mobile broadband and that the impact on fixed broadband is extremely low (circa 0.1%).

6.2.6 Measures increasing the number of Internet users (M6)

We suggest assessing collectively the relevance of measures aiming at increasing the number of people using the Internet such as:

- undertaking public campaigns to promote the digital economy and raise awareness of the benefits arising from the use of Internet
- supporting financially the creation of high-value digital content, for example content in national language, or audiovisual digital content.

Though it is not easy to quantify the impact of such measures, we believe they could have an actual impact on the share of people having never used the Internet, which is one of the econometric drivers we used to assess future demand for broadband services.

We assumed that such measures would reduce the share of Macedonian people having never used the Internet by 15% in the medium and long term, which would be reduced from 33% in 2014 to 22% and 17% in 2019 and 2023 respectively, against 26% and 20% in 2019 and 2023 respectively in the base case.

In our econometric analysis, such a reduction translates into circa 30 000 additional high-speed broadband subscribers in 2023, as well as 3000 additional broadband subscribers and 5000 additional mobile broadband subscribers.

The following figures present the results of our analysis in the base case and when testing the impact of this measure.

Figure 6.8: Penetration premium of fixed broadband, high-speed fixed broadband and mobile broadband compared to base case when assessing the impact of measures increasing the number of Internet users [Source: Analysys Mason, 2015]

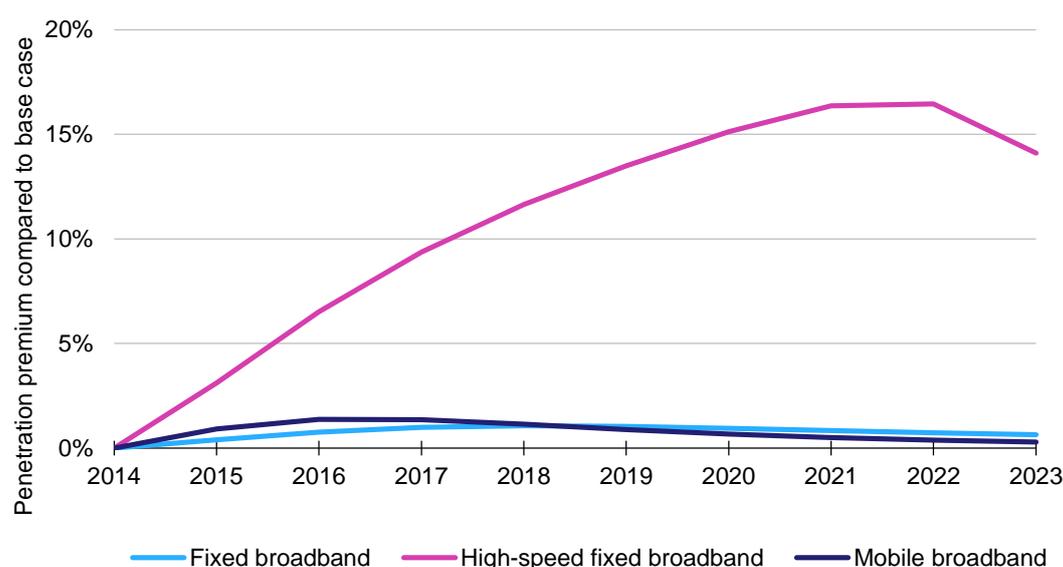


Figure 6.9: Key results of our analysis in the base case and when assessing the impact of measures increasing the number of Internet users [Source: Analysys Mason, 2015]

	2019 With measure	2019 Base case	2019 evolution	2023 With measure	2023 Base case	2023 evolution
Fixed broadband subscribers / penetration	443 579 / 69%	439 036 / 68%	1.0%	498 419 / 76%	495 266 / 76%	0.6%
High-speed fixed broadband subscribers / penetration	90 599 / 14%	79 823 / 12%	13.5%	265 000 / 41%	232 253 / 36%	14.1%
High-speed fixed broadband coverage	47%	47%	–%	58%	58%	–%
Mobile broadband subscribers / penetration	1 807 163 / 87%	1 791 370 / 87%	0.9%	1 940 576 / 94%	1 935 124 / 94%	0.3%

6.2.7 Measures increasing the Internet skills of the population (M7)

We suggest assessing collectively the relevance of measures aiming at increasing the Internet skills of the Macedonian population such as:

- ensuring everyone has the opportunities, skills and knowledge to use online services. This could involve support to ICT training and education, both in schools and for adults
- setting up public access points to information, for people disadvantaged geographically, in weak economic conditions, with low digital skills, with low infrastructures.

Though it is not easy to quantify the impact of such measures, we believe they could have an actual impact on the share of people having medium or high Internet skills, which is one of the econometric drivers we used to assess future demand for broadband services.

We assumed that such measures would increase the share of Macedonian people having medium or high Internet skills by 15% in the medium term, which would increase from 44% in 2014 to 61% and 71% in 2019 and 2023 respectively, against 54% and 62% in 2019 and 2023 respectively in the base case.

In our econometric analysis, such a reduction translates into circa 30 000 additional high-speed broadband subscribers in 2023, as well as 5000 additional broadband subscribers and 25 000 additional mobile broadband subscribers.

The following figures present the results of our analysis in the base case and when testing the impact of this measure.

Figure 6.10: Penetration premium of fixed broadband, high-speed fixed broadband and mobile broadband compared to base case when assessing the impact of measures increasing the Internet skills of the population [Source: Analysys Mason, 2015]

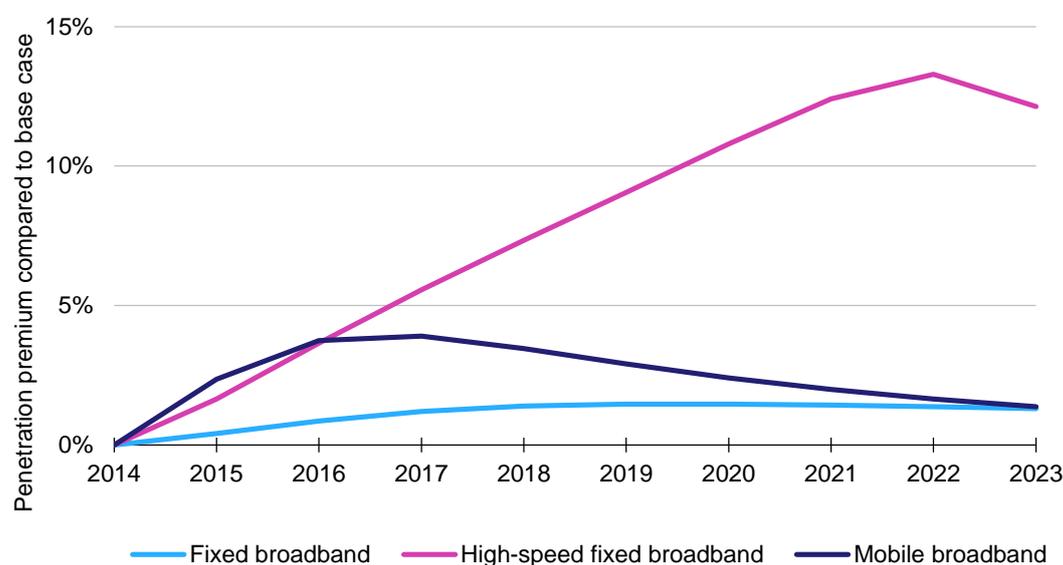


Figure 6.11: Key results of our analysis in the base case and when assessing the impact of measures increasing the Internet skills of the population [Source: Analysys Mason, 2015]

