Converged Heterogeneous Advanced 5G Cloud-RAN Architecture for Intelligent and Secure Media Access

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Deliverable leader: APFutura

Editors list: Enrique García (APFUT)

Oriol Riba (APFUT)

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List of Contributors

Participant	Short Name	Contributor
i2CAT Fundació	I2CAT	Shuaib Siddiqui
APFutura	APFUT	Enrique García, Oriol Riba
Innoroute	INNO	Andreas Foglar
InCites	INCI	Theodoros Rokkas, Ioannis Neokosmidis
JCP-Connect	JCP-C	Yaning Liu, Dessy Yankova
University of Essex	UE	Geza Koczian, Mike Parker
Cosmote	COSMO	Costas FilisGeorgios Lyberopoulos. Eleni Theodoropoulou, Ioanna Mesogiti, Konstantinos Filis
Intracom Telecom	ICOM	Konstantinos Katsaros
Telekom Slovenije	TS	Pavel Kralj
Ethernity	ETHER	Eugene Zetserov

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Executive Summary

This deliverable D5.5 “Business model analysis” provides a 5G business modelling analysis for future 5G deployment, based on the technical features of the CHARISMA architecture. A successful business plan is also predicated on suitable market conditions, and an Appendix is also supplied offering a market analysis for five different EU countries, revealing the deployed infrastructures in each country, the penetration of LTE connections, and showing that the people in those five countries have more facilities to access to a mobile connection than just a NGA connection.

A sound business model will assist telecommunications operators in their decisions to invest in the creation of new infrastructure to support their customers’ needs and aspirations. In this context, CHARISMA proposes the evolution of the existing business models in both retail and wholesale offering, to create new 5G opportunities without a negative impact on existing network architecture. The business model analysis focuses on the three features in which CHARISMA was been specially designed to promote: Low Latency, Security and Open Access, which together will enable the emergence of new 5G business models and commercial opportunities.

The Open Access concept for infrastructure sharing allows infrastructure owners to dynamically share their resources (virtual and physical) in an isolated way, among several network operators to offer different services to their customers.

Low Latency improves both end-to-end connectivity performance as well caching download speed. Here, caching opens an entirely new space of 5G business opportunities for both operators and content and service providers.

Regarding Security, CHARISMA implements a holistic management platform, combining cloud, network slicing, SDN and NFV technologies while focusing on the delivering end-to-end security across all layers of the converged and virtualised open access network.

1. Introduction

This deliverable D5.5 provides the analysis of the 5G Business Model exploiting the technical benefits that the CHARISMA project is expected to provide. This document complements the information already provided in the deliverable D5.4 (Roadmapping to CHARISMA and 5G networking) and to be provided in the deliverable D5.6 (Techno-economic analysis report). Any 5G Business Model must also be created within the context of a European market analysis, and that is also discussed within this report as an Appendix, in order to create a holistic vision of a future evolution of telecommunications in Europe, and how 5G and the CHARISMA project can fit into this new environment.

This document provides a 5G business model point of view on the basis of the actual environment and the infrastructures deployed in different European countries. It also describes the progress in the deployment of broadband connectivity and how the market has been growing in recent years according to the availability of new services and the emerging needs and expectations of end users, beginning from the initial DSL connections up to the advent of NGA connections.

The deliverable D5.5 is organised as follows. After some short remarks in the chapter 1, we continue with the chapter 2 that provides an overview of the potential innovative business models in 5G, focusing in the three features in which CHARISMA was been specially designed to promote: Low Latency, Security and Open Access. The low latency aspects will provide and improve in the QoE for customers and including the benefits of using vCPE (virtualised customer premises equipment). In this case, using a vCPE simplifies the actual complex environment in which all the IT admins and network engineers are involved, allowing the management of the WAN and its services using a self-service portal. Security is also one of the major objectives of the CHARISMA project, and is implemented via a holistic management platform focused on delivering end-to-end security across all layers of the converged and virtualised open access 5G network. The open access concept in CHARISMA is extended to also meet the requirements of network slicing, allowing secure multi-tenancy operation. Chapter 3 presents a Business Modelling Methodology that includes the roles and relationships for the ecosystem of 5G networks, revenue streams and cost drivers, from the CHARISMA point of view. Chapter 4 provides an overview of the functionalities that CHARISMA is proposing in this new 5G business model such as vCache, vCPE, and multi-tenancy features. vCache peering is used as a network acceleration technique, storing copies of retrieved content with the purpose of serving them to users upon similar request, lowering the traffic in the network and achieving a low latency transmission. vCache can therefore be seen as a service (Caching-as-a-Service) opening the door to new business opportunities for content providers and even for operators. vCPE additionally allows service providers to apply the broader advantages of NFV to customer-facing deployments from the enterprise to the customer, including elastic, remote deployment, personalization, scalability and automated provision of services. Finally, multi-tenancy is seen as a technique that enables infrastructure providers to efficiently allocate network and infrastructure resources to other business customers such as MVNO, and smart grids, etc.

At the end of the document we have supplied an Appendix that covers an analysis review of the access (final-drop) market in five different European countries, focusing on the penetrations of the fixed and mobile communications, and the deployed infrastructure to achieve these penetrations. Portability, bundling of services, and the revenue by operators and by services are other important market information in this Appendix. All the information that appears in the Appendix come from different sources for each country; but most of them are from documents published by the European Commission and from other entities such a CNMC, and ARCEP, etc.

2. CHARISMA Business Model Innovation Analysis

The 5G CHARISMA architecture has the objectives to innovate along three major technical themes: i) Low latency; ii) Open access; and iii) Security. These have been researched and discussed in the more technical work packages of the CHARISMA project and reported in other technical deliverables from WP1, WP2 and WP3. However, apart from the scientific interest in pursuing such technology innovation, there is also the commercial interest that is driving these innovation directions. This is because there is the strong expectation that these particular innovations will also enable the emergence of new business models and commercial opportunities, as well as help deliver the more conventional CapEx, OpEx and TCO benefits expected from such an advanced 5G network architecture.

One of the key technology innovation drivers that is helping to push forward the development of 5G networking is the emergence of the intelligent transportation system (ITS) paradigm, e.g. as particularly associated with driverless (self-driving, automated) cars, as well as for trains, buses, and aviation, e.g. as being investigated in the H2020 project, Transforming Transport project [1]. ITS systems particularly rely on high-speed, ultra-high reliable and secure 5G digital connectivity [2], and a competitive and resource-efficient transport system, e.g. as outlined in the 2011 EU Transport whitepaper "Roadmap to a Single European Transport area" [3]. A critical aspect to such ITS infrastructure is the low-latency operation of the network, both for end-to-end connectivities, e.g. as required for sensor data to and from the moving automated vehicle to fixed cloud-based infrastructures, and for real-time data gathering of the transport infrastructure, as well as application service initialisation times, e.g. for on-board passenger infotainment systems, as well as high-speed instantiation times for virtualised network functions (VNFs) in an increasingly softwarised telecommunications infrastructure.

To this end, key performance indicators (KPIs) have been defined within the 5G-PPP community [4] targeting 5 ms end-to-end latency times, and 10 ms instantiation times. One of the key objectives of CHARISMA is to create a 5G networking infrastructure based on both technology and architecture innovations to provide an ultra-low latency 5G technical solution suitable for future ITS applications. In this way, the CHARISMA architecture is expected to have important implications and impact for innovative 5G business models, which particularly rely on the high performance characteristics of low latency, open access, and security. Indeed, the final demonstrators being planned for the conclusion of the CHARISMA project are based on these performance objectives, and have been founded upon well-defined use case scenarios (i.e. public transportation, and high-speed video streaming; these use cases being outlined in greater detail in the CHARISMA deliverable D1.2) that are expected to impact greatly on new 5G-based business models and innovative commercial exploitation schemes.

In the following sections, we discuss in greater detail the individual implications of some of the key technical innovations being pursued in CHARISMA, and we describe some of the innovative services and new business opportunities that these are presenting.

2.1. 5G business model innovation potential

5G will deliver a factor 5-1000x improvement in the performance characteristics of networks where the division between fixed and mobile networks and services are integrated ever more tightly together. All of this factors, and several others, are creating and driving new business models for 5G

The actual business models do not always cover the need of the subscribers; this is being switched to new models, where subscribers are forcing the community to create infrastructure in order to support better services. In these models, the infrastructure build is being decoupled from service provisioning in an open network paradigm, and build-outs are focused on smaller geographical areas and rural areas with more favourable revenues and cost situations. Parts of this model shift might be applicable to 5G, since fibre and 5G are becoming more connected than any fixed and mobile generation in the past.

The broadband business model that has been driving fixed and mobile broadband networks investments has been centred around subscriber growth. In this context, the business model for the introduction of DSL/Cable was as an evolution of the dial-up model, with narrowband data subscribers converting to broadband, with web-based services acting as an additional engine to fuel growth. The business model for Mobile Broadband, introduced with the emergence of 3G, was to a large extent a replica of the earlier DSL/Cable model.