	2019 With measure	2019 Base case	2019 evolution	2023 With measure	2023 Base case	2023 evolution
Fixed broadband subscribers / penetration	445 476 / 69%	439 036 / 68%	1.5%	501 750 / 77%	495 266 / 76%	1.3%
High-speed fixed broadband subscribers / penetration	87 049 / 14%	79 823 / 12%	9.1%	260 446 / 40%	232 253 / 36%	12.1%
High-speed fixed broadband coverage	47%	47%	–%	58%	58%	–%
Mobile broadband subscribers / penetration	1 843 349 / 89%	1 791 370 / 87%	2.9%	1 961 695 / 95%	1 935 124 / 94%	1.4%

6.2.8 Providing subsidies or social tariffs to low-income citizens (M8)

In some European countries, universal services requirements mandate a designated operator to provide (at its own costs provided they remain “reasonable”) discounted tariffs for fixed telephony or fixed broadband services to citizens that are in a difficult financial situations (e.g. benefitting from minimal revenue allowance from the State). A government could also decide to directly provide subsidies for broadband access to citizens in a difficult financial situation.

This measure implicitly recognises the importance of telecoms services for citizens and ensures that the largest possible share of the population can benefit from these services by making them more affordable to people.

In our modelling, we assumed this measure would affect the following drivers:

- the share of the population being eligible to a discount varies at a regional level depending on regional GDP per capita compared to the national level (between 5% of eligible subscribers in the regions with the highest GDP per capita up to 30% eligible subscribers in the regions with the lowest GDP per capita)
- at a national level, this translates into 13% of the population being eligible to a discount
- therefore we assumed that 13% of fixed broadband and high-speed fixed broadband users would be granted a 40% discount on their connection (using ARPU as a proxy).

In our econometric analysis, this decrease in ARPU mostly affects the high-speed broadband market, and results in a 10 000 subscriber increase. The impact over the fixed broadband market is very limited as fixed broadband penetration is close to saturation and the remaining people who are not using broadband have no interest in Internet or lack adequate skills to use Internet. However, people who have an interest in broadband would shift from basic fixed broadband offers to high-speed fixed broadband offers if prices become more affordable.

The following figures present the results of our analysis in the base case and when testing the impact of this measure.

Figure 6.12: Penetration premium of fixed broadband, fixed high speed broadband and mobile broadband compared to base case when assessing the impact of providing subsidies or social tariffs [Source: Analysys Mason, 2015]

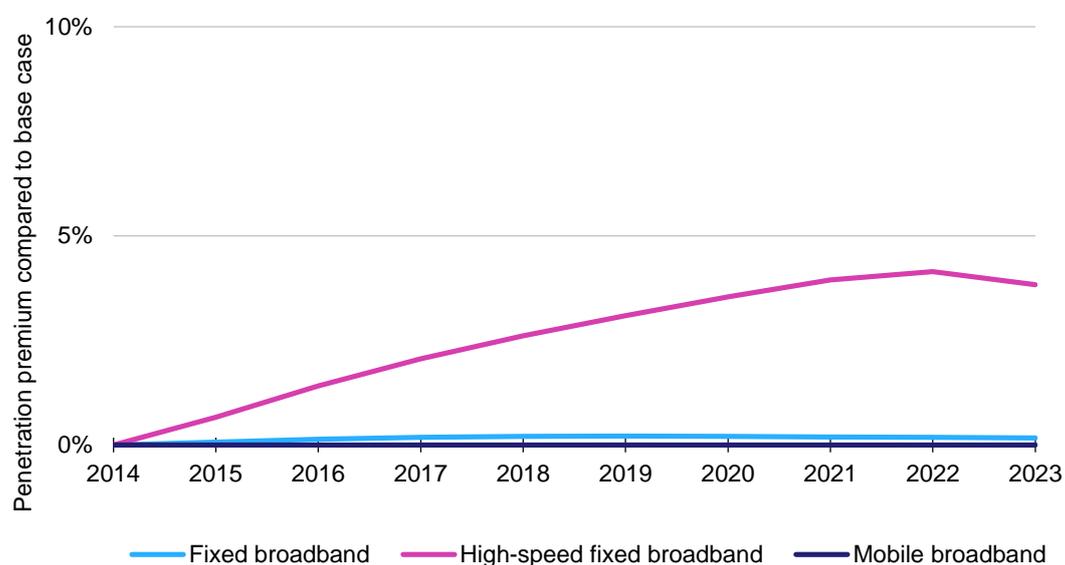


Figure 6.13: Key results of our analysis in the base case and when assessing the impact of providing subsidies or social tariffs [Source: Analysys Mason, 2015]

	2019 With measure	2019 Base case	2019 evolution	2023 With measure	2023 Base case	2023 evolution
Fixed broadband subscribers / penetration	439 973 / 69%	439 036 / 68%	0.2%	496 078 / 76%	495 266 / 76%	0.2%
High-speed fixed broadband subscribers / penetration	82 290 / 13%	79 823 / 12%	3.1%	241 149 / 37%	232 253 / 36%	3.8%
High-speed fixed broadband coverage	47%	47%	–%	58%	58%	–%
Mobile broadband subscribers / penetration	1 791 370 / 87%	1 791 370 / 87%	–%	1 935 124 / 94%	1 935 124 / 94%	–%

6.2.9 Cutting VAT for services in the ICT sector (M9)

We assessed the impact that a reduction of the ICT sector's VAT rate would have on demand for broadband services in Macedonia.

We assumed a reduced VAT of 5% for all telecoms service, against 18% currently. This would translate into a reduction of 11% in retail prices, which we modelled as a similar reduction in ARPU in our demand-side econometric analysis (though in effect the ARPU would remain the same as it excludes VAT).

In our econometric analysis, such an ARPU reduction translates into circa 20 000 additional high-speed broadband subscribers in 2023, as well as 2000 additional broadband subscribers and 10 000 additional mobile broadband subscribers.

The following figures present the results of our analysis in the base case and when testing the impact of this measure.

Figure 6.14: Penetration premium of fixed broadband, fixed high speed broadband and mobile broadband compared to base case when assessing the impact of cutting VAT for services in the ICT sector [Source: Analysys Mason, 2015]

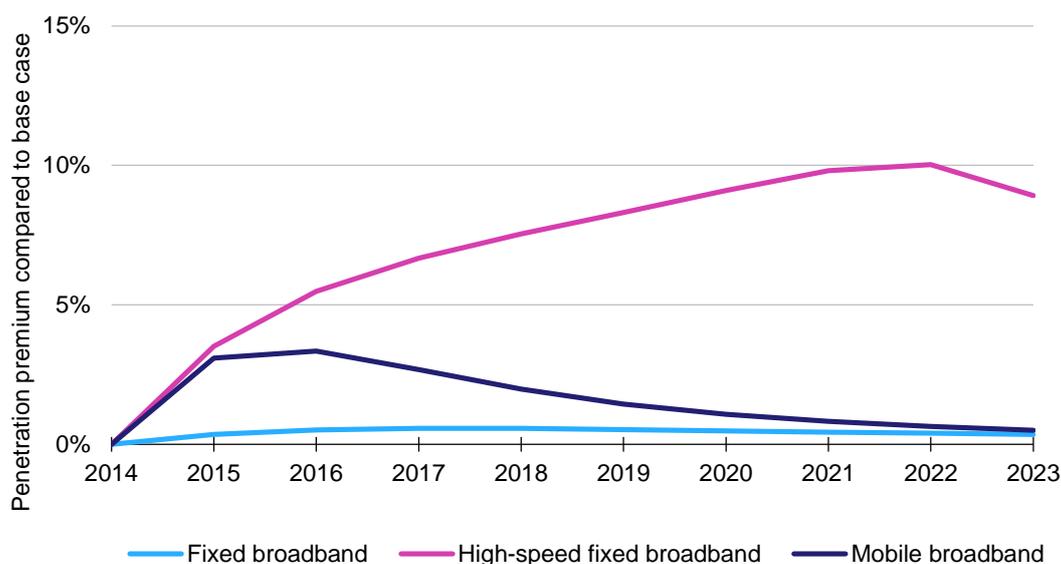


Figure 6.15: Key results of our analysis in the base case and when assessing the impact of cutting VAT for services in the ICT sector [Source: Analysys Mason, 2015]