The success of broadband to date has been based on the services operating over the top of the broadband network – a world where best effort connectivity is sufficient to deliver services from cloud-based data centres to an app on the phone. Most app providers have been operating with a *freemium* model, where rapid growth of the free offering has been essential to drive advertising revenues, and then to convert a fraction of the free customers onto a premium offering.

The broadband business model has secured rapid growth over the last 20 years, with this model enabling both fixed and mobile broadband to reach the point of saturation in developed markets.

The mobile broadband market in developed markets is at (or is approaching) saturation, and is driven by the revenues from consumers or consumer-driven services offered to business. 5G is expected to expand the addressed market into B2B applications – a scenario where the 5G network will improve or rationalize existing business processes with a digital/networked alternative. The potential efficiency improvements for these B2B applications brings very different businesses into play. Some of these efficiency improvements can already be solved with 4G and can happen without requiring new business model innovations. But a larger number are expected to leverage the capabilities and characteristics of 5G via new business models.[5]

2.2. Expansion of platform-based business models

Platform-based business models already play a prominent role in the market today, with all ten of the largest Internet sites in the US built around platform-based business models. Businesses designed this way have significantly higher valuations than non-platform based businesses.

As we enter the 5G era, the number of industries and businesses designed around platform-based business models is growing quickly. The growth of platform-based business models and the strong connection to the mobile eco-system are likely to tie the two tighter together. Combining platform-based business models with the new network is a real possibility as networks become more agile and flexible, across all networking facets: all the way from capabilities, through to provisioning and billing options.

There are a larger number of capabilities in a 4G network that are combined in well-defined and rigid ways. The ability to leverage all these parts and combine them in new ways in the 5G context is an area now triggering interesting business model innovations.

2.3. New Business Models

It is an essential requirement that 5G provides a future-proof technology platform allowing the evolution of existing business models in both retail and wholesale offerings. Furthermore, it should open opportunities to create completely new business models without having a negative impact on existing network architectures.

For network operators, the capability to evolve and enable new business models should be supported in a cost-efficient manner, without having architectural impact. Using 5G networks, third party service providers should be able to offer their services in a very short time-to-market manner and based on mutual service level agreements, where the network will be delivering data using agreed network functions, capabilities and attributes.

5G need to be designed from the outset, such that the network operator is able to create a large variety of relationships between its network infrastructure and the customers/service providers. With respect to the business model in the 5G vision, the following requirements are formulated:

2.3.1. Transport Providers

The transport provider business model applies for both retail and wholesale commercial relations and offerings. It assumes that the customer and service provider are decoupled from the physical infrastructure and they are offered no configurability, and a very low level of configurability, respectively. The 5G system should enhance the efficiency of this model by enabling the operator to configure the data flow to use only the necessary functions in the network, on demand and in a programmable manner, to optimize operational and management costs. This requires a modular network architecture, having the capability to be exposed to the 5G provisioning/configuration system.

2.3.2. Service Provider and Network-as-a-Service Provider

Partner service provider and Network-as-a-Service provider models refer to the 5G high-level requirement to allow creation of different levels of relationship between operators and application/service providers.

Exploiting flexibility, 5G should be able to support different levels of abstraction and business models as known today (e.g., Infrastructure-as-a-Service, Platform-as-a-Service, Network-as-a-Service) as well as allowing the creation of completely new business models not foreseen at the time of writing this document. The key requirement is that Service providers should be able to configure and manage the service, while operators will have freedom to manage and evolve the network.

In this context, 5G should provide an abstraction layer as an interface, where all types of in-networking functionality (control plane and data plane related) can be exposed to the application layer functions and/or service providers based on a service level agreement. Application/Service provider will then be able to use a sub-set of the network capabilities in a flexible, configurable and programmable manner, and to use the network resources depending on their service preference.

These exposed in-networking capabilities or information may include charging capabilities, authentication, mobility, reliability functions, mobile user's footprints, etc. For example, a 3rd party application can be charged for its user's traffic instead of charging to its users; operators can provide (regularly or on-demand) to an intelligent traffic management application the number of UEs present in a certain area without violating a user's privacy. Some radio information can also be exposed, such as real-time loading, QoS, UE measurement report, mobility, signal strength, etc. Real-time QoS may, for example, allow video applications to adjust bit rates to improve the streaming experience.

2.3.3. Network Sharing Model

Network sharing business models involve a relationship between the service provider and the operator, and between operators, in which their respectively owned physical network infrastructures are tightly coupled. The 5G system should provide methods and instruments for various network sharing schemes developed to maximise the overall synergies of network sharing agreements and to enable flexible business models and commercial relationships that potentially may change rapidly. This should also apply to the current network sharing models. With 5G, it should be possible to provide sufficient flexibility to accommodate the capacity needs of dynamically hosted operators, on a real-time basis (e.g., for a capacity brokering architecture, where network resources are provided dynamically depending upon the bids offered).

Technical capabilities should include spectrum sharing or reuse, enhanced mobility techniques and enhanced controls for access network, access point, access node, and spectrum selection at an operator policy level.[6]

2.4. Implications of CHARISMA: Open access, security, low latency, caching.

2.4.1. Implications of Open Access:

The open access concept for infrastructure sharing has been around for quite some time now. CHARISMA 5G leverages on this concept and extends it to meet the network slicing requirements of a 5G network. This extension allows CHARISMA 5G to offer multi-tenancy. That is, it allows infrastructure owners to dynamically share (control, manage, orchestrate) their resources, virtual and physical, in an isolated manner, among several network operators to offer different customized services to their end customers. This environment opens new dimensions of business relations and opportunities between the infrastructure owner, the network operator and the service provider. Apart from the traditional infrastructure owner, network operator and service provider roles, CHARISMA 5G identifies new roles, business relations and opportunities in the 5G ecosystem.

The currency of shared resources among the multiple tenants (i.e., network operators) on the same infrastructure is called a *network slice*. CHARISMA 5G defines a network slice as a collection of, physical or virtual, network, compute and storage resources under the administration of a single domain. A network slice is completely isolated from other network slices that may belong to the same or another network operator. The dynamic provisioning of customized network slices not only contributes to the obvious OPEX and CAPEX gains, but also facilitates the rapid end-to-end service provisioning for a network operator.

A network slice can be tailored to yield optimum performance for a particular service. That is, a network slice can be customized to support a particular vertical and can be used by network operators to further optimize the offered service.

Thus, the implication of open access/multi-tenancy not only opens new faster business opportunities for traditional players, but also makes room for new ones detailed later in this section.

2.4.2. Caching in 5G

In the 5G paradigm, caching plays a significant role as it allows low latency delivery of content and it is an enabler of (mobile) edge computing. More than just improved efficiency and fast download speed, caching opens an entirely new space of business opportunities for both operators and content and service providers. We expect that both groups will enjoy new revenue streams while end-users will have a better

quality of experience (QoE). New paradigms such as Device-to-Device (D2D) caching are also offering a new twist to the more traditional concept of caching at the base station or edge level.

Major benefits of caching in 5G networks include:

- Optimization of bandwidth and improved management of network resources for operators;
- Secure and fast delivery of personalized content for content providers;
- Enablement of edge computing for service providers.

2.4.2.1. Content caching

Today the majority of users (mobile and fixed) have content-oriented usage of their connection means. In recent years more than 80% of mobile traffic comes from Over-the-Top (OTT) providers, such as Netflix, Youtube, Facebook etc. This highly personalized, secure and bandwidth hungry traffic has had a straining effect on operators. OTT providers have basically delivered their services to mobile users while leaving operators with the bill for accommodating this growing traffic.

The current business models in content delivery have been characterized by CDN networks and free installation of cache servers. CDN network provide a series of mirrors with global coverage to content providers. They are paid to ensure low latency. Since 2011 OTT providers like Google and Netflix have started to deploy edge servers for free in telecom operators' networks offering a comprise solution – they pay for servers (H/W and S/W) and remotely manage them. The telecom operators have in return provided Google and others with rack spaces, power and GE ports for free.

The 5G era offers a new set of possibilities in which operators have the chance to strengthen their position versus content providers. Possible business models include:

Freemium – the current symbiosis between network operators and OTT/content providers can continue by operators offering access to the 5G network to major OTT providers for free, as this can drive the faster adoption of 5G.

Paid access to network resources - Features such as tenancy, open access and slicing open new possibilities for operators and OTT providers. A new set of OTT/content providers can arise, fed by the existence of multiple VNOs. In a future when 5G connectivity is ubiquitous and relatively cheap, VNOs can assemble quickly needed resources and activate caching VNFs according to the needs of new OTT Service Providers, which can target their audience in a much more refined way.

CDN providers can also easily migrate into the position of content VNOs, managing the distribution and activation of caching resources.

An entirely new category of OTT content providers can appear, targeting specifically 5G mobile users. Using caching as a NVF, offers content providers the ability to use agile caching of personalized and secure content, which will be invisible to other content providers, keeping all sensitive data insulated from other participants.

The increased competition and potential entry of new players will make the "content delivery" space much more dynamic, while operators can keep the control and have a chance to increase their earnings rather than being largely sidestepped.

The pricing models for the use of NVFs as caching will be highly dependent on the overall pricing strategy of the network operator. Between the operator and provider of NVFs the pricing of caching will most likely be dependent upon:

- The number of activations of the NVF for a given period of time;
- The time the NVF is being used for content delivery – full-time use as in a home router or one time activation for an event;
- The capacity used, etc.

In the cases when caching is used as a shared resource in the network, the operator can charge the content provider by fixed price.

2.4.2.2. Edge computing

(Mobile) edge computing is another big trend largely driven by caching at the edge level, including D2D caching techniques. Beyond caching and streaming of content, a new set of context-aware, low latency and secure services are enabled by the use of caching in diverse areas such as health (medical data in hospitals), smart manufacturing, events, etc.

These market niches are relatively difficult to exploit by network operators today, as the ability to provide vertical specific services is a shared task between a fragmented set of actors. 5G architectures provide a platform bringing and streamlining these interactions. The "app store" model of picking NVFs and combining them into bundles enabling vertical specific services, offers to caching NVFs the ability to empower a large set of use cases.

Caching offers a simple, yet effective solution for operators and service providers to deliver content and enable new services in an optimized way and take advantage of new business opportunities.

2.4.3. Exploitation of hierarchical routing

The hierarchical routing proposed by InnoRoute explores the 64-bit address prefix of IPv6. Using an 8-bit code word 56 bits are available for hierarchical addressing. In a derivation of the Korea Telecom proposal of 2000 (https://www.google.com/patents/US6868416) the international telephone number according to ITU-T Recommendation E.164 can be mapped to the prefix. In the InnoRoute "**6Tree**" proposal an 8-bit 'escape' code 10101111 (AF_{hex}) is used to clearly discern hierarchical packets. The remaining 14 digits are available to code up to 14-digit telephone numbers. This proposal has several advantages:

- Simplified (source) routing without lookup tables, longest prefix match etc. can be done at wire speed.
- Easy configuration of routers without expert knowledge.
- Fixed and predictable routing without external manipulation of routing decisions.
- Easy understanding of IPv6 address for everybody.
- Allows source address check.

A market analysis revealed that SMEs with a size of between 10 and 100 people will be the first target group to be addressed. In particular, SMEs with (a) branch offices and/or (b) local cloud service providers will benefit most from 6Tree. These SME have not enough size for their own IT security department similar to large companies. They fear threats such as Ransomware or data leak. InnoRoute will offer them the TrustNode router together with an access to the 6Tree routing network, with the offer also having a main feature of built-in security.

Within a 6Tree network each subscriber has a unique IPv6 address thanks to the prefix, which contains the E.164 unique telephone number. The hierarchical structure of the E.164 number allows checking of the prefix in all nodes along the uplink path in the network. Whenever a subscriber in a 6Tree network receives a packet he can rely on its source address. This feature offers an significant increase in security. A

subscriber can, for example, introduce white lists for packet acceptance; with typically, branch offices, business partners, cloud service providers and SW suppliers being within the white lists.

As a second feature, low latency and jitter will be promoted, exploiting the results of CHARISMA project. In particular, regional traffic and connection to local cloud service providers will benefit from the low latency optimisation of the TrustNode, which has been done within CHARISMA.

The 6Tree network has 2 features, which allow for a gradual extension:

- The hierarchy of up to 14 levels with a concentration of 10:1 per level leads to the fact that for each TrustNode at the lowest level, an average of 0.1111111111111 TrustNodes must be installed in the network. Hence by setting the price of a customer TrustNode to 1.1111111111111 the subscriber finances also his part of the hierarchy.
- Not all layers within the 6Tree network must be populated from the beginning. For example, a subscriber TrustNode with the address AF49894524199X can be directly connected to output 8 of the network TrustNode AF49X if no other subscribers with prefix AF498 exist.

InnoRoute plans to establish a private trial network in Q2 of 2017 between its own sites and a business partner site. After successful trial the service will be offered to SMEs. For this purpose, a subscriber TrustNode will be derived from the research TrustNode under the brand name '**MaxBox**'. Figure 82 shows a picture taken from the flyer which is under preparation at InnoRoute. It is inserted between the existing DSL Modem 1 and the local Ethernet. A new DSL Modem 2 is purchased by the subscriber with a new DSL access line to access the 6Tree network – tentatively branded here i-Autobahn. We assume that the term 'Autobahn' reveals positive associations to German highways, where the speed is unlimited. For future offerings outside Germany this has to be checked. The MaxBox local access ports 0…9 can be configured to carry 'normal' Internet packets, 6Tree packets (i-Autobahn ports) and both normal and 6Tree packets (ports called 'gemischt' in Fig.82). A SME could connect for example in-house servers to the i-Autobahn ports and allow access only to their branch offices.

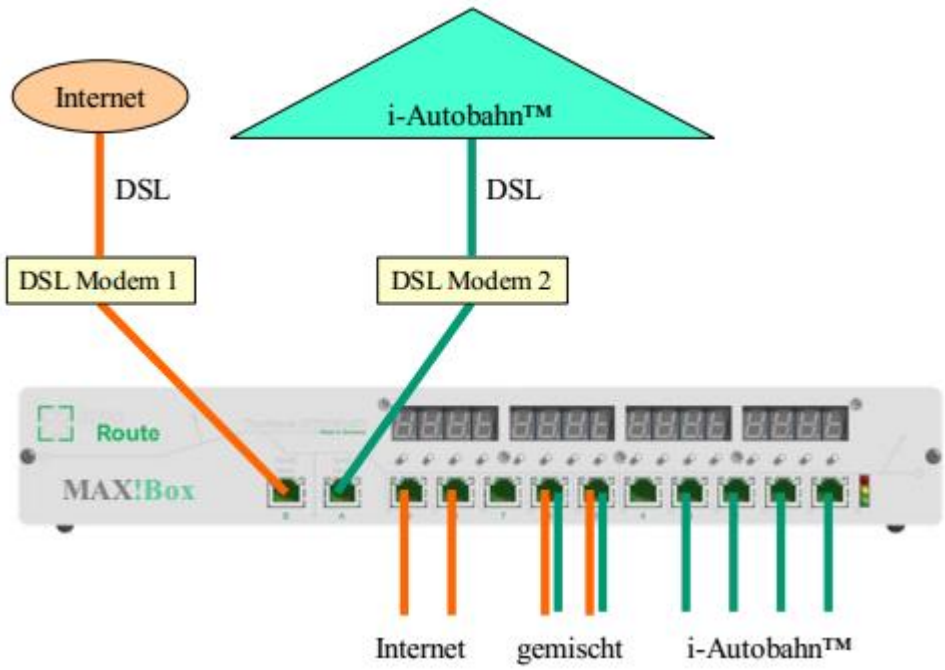

Figure 1: Subscriber TrustNode wiring

In the initial phase of i-Autobahn deployment a secure VPN tunnel over the existing Internet will be used to access the 6Tree network. Later, the lowest level infrastructure TrustNode will be co-located in the access network premises of the network operator. A feasibility study is planned to be carried out within CHARISMA with Apfutura and Telecom Slovenia. The solution will consist of a special VLAN for 6Tree

service and possibly use of DHCPv6 with option 82 to assign port depending IPv6 address prefixes. See *Figure 2*:

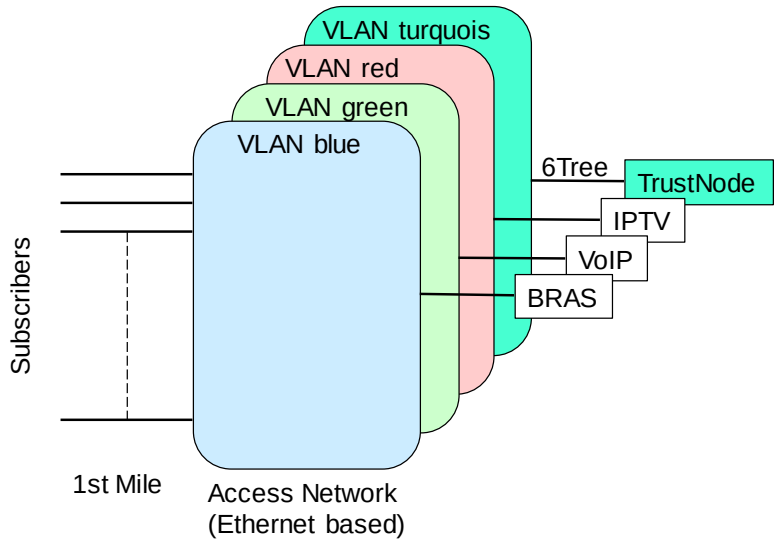

Figure 2: TrustNode in Access Network

The outcome of the CHARISMA demo shown in *Figure 2* will allow one to derive a TrustNode optimised for access networks.