	2019 With measure	2019 Base case	2019 evolution	2023 With measure	2023 Base case	2023 evolution
Fixed broadband subscribers / penetration	441 364 / 69%	439 036 / 68%	0.5%	497 035 / 76%	495 266 / 76%	0.4%
High-speed fixed broadband subscribers / penetration	86 458 / 13%	79 823 / 12%	8.3%	252 968 / 39%	232 253 / 36%	8.9%
High-speed fixed broadband coverage	47%	47%	–%	58%	58%	–%
Mobile broadband subscribers / penetration	1 817 275 / 88%	1 791 370 / 87%	1.4%	1 944 768 / 94%	1 935 124 / 94%	0.5%

6.3 Likely impact of measures and potential difficulties in implementing them

We summarise below the main measures we have identified, and whose impact on the development of the broadband market and high-speed broadband market we have assessed:

- M1: Mobile network **sharing**
- M2: **Access** to non-telecom infrastructure
- M3: **Spectrum** assignment
- M4: **Coverage** obligation
- M5: Mandating wholesale NGN access at sustainable **price**
- M6: Measures increasing the number of Internet **users** such as public campaigns to promote digital economy and supporting the creation of digital content of high value
- M7: Measures increasing the Internet **skills** of the population such as ensure everyone have opportunities, skills and knowledge to use online services and setting up public access points to information regarding use of digital services
- M8: Providing subsidies or **social tariffs** to low-income citizens
- M9: Cutting **VAT** for services in the ICT sector

We provide below a high-level classification of our suggested main recommendations in terms of:

- likely impact on market development
- difficulty of implementation, in terms of cost, timescale, legal complexity or political implication and likelihood of success.

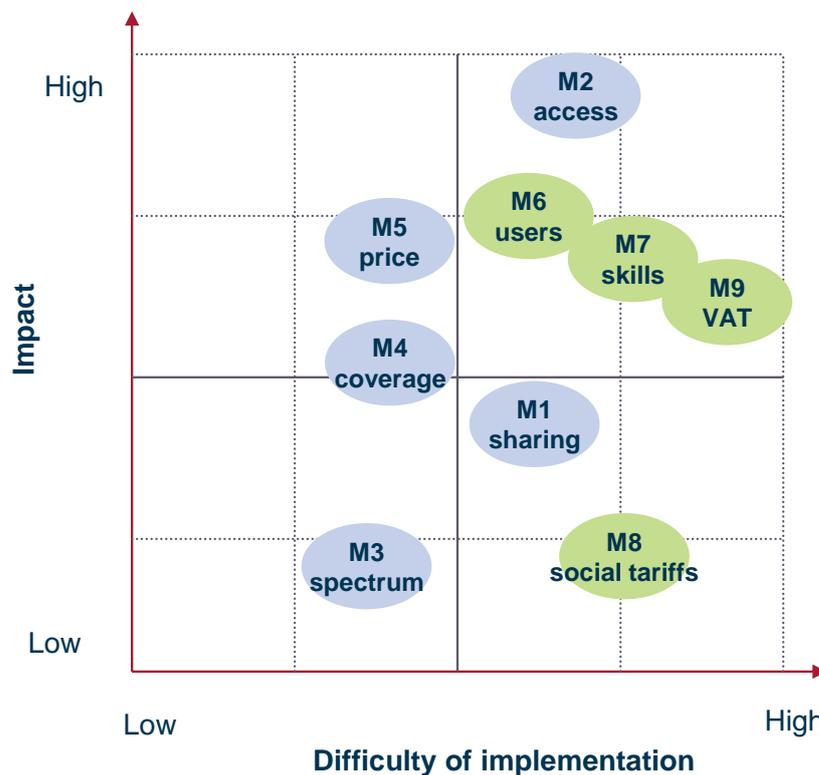


Figure 6.16: High-level classification of suggested measures by impact on future market development and difficulty of implementation²⁶
[Source: Analysys Mason, 2015]

The classification provided is aimed at defining intervention priorities.

Recommendations with highest impact and lowest difficulty of implementation: quick wins with highest priority

- **M5** (mandating wholesale NGN access at sustainable price): this measure should have an important impact on take-up of high-speed broadband services as it would result in the possibility of alternative operators competing with the operator deploying its own infrastructure. Therefore, this measure will stimulate competition in the high-speed broadband market. In addition, this measure is in line with the AEC objectives and work undertaken for mandating wholesale NGN access and therefore could be implemented in the short term.
- **M4** (coverage obligations): this measure is easy to implement as it requires adding coverage obligations to the next spectrum award for mobile services. This measure may not have a sizable impact on take-up of high-speed broadband services but will ensure that the whole of the Macedonian population is covered by at least one high-speed broadband network. Furthermore, some of the existing mobile operators are willing to cover close to 100% of the population with LTE technology.

²⁶ Supply-side measures are displayed in blue and demand-side measures in green.

Recommendations with highest impact and highest difficulty of implementation: long-term actions with high priority

- **M2** (access to non-telecoms infrastructure): this measure can have a significant impact on take-up of high-speed broadband services as it would reduce the costs of rolling out fibre to the premises. However, this measure would be difficult to implement in practice as it needs some collaboration among, and goodwill from, players outside the telecoms sector. Considered as best practice, this measure is implemented in many European countries and is also suggested by the EC.
- **M6** (measures increasing the number of Internet users): this measure has an important impact on take-up of high-speed broadband services through educating people to the benefits of using the Internet (in general) and high-speed broadband (in particular). This could be achieved through marketing campaigns and may take some time in practice to achieve results but is important for the long-term evolution of the market.
- **M7** (measures increasing the Internet skills of the population): this measure also has an important impact on take-up of high-speed broadband services. This could be achieved through the provision of training in schools and for the elderly. It may take some time in practice to achieve results but is an important measure for the long-term evolution of the market.
- **M9** (cutting VAT for services in the ICT sector): this measure also has a positive impact on take-up of high-speed broadband services. However, it can be complex to implement in practice as it will affect the government's revenues, which may then want to identify alternative sources of revenue to compensate for this reduction in income.

Recommendations with lowest impact and lowest difficulty of implementation: quick wins with lower priority

- **M3** (spectrum assignment): this measure should be rather easy to implement with the attribution of additional spectrum bands to mobile services, in line with the EC's objectives. Even if the impact of this measure is not perceived in the short to medium term due to rather low data traffic usage, it may become important in the medium to long term with the proliferation of smartphones and local content, which would drive traffic usage upwards.