2.4.1. Implications of security

CHARISMA implements a holistic management platform, combining cloud, network slicing, SDN, and NFV technologies while focusing on delivering end-to-end security across all layers of the converged and virtualised open access 5G network to support:

- Data confidentiality through novel approaches for secret key generation at the physical wireless/optical layer in the framework of shared randomness in communication channels.
- Data integrity using deep packet inspection of virtualised security functions dynamically deployed and combined with behavioural modelling of the virtualized network components.
- Provider isolation utilizing new methodologies providing isolation between tenants of the physical infrastructure.
- Authentication and authorisation exploiting recursive trust delegation mechanisms for the different stakeholders' relationships involved in open access networks.

Security is one of the major objectives of the CHARISMA project, because its impact in future 5G systems is considered crucial, since 5G networks will be designed to serve not only new functions for people and society, but also to connect industries (such as manufacturing and processing, intelligent transport, smart grids and e-health). With 5G, it is possible to foresee new models of how network and communication services are provided. For example, a car manufacturer may wish to provide management services for cars. Establishing direct roaming agreements with various 5G network providers could be a cost-efficient way to achieve this. However, in order for this business model to be successful, advanced data integrity and confidentiality must be provided by the 5G networks.

With the advances of mobile Internet, more and more vertical industries, including health care, smart home, and smart transport, will resort to 5G networks. As open network platforms, 5G networks raise serious concerns on privacy leakage. In many cases, privacy leakage can cause serious consequences.

In future 5G networks new service delivery models will be used, involving new actors in the ecosystem. Cloud and virtualization technologies and Anything-as-a-Service will be used to reduce costs, and to deploy

and optimize services more rapidly. Telecom networks will expose application programming interfaces (APIs) toward users and third-party service providers to a higher degree, for example, for the purpose of optimized delivery using location awareness, content adaptation and caching. Such optimizations will sometimes be provided by third-party software executing on shared hardware platforms alongside dedicated telecom software [7]. Advanced security techniques will be absolutely necessary for the success of these new models.

What characterizes 5G, even more than 4G, is that it will have a crucial role in the operation of society. As an example, consider the bring-your-own-device trend in enterprises. Today all user devices can be assumed to be trustworthy, as they are all of the same type, all issued and managed by the corporate IT department. However, in the future users will want to use their personal devices instead, using the available 5G networks, posing threats as potential Trojan horses behind corporate firewalls. For current mobile systems, the trust model is rather straightforward, involving a subscriber (and their terminal) and two operators (the home and serving networks). Since 5G is aimed at supporting new business models and involves new actors, trust models will change, giving rise to extended requirements in areas such as authentication between various actors, accountability and non-repudiation.

Today's networks host various values – examples include revenue streams and brand reputation. The accessibility of these values via the Internet has already attracted hacktivists, underground economies, cybercrime and cyber-terrorists. The values hosted in, and generated by, the 5G system are estimated to be even higher; and the assets (hardware, software, information and revenue streams) will be even more attractive for different types of attacks. Furthermore, considering the possible consequences of an attack, the damage may not be limited to a business or reputation; it could even have a severe impact on public safety. Therefore intrusion detection and attack resistance are absolutely necessary for the retaining of these network values.

Also, in the 5G business environment, security is a necessary enabler for continuity of business. Users already realize that security and privacy are important, and they could be aware of the security/privacy service provided to them (mainly by their MNOs). It is believed that the extent and strength of the security mechanisms provided correlate with the perceived security level, at least in the long run. Perception is closely related to trust; hence negative changes may happen very quickly (e.g. because of front-page news about observed attacks) [8]. In the 5G context, users may already have some perception of the provided security level based on experience with earlier generations. However, in order for new business to be successful, it is important that the perceived (by the user) security and privacy features of the 5G system will outperform the ones of the 3G/4G networks.

2.4.2. Low Latency to vCPE

The vCPE model comes as a part of SDN concept, having advantages mostly for the telecoms operators and to improve QoE for customers. Solutions must simplify the complex world of enterprise WAN and residential networking, and so stimulate the imagination of many network engineers and enterprise IT admins. The vision of being able to consume, configure, and manage the WAN and its services through self-service portals and automation has made vCPE the most common network functions virtualization (NFV) use case.

Another major driver is the cost savings from using low cost CPE devices and network services delivered over the top. For CSPs, it's also about eliminating site visits, creating flexible service options, automating service creation, and virtualizing assets.

However, when telcos started deploying these solutions they realized that reality is more complex. Additionally, the vCPE services failed to deliver promised savings, and in some cases, they were more expensive and lower quality.

To better understand the CPE cost model and the evolution to virtual CPE, let's look at how the services have traditionally been delivered. Those services are built around three elements: the CPE, the network, and the Telco delivering the service. Price was based on the functionality, value, and reliability of the services built into the CPE device and the associated network connectivity, bandwidth, and service offering. Therefore, enterprises wanting reliable services had to invest in expensive CPE boxes and reliable network services (MPLS) or xDSL/PON.

Here's the math: Service (CPE + Network <VPN/SLA>) / Number of sites = Total cost per site/month.

The architecture looked something like this:

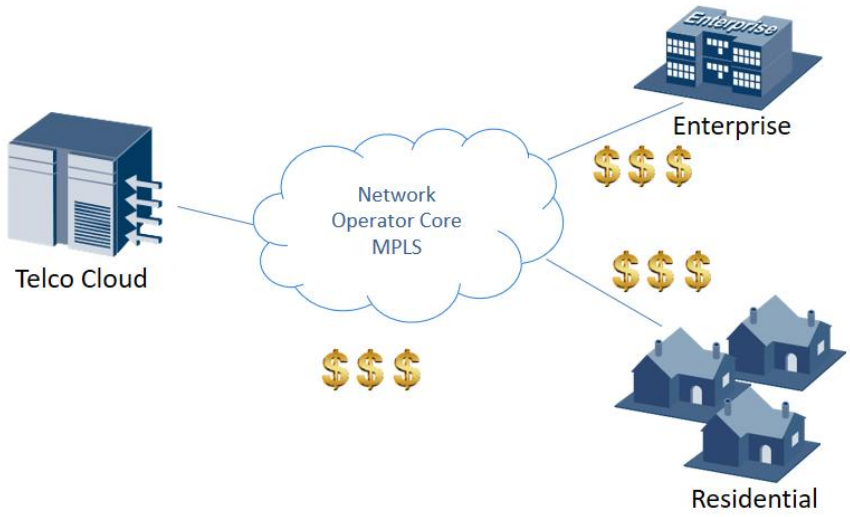

Figure 3: vCPE Architecture 1

The NFV idea shifts the functionality, value, and cost…

…from the network edges to a centralized cloud

…from hardware to software-based functions

…from MPLS to over-the-top (OTT) networking and direct Internet access

…from labor-intensive delivery to self-service and automation

As such, the new vCPE architecture looks like this:

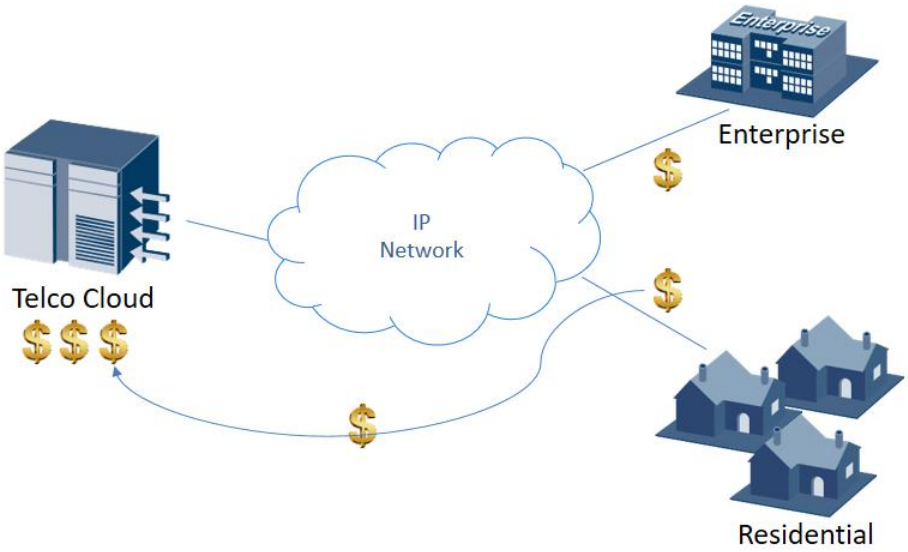

Figure 4: vCPE Arquitecture 2

2.4.2.1. Elements of the vCPE solution in depth:

2.4.2.1.1. The CPE

Prices have dropped and market commoditization is underway. However, there is a *problem:* in some countries the major network vendors have no reason to support this evolution, and in fact, are making it difficult by bundling the service with a specific, proprietary CPE device.