Recommendations with lowest impact and highest difficulty of implementation: long-term actions with lowest priority

- **M1** (Mobile network sharing): the impact of this measure is relatively modest as mobile operators have already a mobile network covering more than 99% of the population and have been awarded lower frequencies (i.e. 800MHz) to roll out their LTE networks. This measure would lead to more cost reduction for operators (not necessarily passed on to end users). Furthermore, the implementation of such a measure is not straightforward and can be based on commercial agreements rather than regulatory obligations.
- **M8** (providing subsidies or social tariffs to low-income citizens): this measure also has a modest impact. The implementation of this measure can be complex and requires an identification of the entity (or entities) that should bear the cost of providing these social tariffs.

Annex A DAE and national broadband plan targets

In May 2010, the European Commission (EC) published its *Digital Agenda for Europe* (DAE), which aims to “*help Europe’s citizens and businesses to get the most out of digital technologies*”.²⁷ The DAE is one of seven major initiatives under Europe 2020, ‘*the EU’s strategy to deliver smart, sustainable and inclusive growth*’.

The DAE contains 101 actions, grouped around seven priority areas, each covering a different approach to support the development of the digital economy:

- EU as a digital single market
- interoperability and standards
- trust and security
- high-speed and ultra-high-speed Internet access
- research and innovation
- enhancing digital literacy, skills and inclusions
- ICT-enabled benefits for EU society.

The DAE sets out detailed guidelines for broadband, though Member States are ultimately responsible for the implementation of measures at a national level. Consequently, most European countries have a national broadband plan in place that defines specific goals and the different policy instruments required to reach them. Through its Digital Agenda Scorecard, the EC assesses the progress of each country with respect to the targets set in the DAE.

The DAE also contains 13 specific goals representing some of the aspects that a regulator should monitor to ensure that national targets are met. Progress against these targets is also measured in the Digital Agenda Scoreboard. These include:

- broadband coverage (with targets defined for 2013 and 2020)
- broadband take-up
- use of Internet across society (including by disadvantaged/elderly people)
- e-commerce
- e-government
- cross-border communications (lowering roaming charges).

²⁷ See <http://ec.europa.eu/digital-agenda/en/digital-agenda-europe>

Figure A.1 below shows the main targets covering broadband roll-out as defined in the DAE, as well as the progress achieved at EU level since the publication of the DAE. These targets include:

- broadband coverage for all – ubiquitous broadband coverage by 2013
- high-speed broadband coverage for all – 100% coverage at speeds above 30Mbit/s by 2020
- take-up of high-speed broadband – 50% of European households with a broadband subscription above 100Mbit/s by 2020
- population using Internet – 75% of population using Internet regularly by 2015.

Figure A.1: DAE targets and progress against these targets at an EU level [Source: EC, Digital Agenda Scoreboard 2014]



As regard development of broadband and high-speed broadband infrastructure, all countries have not reached similar coverage in 2013 as shown in Figure A.2 for terrestrial fixed broadband coverage and in Figure A.3 for terrestrial mobile broadband coverage.

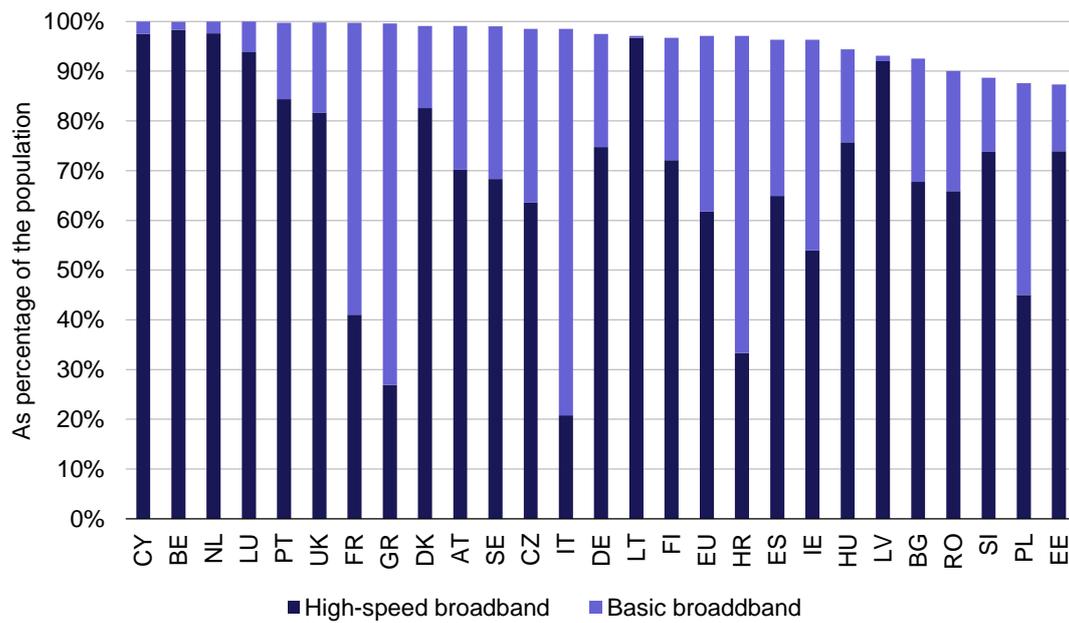
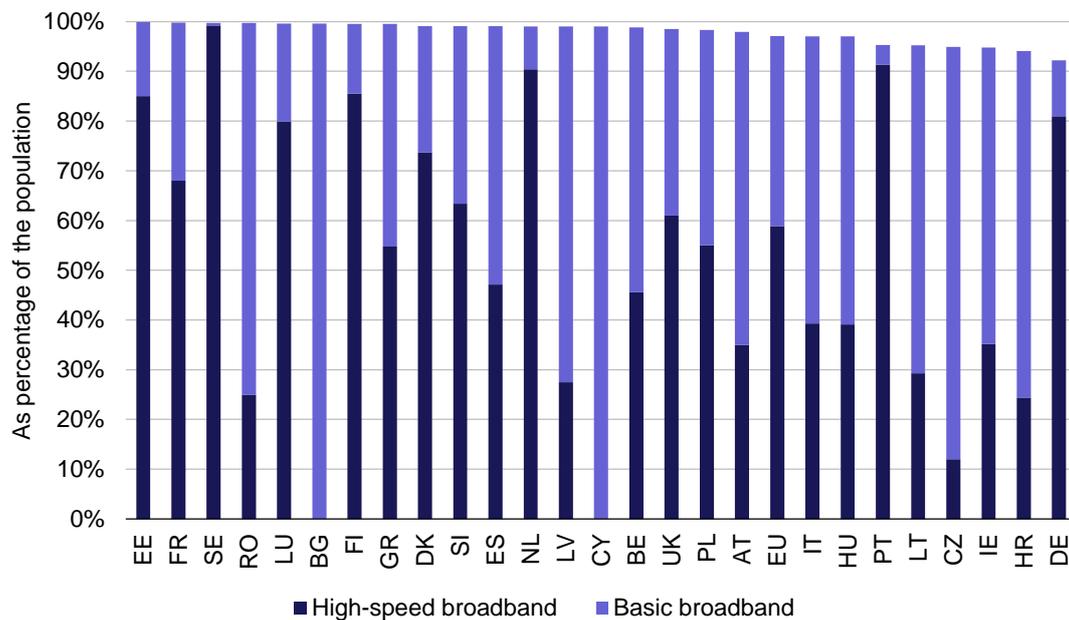
Figure A.2: Fixed broadband coverage in EU countries, 2013 [Source: EC's 18th implementation report, 2014]Figure A.3: Mobile broadband coverage in EU countries, 2013 [Source: EC's 18th implementation report, 2014]