2.4.2.2. ***The Network***

Most vCPE solutions leverage OTT networking like software-defined wide area networking (SD-WAN) which, in theory, drives down the cost of bandwidth. However, again, there is a *problem:* as Enterprises are offered OTT networking solutions from non-traditional service providers and networking vendors, traditional CSPs will be forced to adopt this technology and cannibalize existing WAN revenue streams. For residential networks, there is the problem of IOT (interoperability tests) when new technologies are coming to improve bandwidth. Currently vendors are doing their "best" to add proprietary functions so as to prevent full IOT.

2.4.2.3. ***The Cloud / VNFs***

It's expensive and complex to run virtual network functions (VNFs) while delivering a positive service experience. This leads to yet another *problem:* There are a variety of network functions needed to build a service offering:

- Routing Stacks
- Security and unified threat management
- Quality of service
- Application visibility
- Content management
- Orchestration and Management tools…..

Legacy networking vendors that have built their solutions on dedicated hardware are being forced to quickly adopt a software model. Most vendors have taken the easy way by simply offering a "virtual

appliance." This takes the same code base as the hardware solution and runs it in software on a hypervisor. However, this approach also suffers from some problems:

- Closed or proprietary management interface
- Lack of service and capacity elasticity
- Legacy cost model and licensing
- Heavy virtualization footprint
- Service (CPE + Network + VNF) / Number of sites = Total cost per site/month.

The addition of a VNF element to the cost formula is challenging and largely misunderstood. To find out the real cost of the VNFs we need to include costs for:

- VNF licensing
- Virtual infrastructure (CPU, RAM, storage)
- Management and orchestration

First-generation vCPE solutions were driven by legacy networking vendors promoting a turnkey solution. Their solution provides the CPE with the network gear, the VNFs, and the orchestration framework. These solutions promise:

- Faster time to market
- Lower up front costs
- Open application program interfaces (APIs)
- Turnkey integration

However, these first-generation solutions have a dark side: lock-in. Turnkey vCPE solutions are just another kind of "networking box" that is closed, expensive, and tightly locked into the vendor's revenue model. We end up with a solution in which the savings of CPE commoditization and OTT networking are outweighed by the cost increase of legacy VNFs and the infrastructure needed to run them.

2.4.2.4. Solution

Openness is the way forward, and is also the right way to build vCPE models and to achieve the promised cost model. But the only way to get there is by opening up the model to use cloud native functions. Thus next-generation vCPEs will be built on network functions with the following principles:

- Standard based and model driven
- Simplified and streamlined on-boarding
- Service and capacity elasticity
- API Driven
- Open and extensible
- Use a cloud economics cost model
- Full compatibility and IOT

The vCPE framework powered by open source cloudify is an open NFV orchestration platform enabling Telcos to deliver next-generation vCPE solutions based on these principles by leveraging any CPE device, use any network service and facilitate on-boarding of any VNF. The next-generation, cloud-native network functions market is growing fast. Rapid development is also happening in the adoption of container technologies for network functions. Next Generation network has to look like a NF-Store, where the

Functions (analogous to today's mobile Applications) are available and pass Compatibility and Security checks.

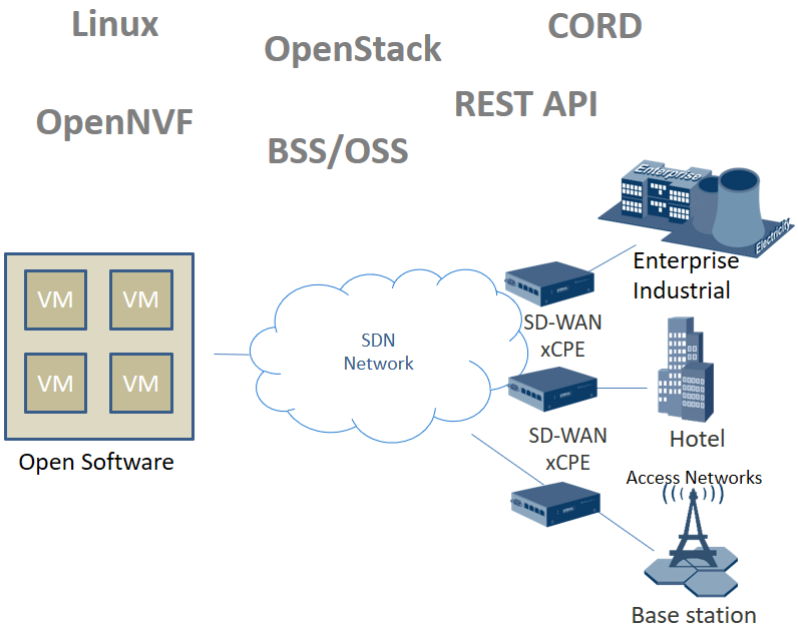

Figure 5: vCPE Solution

2.4.2.5. Summary

Commercially successful models must adopt a framework that drives a cost reduction for all the solution elements: from the CPEs, the network, and the VNFs. They must embrace fast technological innovation to unlock new opportunities, capabilities, and models that CSPs can benefit from. The only way to build the network of the future is to keep it open. Any project targeted for Next Generation network needs to take this into account. Another cornerstone of success is IOT and joint R&D projects enable the creation of a common vision and success.

2.5. Summary

The 5G CHARISMA architecture propose a new business model for operators, content providers, service providers, etc., and a lot of benefits for the end-user (low latency, better performance, etc.). But to complete the whole vision of CHARISMA, a business model of reference is necessary that identifies the actors of the 5G business ecosystem, their roles and relationships, as well as the anticipated revenues and costs.

3. CHARISMA Business Modelling Methodology

This section presents the reference business model that includes the roles and relationships for the ecosystem of 5G networks from the CHARISMA point of view.

Business modelling is a general term that is used widely in various sectors such as academia, consultancy firms and companies. One would expect that there is a common understanding on what is a business model, and what purpose it serves; but a thorough research can reveal that there are different interpretations of the term and a lot of existing definitions in use. Among the most well known definitions are the ones presented in references [9]-[14], and their descriptions lie between the more abstract strategic issues and the more detailed business process considerations and assumptions.

The definition for a business model that is adopted in this deliverable is based on the definition given by Timmers [9], and Chesbrough & Rosenbloom [15].

A business model consists of a description of all the business players, their roles and relationships, their relative position within the value network and a description of the cost structure and possible sources of revenues. In our view company, specific internal value chains, marketing models and sources of revenue are not specified.

In this deliverable D5.5, the concept of a value network is adopted instead of the traditional value chain approach that is more company specific. The definition of a value network is based on [16] and is a network of relationships that generates economic and other types of value through dynamic exchanges, that may be tangible or intangible, between two or more participating players.

In the next section the following terms will be used:

- Player: an entity that participates in the business model. It can provide or consume services (from other entities);
- Role: The functionalities of each player that participates in the business model. Players can take one or more of these roles;
- Relationship: it illustrates the interaction between two roles or players in the mode;
- Revenue model: it describes the revenue streams for a player in the model.

The telecommunication market has been one of the fastest growing industries in the world over the last thirty years. The introduction of mobile communication voice services at first, the evolution of Internet and companies associated with these sectors, have added extra dimensions to the telecommunication market that was initially dominated by fixed line operators. The shift from voice services to data services enabled the introduction of new services and opened new revenue sources.

5G tries to address current limitations that are present in today's networks, regarding delay (latency), throughput and service availability. Expected improvements in several aspects as described in the previous section can create new potentials for innovation for many SMEs that have not been unleashed until now. The provision of this new generation of services involves several players, in contrast to the traditional voice services that existed in a vertically bundled industry. Content providers and the so-called Over The Top players have emerged from this change and now have a significant presence in the telecoms landscape.

Technological evolution as the one promised by 5G affects all aspects of business models, their structure, relative processes and revenue models. 5G will bring changes to the telecom ecosystem as we have known it until now. The telecoms market is characterized by high capital expenditure, increased competition, regulation obligations (at EU level), rapid technology changes and fast depreciation of equipment.

All these factors affect the telecom landscape and the players within it face a complex and variable environment with new business models. This environment cannot be described in a linear way using value chains. The way of understanding these new business models is by understanding the value network of all involved parties. New relationships are emerging and concepts such as infrastructure sharing, revenue sharing, and new pricing schemes must be identified.

Traditional Network Operators that have full ownership of all the physical network components and layers are starting to explore infrastructure sharing schemes in an effort to reduce the associated costs. Sharing models can be used in order to reduce costs associated with both CAPEX (equipment acquisition) and OPEX (site rents, energy consumption and maintenance tasks). Slicing can cover different needs providing separated networks that can be created in a dynamic and easy configurable and managed way.

The next figure is an illustration that highlights all the roles associated with the 5G CHARISMA solution.

Figure 6: CHARISMA 5G ecosystem solution

The next table provides a description of all the roles that are illustrated in the previous figure.

Role	Description
Broker	An intermediate between
Device Vendor	A vendor that provide devices to end-users (mobile phones, tablets, IoT devices, etc.)
End Customer	It is the consumer of services provided in the ecosystem. It can be either a single (B2C relationship) user or Business entity (B2B relationship).
Fixed Network Operator	An entity that has the ownership and the management of a fixed network (core and access network). It provides (fixed) connectivity to end customers.
ICT Equipment Vendor	An entity that sells ICT equipment. It can be either a manufacturer or a reseller that sells the equipment.
ICT Infrastructure Provider	An entity that owns ICT equipment (resources). It provides these resources to Operators.
Mobile Network Operator	An entity that has the ownership and the management of a mobile network. It provides (mobile) connectivity to end customers.
Network Function Provider	An entity that develops network functions. It provides them to operators.
Service Provider	An entity that provides services to end customers using the connectivity provided by the operators.
Virtual Network Operator	An entity that doesn't own network resources. In order to provide connectivity services must make an agreement with the operators (fixed or mobile) and use their network resources.

Table 1: Description of 5G ecosystem roles

One of the crucial parts in the business model is the understanding of relationships among the roles participating in the ecosystem. All the relationships that are identified within the CHARISMA concept are illustrated in the next figure.

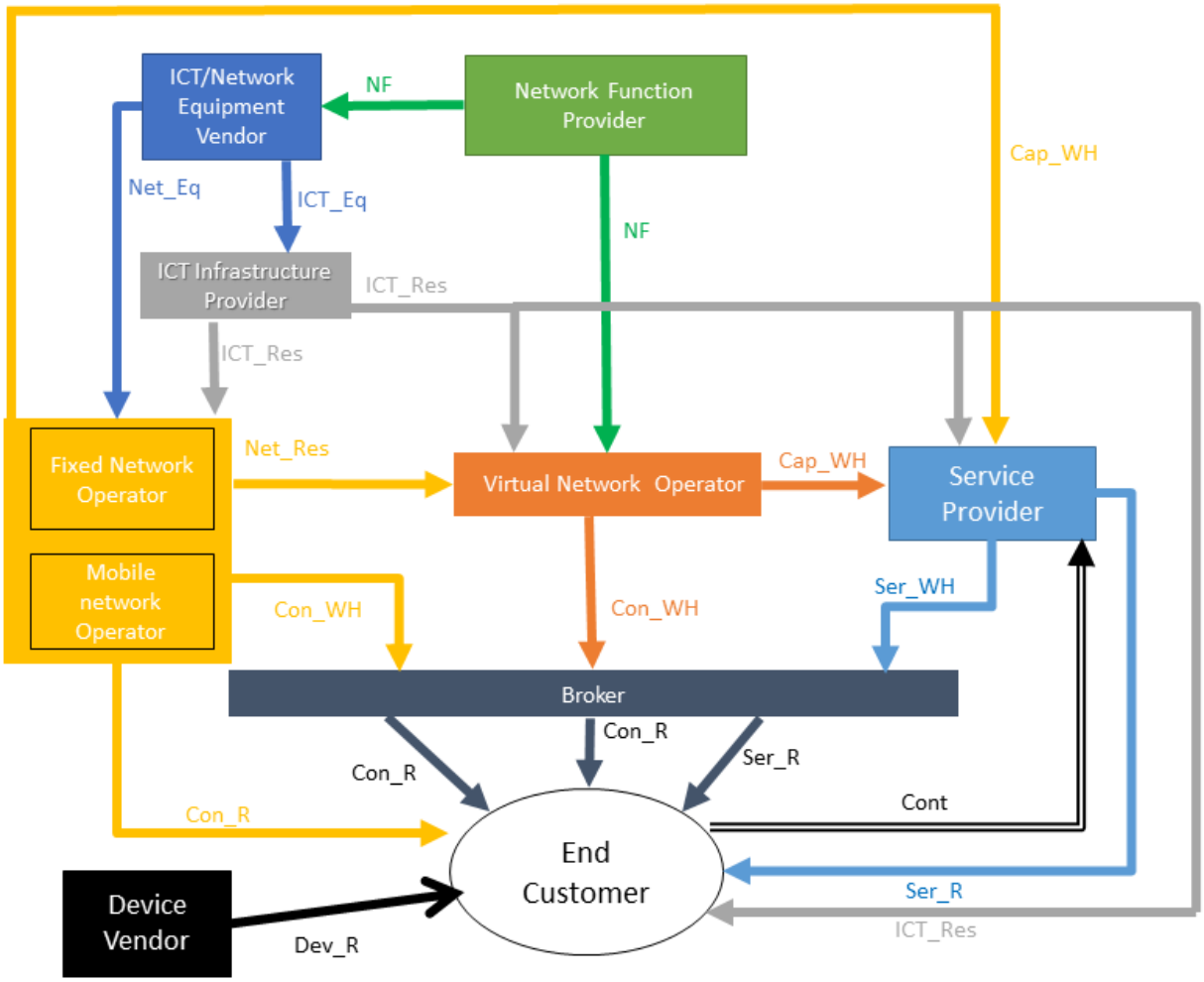

Figure 7: CHARISMA Reference Business Model Relationships

The business relationship interfaces are described in the next table:

Table 2: Interfaces used in the Business model

Interface	Type	Description
Cap_WH	Capacity	Represents the relationship between actors for the provisioning of capacity services. This relationship exists between Operators (Mobile, Fixed, Virtual) and Service Providers.
Con_R	Connectivity	Represents the relationship between actors for the provisioning of retail connectivity services. This relationship exists between Operators (Mobile, Fixed, Virtual) and End Customers. In case of a broker this acts as an intermediate in the previous relationship.
Con_WH	Connectivity	Represents the relationship between actors for the provisioning of wholesale connectivity services. This relationship exists between Operators (Mobile, Fixed, Virtual) and Brokers.
Cont_R	Services	Represents the relationship between actors for the provisioning of user generated content. This relationship exists between the End Customer and the Service Provider

Dev_R	Device	Represents the relationship between actors for the distribution of devices. This relationship exists between the Device Vendor and the End Customer.
ICT_Eq	Device	Represents the relationship between actors for the provisioning of ICT related equipment. This relationship exists between the ICT/Network Equipment Vendor and the ICT Infrastructure Provider.
ICT_Res	Resources	Represents the relationship between actors for the provisioning of ICT resources. This relationship exists between the ICT Infrastructure Provider and the Operators (Fixed, Mobile or Virtual) and the Service Providers.
Net_Eq	Device	Represents the relationship between actors for the provisioning of Network related equipment. This relationship exists between the ICT/Network Equipment Vendor and the ICT Infrastructure Provider and the Operators that own network equipment (Fixed, Mobile).
Net_Res	Resources	Represents the relationship between actors for the provisioning of Network Resources. This relationship exists between Operators that own network resources (Fixed, Mobile) and the Virtual Network Operators
NF	Services	Represents the relationship between actors for the provisioning Network Functions. This relationship exists between the Network Function Provider and the Virtual Network Operator and the ICT/Network Equipment Vendor
Ser_R	Services	Represents the relationship between actors for the provisioning of wholesale Services. This relationship exists between the Service Provider and the Broker.
Ser_WH	Services	Represents the relationship between actors for the provisioning of retail Services. This relationship exists between the Service Provider and the End Customer.

Revenue streams and cost drivers

Table 3: Revenue Streams and Cost Drivers

Actor	Role	Revenues		Costs	
		Interface	**Stream**	**Interface**	**Stream**
Broker	Reseller	Con_R	Resell connectivity products to end customers	Con_WH	Buy connectivity products from Operators
		Ser_R	Resell services to end customers	Ser_WH	Buy services from Service Providers
	Intermediate	Con_R	Provides comparison of connectivity	Con_WH	Buy connectivity products from

			products to end customers		Operators
		Ser_R	Provides comparison of services to end customers	Ser_WH	Buy services from Service Providers
Device Vendor	Device Manufacturer	Dev_R	Sells devices to end users	Not Specified	Build Distribution Channel
	Device Seller	Dev_R	Sells devices to end users	Not Specified	Buy devices from manufacturers
					Build Distribution Channel
End Customer	End Customer	Cont	Sell content to Service Providers	Con_R	Purchase connectivity
				Ser_R	Purchase services
				Dev_R	Purchase user equipment
Fixed / Mobile Network Operator	Connectivity Provider	Con_R	Sells connectivity services to End Customers	Net_Eq	Buys network equipment from ICT/Network Equipment Vendor
		Con_WH	Sells connectivity service to Brokers	ICT_Eq	Rents ICT Infrastructure resources from ICT Infrastructure provider
		Net_Res	Rents resources to Virtual Operator		
ICT Equipment Vendor	Device Manufacturer	Net_Eq	Sells Equipment to Fixed/Mobile Network Operator	Not Specified	Buy/Construct Equipment
		ICT_Eq	Sells Equipment to ICT Infrastructure provider	Not Specified	Buy/Construct Equipment
				NF	Buys Network Functions for the equipment
ICT Infrastructure Provider	ICT Infrastructure Provider	ICT_res	Rents ICT resources to Operators, End Customers or Service Providers	ICT_Eq	Buys Equipment from ICT Equipment Vendor
Network Function Provider	Network Function Provider	NF	Sells network functions to Equipment Vendor	Not Specified	Development of Network Functions

			or Virtual Network Operator		
Service Provider	Service Provider	Ser_WH	Sells wholesale services to Brokers	Cont	Buys content from End customers
		Ser_WH	Sells Services to End Customer	ICT_Res	Rents ICT resources from ICT Infrastructure provider
				Cap_WH	Rents capacity from Network Operators
				Not Specified	Cost of developing Services
Virtual Network Operator		Cap_WH	Provide capacity to Service Providers	NF	Buys Network Functions
		Com_R	Sells connectivity services to End Customers	ICT_Res	Rents ICT resources from ICT Infrastructure provider
		Com_WH	Sells connectivity service to Brokers	Net_Res	Rents Network Resources from Fixed or Mobile Network Operator