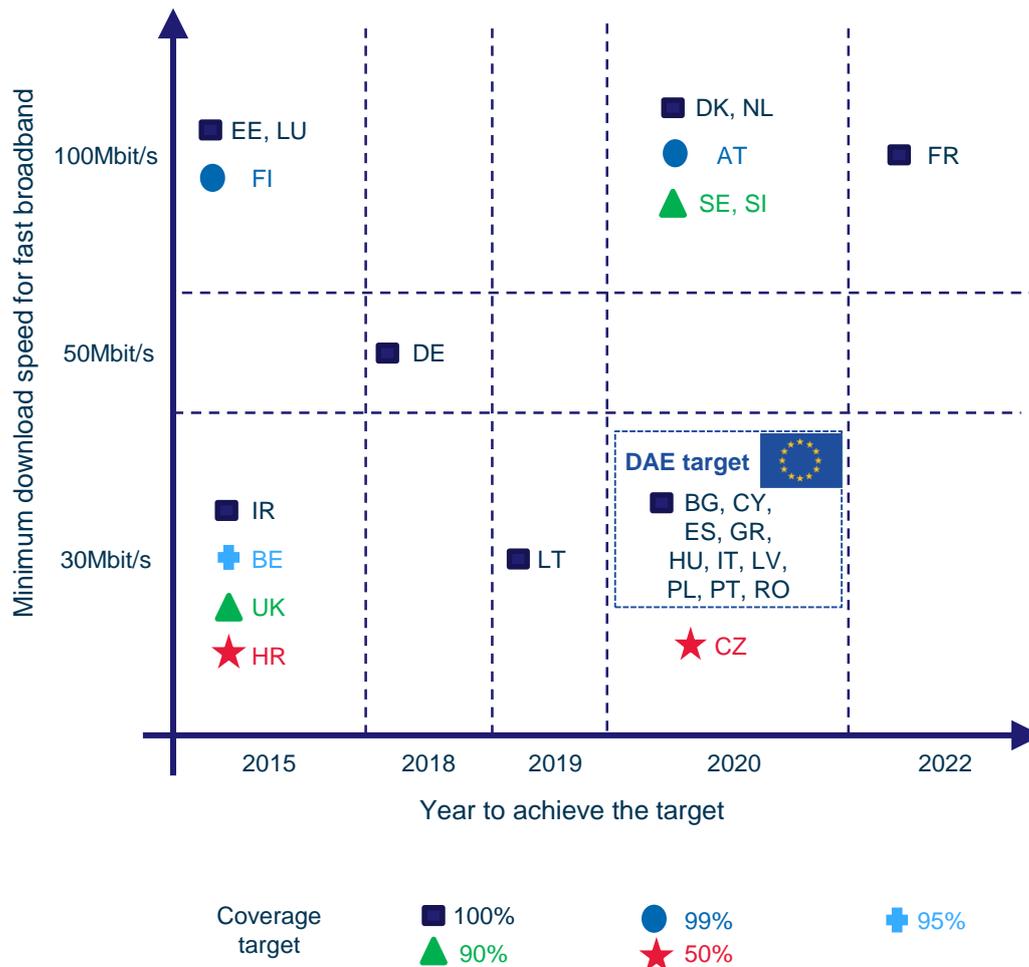
Figure A.4 below compares the targets for high-speed broadband as defined in the national broadband plans of the EU-27 countries surveyed:

- 19 countries defined a target of 100% coverage for high-speed broadband, while 2 countries (Austria and Finland) defined a target of 99% coverage
- 8 countries defined high-speed broadband as connections of between 50 and 100Mbit/s

- 4 countries defined a target coverage for high-speed broadband between 90% and 95% of households (two at 100Mbit/s, two at 30Mbit/s)
- 2 Eastern European countries set a target of 50% household coverage, at a minimum speed of 30Mbit/s.

Regarding the date by which the set target is to be reached, 17 countries set it at 2020, 7 countries at 2015 (well before the DAE target) and 3 countries set it respectively at 2018, 2019 and 2022.

Figure A.4: National targets for high-speed broadband in Europe [Source: Analysys Mason, 2015]



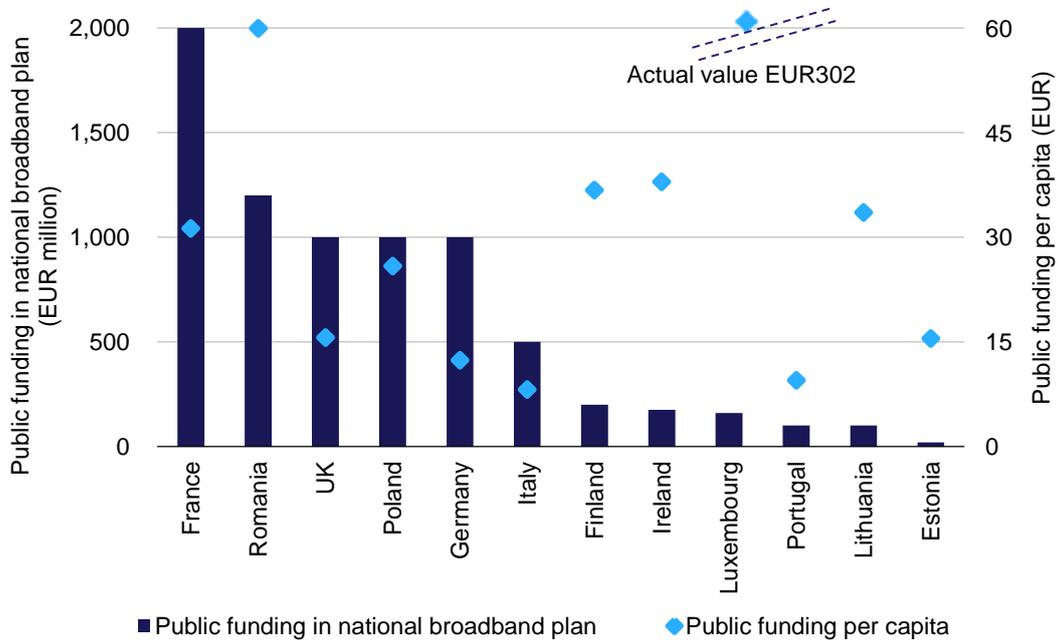
Regarding the target that 50% or more of European households should have broadband subscriptions above 100Mbit/s by 2020, 10 of the study countries have implemented this target in their national broadband plans (mostly Eastern European or Baltic countries), while the remaining 17 countries have not included a take-up target in their plans.

In most countries, reaching ubiquitous or near-ubiquitous coverage of high-speed broadband is likely to require public funding, as the high costs of rolling out broadband infrastructure threatens the economic viability of high-speed broadband in low-density areas.

The EU has set aside a budget to accelerate the roll-out of broadband networks in low-density areas across Member States. In addition, many governments have set funds aside to support network roll-outs in low-density areas.

Figure A.5 below shows the level of public funding for the roll-out of broadband announced in some of the national broadband plans analysed. National funding is mostly distributed between EUR10 and EUR40 per capita, with larger European countries planning to spend EUR1 billion or more on high-speed broadband roll-outs. It should be noted that public funding at other levels (e.g. from local/regional authorities) is likely to also be available in most of these countries, and that EU countries that are not referenced here might have some form of public funding for broadband, though it was not explicitly mentioned in their national broadband plan.