3.1. Summary

In this chapter, we have identified the various roles and relationships of all the actors involved in the 5G business model, and we have established a clear view of the revenue streams and cost drivers for the ecosystem of 5G networks from the CHARISMA point of view. In the next chapter, we now describe the functionalities that the CHARISMA Business Model is proposing, building upon the reference business model that has been presented here.

4. CHARISMA Business Model Functionalities

This chapter presents the business model functionalities according to the roles and relationship seen in the reference business model for the ecosystem of 5G networks from the CHARISMA point of view. The CHARISMA business model functionalities are: vCache peering, vCache (Caching-as-a-Service), vCPE and Multi-tenancy, which are now described in greater detail in the following sections.

4.1. vCache Peering

Building on the advances brought on the front of network virtualization and multi-tenancy, CHARISMA has further focused on the support of service scenarios in the field of caching and in particular the support for cache peering business relationships between VNOs. The envisioned business model focuses on caching as a network acceleration technique, already employed by current network operators. As such, caching allows operators to locally store copies of previously retrieved content with the purpose of later serving them to users upon similar requests. By avoiding to bring content from its origin, network operators provide lower latency to their end users/customers, lower the traffic in their network, reduce transit traffic costs and create opportunities for additional revenue in the form of Content Distribution services to Content Providers. In this work, we focus on fully transparent caching services, where neither end customers, nor content providers are aware of the existence of the caching functionality. This constitutes a complementary model to existing ones involving content providers in the value chain.

In this context, the envisioned business model builds on the expected collocation of virtual network operators (VNOs) within the shared infrastructure. This co-location takes the form of virtual network functions (VNFs) being hosted within the same micro Data Center (µDC) of the ICT infrastructure. In this particular scenario VNFs take the form of virtual caches (vCaches) whose purpose is to accelerate the network as explained above. The collocation of vCaches presents the opportunity for the exchange of cached content over a *sibling/peering link* i.e., upon a cache miss a vCache queries its sibling about the availability of the respective content; if the content is already cached there, it is fetched thus serving the end customer without contacting the origin server. The exchanged content is not-locally cached, so as to avoid content duplicates. The described relationship is in principle symmetric in that both vCaches (of the respective VNOs) can query each other. We note that similar relationships can be established between more than two VNOs; however, we refer to the simple case of two VNOs for simplicity.

Figure 8 provides an illustration of the respective business model. It is noted that the roles/actors of ICT/Network Equipment Vendor, and Device Vendor are omitted for clarity i.e., their presence is valid in the described business model but marginally related to the peering agreement that our work focuses on here. Also, we omit the Service Provider role/actor, as we focus on caching as an acceleration technique, instead of a CDN-like service. Finally, we simplify our business model by directly considering retail services, excluding the mediation of a Broker entity.

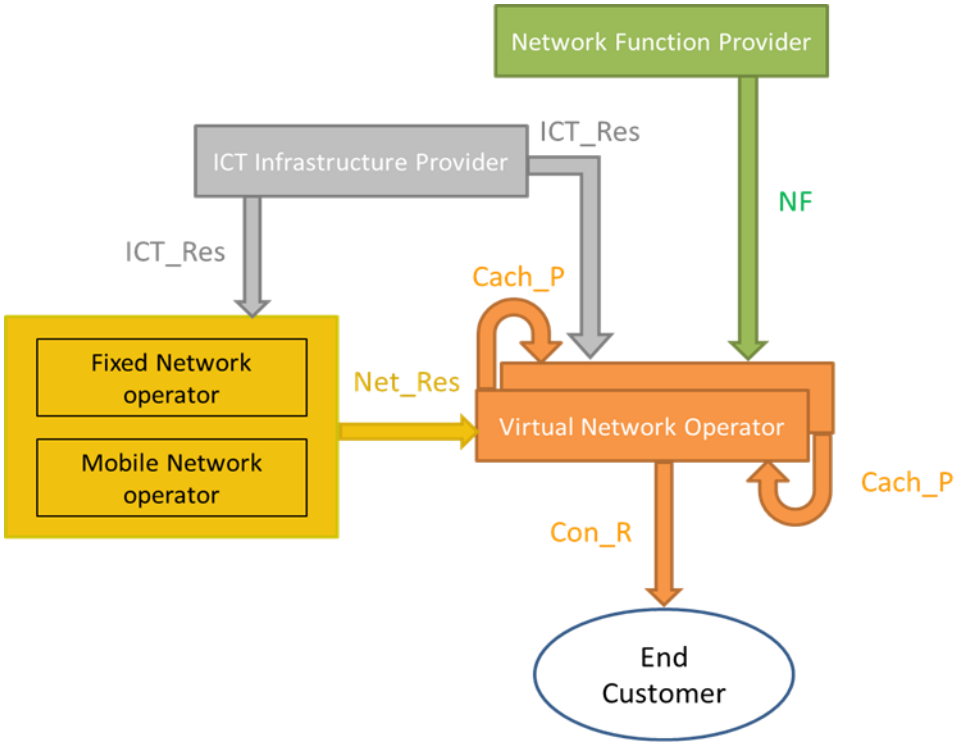

Figure 8: vCache peering business model

ICT Infrastructure Providers and Network operators provide the necessary compute, storage and network resources for the operational need of VNOs. In terms of caching, this translates to data center resources for the instantiation of the vCaches. The latter can be provided by Network Function Provider(s), which may provide optimized vCache instances to VNOs, e.g. optimizing the configuration for the traffic profile of VNOs. The envisioned business model introduces an additional interface between VNOs (Cach_R), which represents the exchange of cache content between the VNOs.

Table 4 presents the revenue streams identified for the vCache peering business model. Again we omit reference to ICT/Network Equipment Vendors, Device Vendors, Service Providers and Brokers. As in the case of inter-domain traffic peering, the costs and revenues have a volume nature, in that they depend on the *amount* of service provisioned. In our case, this may have different interpretations, including the volume of content served over the peering link, the volume and/or rate of requests for content, etc. In consequence, this calls for detailed monitoring and accounting, based on which of the corresponding revenues and costs are determined. In the simplest case, symmetric use of the peering link results in zero costs and revenues over the Cach_R interface, as essentially service is exchanged and mutually beneficial. In more complicated cases, excessive use of the peering link by any one of the VNOs results in the corresponding payment to each counterpart VNO. However, it is noted that the value of the vCache peering service comes from the effect on the Com_R and ICT_Res/ Net_Res interfaces. By accelerating the network service, as explained above, VNOs facilitate the increase of revenue over the Com_R interface, i.e. their retail services to end customers. At the same time, serving cached content reduces the traffic to bring content from its origin, further reducing the respective costs on the ICT_Res/ Net_Res interfaces.

Table 4: Revenue Streams and Cost Drivers for the vCache peering business model

Actor	Role	Revenues		Costs	
		Interface	**Stream**	**Interface**	**Stream**
End	End Customer			Con_R	Purchase connectivity

Customer					
Fixed / Mobile Network Operator	Connectivity Provider	Net_Res	Rents resources to Virtual Operator	ICT_Eq	Rents ICT Infrastructure resources from ICT Infrastructure provider
ICT Infrastructure Provider	ICT Infrastructure Provider	ICT_res	Rents ICT resources to Operators, End Customers or Service Providers		
Network Function Provider	Network Function Provider	NF	Sells network functions to Equipment Vendor or Virtual Network Operator	Not Specified	Development of Network Functions
Virtual Network Operator		Cap_WH	Provide capacity to Service Providers	NF	Buys Network Functions
		Com_R	Sells connectivity services to End Customers	ICT_Res	Rents ICT resources from ICT Infrastructure provider
		Com_WH	Sells connectivity service to Brokers	Net_Res	Rents Network Resources from Fixed or Mobile Network Operator
		Cach_R	Sells cache peering service to other VNO	Cach_R	Rents cache peering service to other VNO

4.2. vCache – Caching-as-a-Service

The use of caching as a network function has multiple benefits for the CHARISMA 5G ecosystem. Beyond allowing acceleration in the network for content delivery and edge applications, the virtualised and decentralised caching as developed in the project opens the door to new business opportunities both for operators and content providers.