Figure A.5: Public funding for network roll-outs as set out in national broadband plans [Source: National broadband plans, Analysys Mason, 2015]



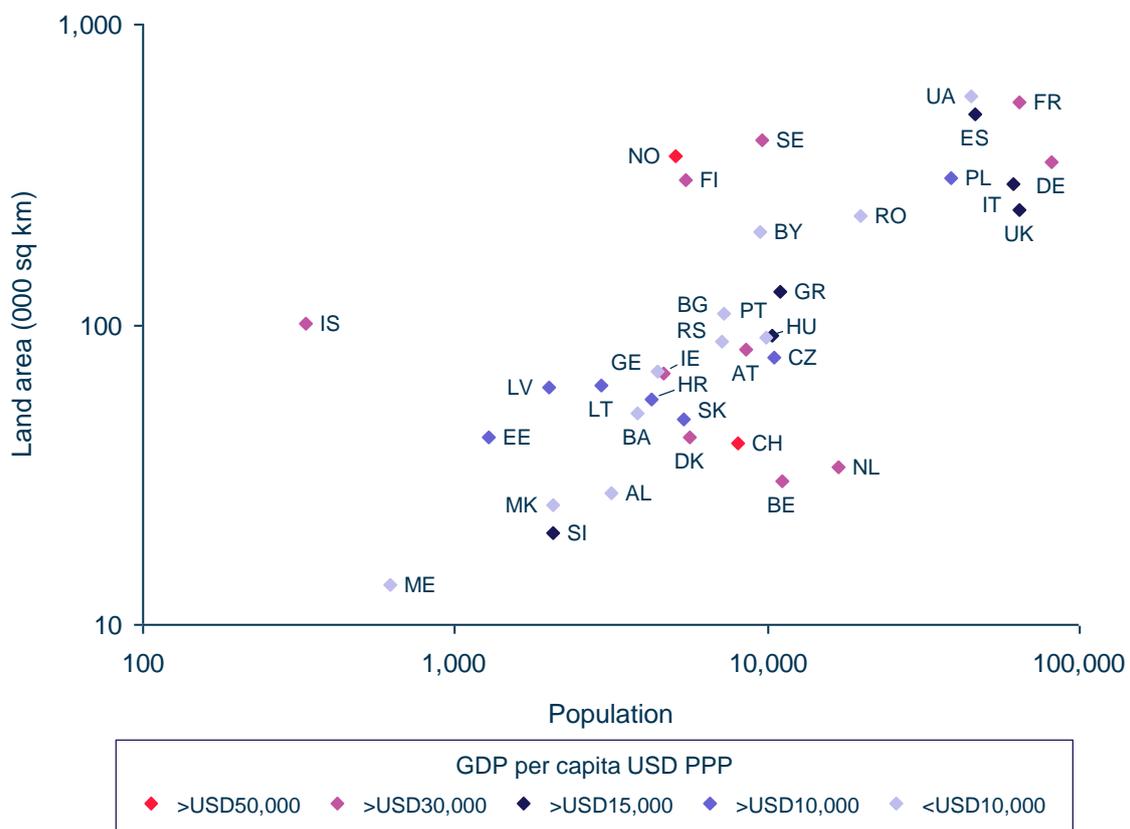
Annex B List of benchmarked countries

This annex outlines the methodology we have used to identify the relevant 18 countries to benchmark against Macedonia.

We have only included European countries in our benchmark as they provide enough relevant reference points within the DAE framework that Macedonia intends to follow.

As presented in Figure B.1, European countries were sorted according to area, 2013 population and 2013 GDP per capita at purchasing power parity (PPP).

Figure B.1: Distribution of European countries by population, land area and GDP per capita [Source: Analysys Mason, Euromonitor, 2015]



Macedonia is at the lower end of the benchmark for the three indicators considered, but a significant number of countries can nonetheless provide a relevant comparison. We therefore decided to include the following countries in the benchmark:

- countries with a population comprised between half that of Macedonia and six times that of Macedonia (i.e. between 1 million and 12 million inhabitants)
- countries with a minimum GDP per capita between USD7500 and USD44 000 at PPP (2 to 12 times that of Macedonia)
- countries no smaller than half of Macedonia's land area and no larger than 10 times its land area (i.e. between 13 000 and 250 000 square kilometres).

These criteria allowed us to exclude countries that are orders of magnitude larger or richer than Macedonia, and therefore could not be compared with Macedonia (in particular, a very large country will have different dynamics for broadband deployment). A total of 14 European countries meet the aforementioned criteria and were therefore included in the benchmark:

- Western Europe – Denmark, Austria, Ireland, Belgium, Greece and Portugal
- Eastern Europe – Slovenia, Estonia, Czech Republic, Slovakia, Lithuania, Latvia, Croatia and Hungary.

In addition, we believed it would be interesting to add as reference point a few 'leading' countries in Europe in terms of broadband market evolution. For this reason, we also included four additional countries (France, Germany, the UK and Spain) within the list of benchmark countries.

Annex C Econometric analysis of broadband demand drivers

A key deliverable for the project are two forecasting tools that will allow the AEC to forecast, test and monitor the impact of the regulatory policies and measures on the demand for high-speed fixed broadband services and mobile broadband services. A description of these tools is provided in Section 3.2 of this report.

A common feature of these two forecasting tools is that an econometric analysis of a dataset that incorporates cross-sectional and time-series data from 29 countries was used to identify and quantify the impact of basic drivers on the demand for high-speed fixed broadband and mobile broadband services. This analysis is used to inform the choice of demand drivers that are incorporated into the forecasting model, and to quantify the impact of the demand drivers on the demand for broadband. The estimated values of these parameters are a crucial input to the forecasting tool.

An overview of the methodology employed and the output of the analysis are provided in this annex, including:

- a description of the panel data
- the general functional form of the estimated models
- the parameter estimates.

C.1 Panel dataset

The values of the parameters that populate the forecasting models described in Section 3.2 were estimated using an econometric analysis of a panel dataset comprising cross-sectional and time-series data from 29 countries. Annual data over the period 2006–2013 was used from the following countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the UK.

These countries were selected on the basis that they had a complete or nearly complete dataset for the demand drivers identified in Section 3.2. In addition, these countries were selected as they represent as diverse a group of countries that could be found for these drivers, particularly those drivers with the potential to be influenced by regulatory policies and measures. From the perspective of the econometric analysis, maintaining a diverse group of countries is important in order to allow the estimation process to distinguish the effect of different drivers on broadband penetration. Maintaining a diverse range of countries is also likely to improve the quality of the forecasts, as it increases the likelihood that economic, demographic and telecoms industry characteristics of Macedonia fall within the range of the countries included in the panel dataset.

The panel dataset also included annual time-series data, for each country, from 2006 to 2013. This information is crucial for modelling the dynamic, year-on-year change in the take-up of broadband.

There are some cases where the dataset is incomplete for a limited number of demand driver observations and for a limited number of countries. One way to address this issue is to exclude either the country or the demand driver from the panel dataset. However, taking this approach would result in wasting a much greater quantity of valuable data that would enhance the quality of the parameter estimates. In order to complete the dataset, the value of these missing observations were interpolated on a case-by-case basis from either the country's time-series data or cross-sectional data from other countries.²⁸

C.2 Econometric model specification

As noted above in Section 3.2.1, the logistic function forms the basis of the forecasting model. One reason for using the logistic function is that it provides a means of capping the demand for the particular broadband forecast within a realistic range determined by the constraints on demand, such as network coverage, the number of households or population size. These constraints on the demand for broadband are illustrated in Section 3.2 by the four indicative graphics of the logistic functions for *fixed broadband*, *high-speed fixed broadband*, *mobile* and *mobile broadband*.

The second reason for adopting the logistic function is that it models a dynamic process for the take-up of broadband. That is, as illustrated by the graphics in Section 3.2, following the launch of a broadband service, its take-up may be low as a small number of 'early adopters' acquire the service. Then, take-up increases and accelerates as the broadband service becomes popular and the majority of the consumers acquire the service. The take-up of the broadband service then slows as demand reaches market saturation, which may be determined by the population size or the number of households, and there are only a small number of 'laggards' left to acquire the service.

The third reason for using the logistic function is that it can easily be transformed into a logit function, which enables the parameter values to be estimated using econometric techniques.²⁹ That is, with the appropriate mathematical operation, the logistic function described in Section 3.2.1 can be transformed to:³⁰

$$\ln\left(\frac{P_i(x_1, x_2, \dots, x_N)}{1 - P_i(x_1, x_2, \dots, x_N)}\right) = a_i + b_1x_1 + b_2x_2 + \dots + b_kx_k + e_i$$

This function is called the 'logit' of $P_i(x_1, \dots, x_k)$, where $P_i(x_1, \dots, x_k)$ is the proportion of the population or number of households, depending on the broadband that is being analysed, that acquires broadband in country i . In other words, each country, signified by the variable i , can be thought of as having its own equation. The variables x_1, \dots, x_k represent the demand drivers in country i , and b_1 to b_k are the parameters that determine the size of the effect of the demand driver

²⁸ See Greene (1993, pp. 273-277) for a discussion on missing observations.

²⁹ For a description of logistic and logit functions and their use in econometrics, and technical issue, see Kennedy (2008, Chapter 16), Gujarati (1995, pp. 554-563), and Greene (1993, pp. 653-655).

³⁰ See Greene (1993, p. 654) for explanation of derivation.

on the logit. The term a_i is the regression equation intercept, which is the constant value for each country but is allowed to differ between countries. Furthermore, as we are modelling a stochastic data-generating process, e_i is the disturbance term that captures the effect of chance events on broadband penetration and errors in its measurement.

The objective of the econometric analysis is to estimate the parameter values for b_1 to b_k for each of the forecast modules discussed in Section 3.2: *fixed broadband*, *high-speed fixed broadband*, *mobile* and *mobile broadband*. The preceding equation illustrates that the ‘logit’ is a linear function of the demand drivers and disturbance terms. This in turn reduces the technical complexity of estimating the values of the parameters compared with the logistic function in Section 3.2.1.

Another feature of the model specification is that it takes into account the structure of the dataset, which pools cross-sectional and times-series data. As noted, the cross-section consists of 29 countries and the time-series consists of annual data from 2006 to 2013. A fixed-effects model specification is used to take account of differences between countries.³¹ In terms of the equation just described, where each of the 29 countries can be thought of as having its own equation, the fixed-effect model makes an allowance for the differences between each country by allowing the constant term a_i for each country’s equation to differ. The fixed-effects model also assumes that each demand driver parameter, b_1 to b_k , is the same value for each of the 29 countries. We exploit this in the design of the forecasting model for Macedonia by incorporating the parameter values b_1 to b_k which are estimated over the 29 countries included in the panel data set, but evaluating the value of the constant a_i separately for Macedonia within the forecasting model.

C.3 Econometric model estimation

Statistical techniques are used to estimate the value of the parameters. These techniques use formulas, which are called estimators, to estimate parameters for a given model specification and dataset. The aim is to use an estimator that will result in a parameter estimate that is notionally close to the ‘actual’ parameter value. Econometricians generally do not know the actual parameter values. If they did, then there would be no need to employ econometric techniques. Instead, an econometrician is guided by the statistical properties of the estimator to judge whether the estimates are likely to be close to the actual parameter values. This analysis takes into account the functional form of the model and the purpose of the modelling exercise, which in this case is to estimate parameters for a forecasting tool.

A commonly used estimator, which can be found on Excel, is the *ordinary least squares* (OLS) estimator. This estimator, however, is not appropriate for estimating the parameter for the logit, fixed-effects panel-data model that includes the previous year’s broadband penetration as a dependent variable, because:³²

³¹ See Greene (1993, pp. 466-469) for a discussion on fixed-effects models.

³² See Gujarati (1995, pp., 362-365, and 557)

- the model includes the dependent variable as a regressor (i.e. the previous year's penetration is one of the demand drivers)
- the country-wise cross-sections in the panel dataset means that the estimator needs to address the differences in variance in the disturbance terms (i.e. the variance the e_i) between countries, which is referred to as heteroskedasticity, and
- the logit model specification introduces heteroskedasticity, which is related to the number of sample observations.

As a result of these issues, OLS does not provide an unbiased estimate of the parameters, and it does not make efficient use of the available information.

In this case, a generalised least squared estimator (GLS) procedure, as opposed to the OLS, is used to estimate the parameter values.³³ The GLS procedure for estimating fixed-effects, panel data models provided in the econometrics package SHAZAM (Professional edition, 11.1.2) was used here.³⁴

C.3.1 Fixed broadband demand-driver parameter estimates

The fixed broadband model's estimate goodness-of-fit is:³⁵ $R^2=0.9982$. The goodness-of-fit is a summary measure of how well the model's predicted values of the dependent variable fit the observations.

The following table presents the parameter estimates for the fixed broadband demand drivers with their T-ratio ratios, which provides an indication of the statistical significance of the estimate values.

Figure C.1: Demand driver parameters for fixed broadband forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter estimates	T-ratio
Fixed broadband penetration in the previous year	2.1881	34.96
Fixed broadband ARPU	-0.0026455	-2.312
Fixed high-speed broadband ARPU	-0.00041488	-2.37
Proportion of households covered by a high-speed fixed broadband network	0.28015	7.588
Availability of high-speed fixed broadband networks	0.086332	4.921
Proportion of households that are urban	-8.8142	-2.791
Proportion of the population that is urban	9.8475	3.082
Population per household	0.92725	9.366
GDP per household	1.3211E-06	5.125
Consumer spending per household	0.000011431	5.217
Proportion of the population with medium or high Internet skills	0.35671	4.317
Proportion of the population that has never used the Internet	-0.48895	-3.89
Years since the introduction of LLU	0.014261	2.185

³³ See Greene (1993, p. 448).

³⁴ See Whistler, White, Bates, and Golding (2011, p. 302) for a description of the GLS procedure.

³⁵ The goodness-of-fit value is reported by SHAZAM using a method proposed by Buse (1973) in the case of Generalised Least Squares estimation.

The T-ratio is asymptotically, normally distributed. As the magnitude of all the T-ratios is greater than the standardised normal variate value of 1.96, then this indicates that the null hypothesis – that the parameter estimate equals zero – can be rejected, at the 5% confidence level, for all the estimates listed in the above table.

C.3.2 High-speed fixed broadband demand-driver parameter estimates

The high-speed fixed broadband model's estimate goodness-of-fit is.³⁶ $R^2=0.9711$. Figure C.2 presents the parameter estimates for the high-speed broadband demand drivers with their T-ratio ratios.

Figure C.2: Demand driver parameters for the high-speed fixed broadband forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter estimates	T-ratio
Fixed broadband penetration in the previous year	4.1339	22.06
Fixed broadband ARPU	-0.0063899	-1.147
High-speed fixed broadband ARPU	-0.0063899	5.351
Proportion of households covered by a high-speed fixed broadband network	0.20879	0.7753
Availability of high-speed fixed broadband networks	-2.5576	-4.405
Proportion of households that are urban	-15.895	-1.65
Proportion of the population that is urban	52.926	5.462
Population per household	4.1614E-06	1.324
GDP per household	0.000033949	2.384
Consumer spending per household	0.68444	1.712
Proportion of the population with medium or high Internet skills	-1.8833	-3.015
Proportion of the population that has never used the Internet	2.6506	1.769
Years since the introduction of LLU	-0.12218	-5.325

The T-ratio is asymptotically, normally distributed. As the magnitude of all the T-ratios is greater than the standardised normal variate value of 1.96, then this indicates that the null hypothesis – that the parameter estimate equals zero – can be rejected, at the 5% confidence level, for all the estimates listed in the above table, except for the: *proportion of households covered by a high-speed fixed broadband network; proportion of households that are urban; GDP per household; proportion of the population with medium or high Internet skills; and years since the introduction of LLU.*

³⁶ The goodness-of-fit value is reported by SHAZAM using a method proposed by Buse (1973) in the case of Generalised Least Squares estimation.

C.3.3 Mobile demand-driver parameter estimates

The mobile model's estimate goodness-of-fit is:³⁷ $R^2=0.9854$. Figure C.3 presents the parameter estimates for the mobile demand drivers with their T-ratio ratios.

Figure C.3: Demand driver parameters for the mobile forecast [Source: Analysys Mason, 2015]

Demand Drivers	Parameter estimates	T-ratio
Previous year's mobile penetration	3.0178	17.92
Mobile ARPU	-0.0066904	-3.286
Mobile broadband ARPU	0.00093377	1.72
Proportion of the population that is urban	0.56439	0.8745
GDP per capita	0.000001149	1.853
Consumer spending per capita	0.000024685	4.215

The T-ratio is asymptotically, normally distributed. As the magnitude of all the T-ratios is greater than the standardised normal variate value of 1.96, then this indicates that the null hypothesis – that the parameter estimate equals zero – can be rejected, at the 5% confidence level, for all the estimates listed in the above table, except for: *mobile broadband ARPU*; *proportion of the population that is urban*; and *GDP per capita*.

C.3.4 Mobile broadband demand-driver parameter estimates

The mobile broadband model's estimate goodness-of-fit is:³⁸ $R^2=0.9982$. Figure C.4 presents the parameter estimates for the mobile broadband demand drivers with their T-ratio ratios.

Figure C.4: Demand driver parameters for the mobile broadband forecast [Source: Analysys Mason, 2015]

Demand drivers	Parameter estimates	T-ratio
Previous year's mobile penetration	2.2183	23.54
Mobile ARPU	-0.043142	-7.163
Mobile broadband ARPU	-0.020584	-20.27
Proportion of the population that is urban	18.365	11.5
GDP per capita	9.9823E-06	9.513
Consumer spending per capita	0.000043985	4.083
Proportion of the population with medium or high Internet skills	2.2779	10.56
Proportion of the population that has never used the Internet	-1.2764	-4.034

³⁷ The goodness-of-fit value is reported by SHAZAM using a method proposed by Buse (1973) in the case of Generalised Least Squares estimation.

³⁸ *Ibid.*

The T-ratio is asymptotically, normally distributed. As the magnitude of all the parameter T-ratios is greater than the standardised normal variate value of 1.96, then this indicates that the null hypothesis – that the parameter estimate equals zero – can be rejected, at the 5% confidence level, for all the estimates listed in the above table.

C.4 References

This section includes a list of the econometric studies on broadband penetration that we have reviewed in developing the econometric analysis:

- Buse, A. (1973), ‘Goodness of Fit in Generalised Least Squares Estimation’, *American Statistician*, 27, 106–8.
- Greene, W. H. (1993), *Econometric Analysis* (2nd edition.). New York: Macmillan Publishing Company.
- Gujarati, D. N. (1995), *Basic Economics* (3rd edition). New York: McGraw-Hill, Inc.
- Kennedy, P. (2008), *A Guide to Econometrics* (6th edition.). Oxford: Blackwell Publishing.
- Whistler, D., White, K., Bates, D. and Golding, M. (2011), *SHAZAM Reference Manual Version 11*. Cambridge, England: SHAZAM Analytics, Ltd.

Annex D Country acronyms

The table below includes a list of two-letter alphabetic codes for the representation of names of countries used in the main body of this report.

Figure D.1: List of ISO 3166-1 country codes [Source: International Organization for Standardization (ISO), 2015]

ISO two-digit code	Country
AL	Albania
AT	Austria
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GE	Georgia
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
LT	Lithuania
LV	Latvia
ME	Montenegro
MK	Macedonia, FYR
MT	Malta
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russia
SE	Sweden

ISO two-digit code	Country
SI	Slovenia
SK	Slovakia
TR	Turkey
UA	Ukraine
UK	United Kingdom

Annex E Glossary of terms

ADSL	Asymmetric digital subscriber line
AEC	Agency for Electronic Communications
AL	Albania
ARPU	Average revenue per user
AT	Austria
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BT	British Telecom
BY	Belarus
CAGR	Compound annual growth rate
CDMA	Code division multiple access
CH	Switzerland
CMTS	Cable Modem Termination System
CPE	Customer premises equipment
CZ	Czech Republic
DAE	Digital Agenda for Europe
DE	Germany
DK	Denmark
DOCSIS	Data over cable service interface specification
DSL	Digital subscriber line
EC	European Commission
EE	Estonia
EIU	Economist Intelligence Unit
ES	Spain
EU	European Union
EX	Exchange
FI	Finland
FR	France
FTTB	Fibre to the building
FTTC	Fibre to the cabinet
FTHH	Fibre to the home
FWA	Fixed wireless access

GDP	Gross domestic product
GE	Georgia
GLS	Generalised least squared estimator
GNI	Gross national income
GPON	Gigabit passive optical network
GR	Greece
HDI	Human development index
HFC	Hybrid fibre coaxial
HR	Croatia
HSPA	High-speed packet access
HU	Hungary
ICT	Information and communications technology
IE	Ireland
IP	Internet protocol
IPTV	Internet protocol television
IS	Iceland
ISO	International Organization for Standardization
IT	Italy
ITU	International Telecommunication Union
LAN	Local area network
LCU	Local currency unit
LLU	Local loop unbundling
LRIC	Long-run incremental cost
LT	Lithuania
LTE	Long Term Evolution
LV	Latvia
MB	Megabit
ME	Montenegro
MK	Macedonia, FYR
MKD	Macedonian Denar
MNO	Mobile network operator
MT	Malta
MVNO	Mobile virtual network operator
NGN	Next-generation network
NL	Netherlands
NO	Norway

NPV	Net present value
NRA	National regulatory authority
ODF	Optical distribution frame
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary least squares
OLT	Optical line termination
OTT	Over the air
PC	Personal computer
PL	Poland
PPP	Purchasing power parity
PSTN	Public switched telephone network
PT	Portugal
RO	Romania
RS	Serbia
RU	Russia
SE	Sweden
SI	Slovenia
SK	Slovakia
SMP	Significant market power
SP	splitter site
TR	Turkey
TV	Television
UA	Ukraine
UMTS	Universal mobile telecommunications service
USO	Universal service obligation
VAT	Value-added tax
VDSL	Very-high-bit-rate digital subscriber line
VoIP	Voice over Internet protocol
WTI	World Telecommunication Indicators