The vCache concept of decentralised virtualised caching is based on the idea of having a series of NFV-based caches, which are initialised and governed by the orchestrator. A virtual Cache Controller (vCC) running as a VNF is created by the orchestrator along with the initialization of caching services for a VNO. It allows the VNO to autonomously manage and configure the vCaches allocated to them. This hierarchical structure of the caching serves both technical and business requirements. On the technical side it ensures cached content is correctly stored and managed in order to provide low latency. On the business side it

aims to deliver a complete caching offer to an operator/VNO, which can be used for both transparent and non-transparent caching, i.e. as a CDN service.

- The vCaches offer general caching functionality which can be initialised anytime and anywhere in the network for various applications;
- The vCC allows VNOs to autonomously manage and configure vCaches. The cache controller can be a dedicated function given the business focus of the VNO – events, social networks content, OTT video, etc. Therefore the cache controller itself can be monetised based on the vertical or client segmentation of the VNO activities;
- The orchestrator initialises and manages the vCC and vCaches. This high level function is the core of the caching capacity on offer from operators. Essentially each time operators offer caching capacity to a VNO or a content provider, they offer a vCC or several vCaches depending on their needs.

Operators can then segment their offers of vCC (or vCache) and apply different levels of SLA (service level agreement), security, etc., which are other virtualised functions.

In the next figure we provide a simplified schema of the interactions between the core set of actors.

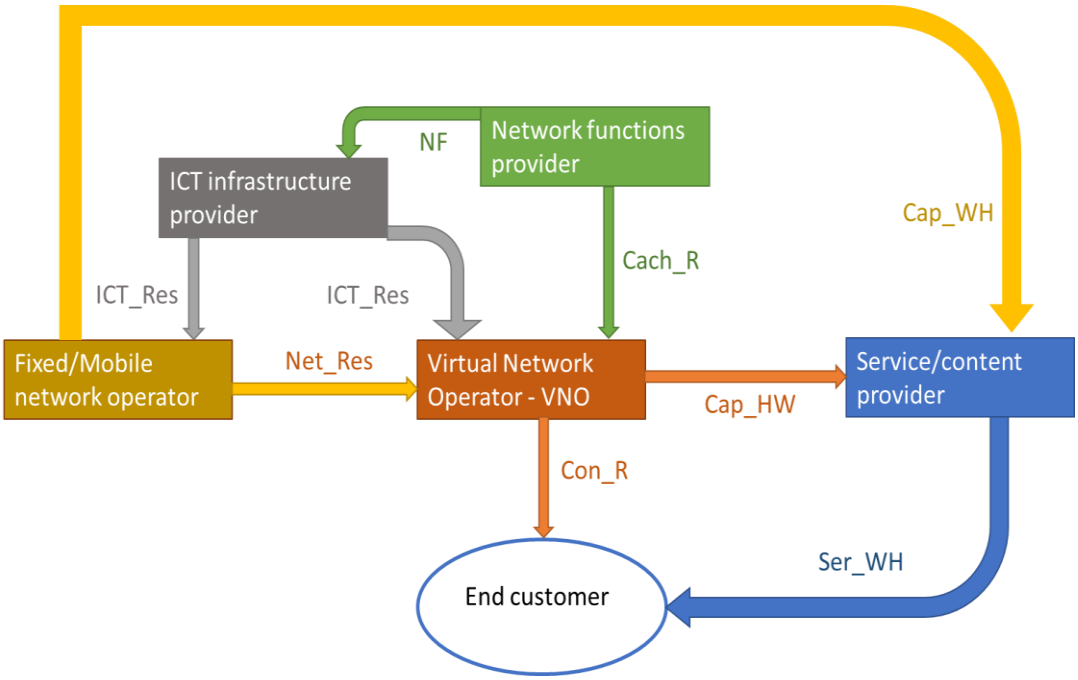

Figure 9: Schema of the interactions between the core set of 5G actors

Operators provide capacity to Service providers and rent resources to VNOs. VNOs purchase network functions from NF providers, rent network resources from operators and provide connectivity capacity to service providers.

Operators can offer both shared and non-shared caching capacity to service or content providers. The shared caching capacity means that the initialisation of a vCache can be used by more than one content/service provider, e.g. a vCache initialised at a sports event can offer caching capacity to multiple content/application providers.

The non-shared vCache offers multiple advantages in the cases of https secure traffic. Today, the majority of content is personalised and secure. The caching of this content is handled by CDN providers or through bilateral agreements between operators and content providers. The vCache decentralised caching gives CDN providers the opportunity to become VNOs who offer secure caching capacity to content providers. The VNO will offer then a dedicated caching service to a content provider to serve their sensitive content. The CDN providers already have strong relationships with content providers, which they only need to

migrate to a 5G environment. The added value of the non-shared vCache is the ability to provide low latency to secure, personalised and "heavy" content.

Since https content is highly personalised and carries sensitive data, it also a likely future move for some big OTT or content providers to take on the role of VNOs themselves, in order to fully control the distribution of content.

The fixed/mobile network operators have a substantially improved position vis-à-vis OTT/content providers thanks to the CHARISMA vCache. The flexible architecture allows them to charge OTT and content providers for the transit of traffic vs the largely free-of-charge status quo they face today. The OTT and content providers will be discouraged from installing their own servers or equipment, as in a 5G network they can reap more benefits by cooperating with network operators while keeping control over the content.

Much like in the abovementioned case of content delivery, the vCache system can be used to provide caching capacity for applications. In this case the caching acts as an enabler of edge computing. The vCache can be used for mixed content&applications use cases – for instance in hospitals or in smart manufacturing where a connectivity offer must handle both efficient delivery of secure content and the functioning of applications with almost zero latency.

The vCache can be initialised in any ICT equipment, given proper agreements between NVF and ICT infrastructure providers are set in place ("NF" interface).

The next table presents the revenue streams identified for the vCache distributed caching business model. We make the assumption that an operator takes an open approach with NF providers regarding the activation of network functions in the network, and the NF provider can monitor this activity for its billing process. We assume also a certain capacity for a vCache to handle an amount of content:

- A fixed annual price for a Cache Orchestrator;
- A fixed annual price for an activated Cache Controller by the Orchestrator;
- A variable price per activated vCache given a certain duration of the activation – for example constantly activated as in a home router or temporarily activated for events.

Alternative pricing can be considered given the amount of cache content per given time period. Another facto,r which can influence the pricing is if the activated vCache is shared between multiple service providers or is exclusively used by one.

The service or content providers are billed given their needs of shared or exclusive caching, the number of vCaches they will need for a certain application etc. In this model we assume that VNOs cannot re-sell the Cache Controller to Service providers.

Actor	Role	Revenues		Costs	
		Interface	**Stream**	**Interface**	**Stream**
End Customer	End Customer			Con_R	Purchase connectivity
Fixed / Mobile Network Operator	Connectivity Provider	Net_Res	Rents resources to Virtual Operator	ICT_Eq	Rents ICT Infrastructure resources from ICT Infrastructure provider
		Cap_HW	Provide capacity to Service Providers		

ICT Infrastructure Provider	ICT Infrastructure Provider	ICT_res	Rents ICT resources to Operators, End Customers or Service Providers		
Network Function Provider	Network Function Provider	NF	Sells network functions to Equipment Vendor or Virtual Network Operator	Not Specified	Development of Network Functions
Virtual Network Operator		Con_R	Sells connectivity services to End Customers	ICT_Res	Rents ICT resources from ICT Infrastructure provider
				Net_Res	Rents Network Resources from Fixed or Mobile Network Operator
		Cap_HW	Sells caching services to Service and Content Providers	Cach_R	Rents vCache system from NF provider
Service Provider	Service Provider	Ser_WH	Sells Services to End Customer	Cap_WH	Rents capacity from Network Operators and VNOs

Table 5: 5G actors and their roles for vCache business model

4.3. vCPE

Virtual Customer Premises equipment (vCPE) was among the earliest use cases for network functions virtualization (NFV), and it remains the leading business case for service providers (SPs). By taking advantage of open, modular and carrier-grade network virtualization solutions to offer vCPE, carriers can accommodate increasing network complexity, meet continued growth in demand for capacity and add new services. vCPE allows service providers to apply the broader advantages of NFV to customer-facing deployments from the enterprise to the consumer, including elastic, remote deployment, personalization, scalability and automated provisioning of services. The primary benefits of vCPE for enterprises is the ability to reduce IT and networking costs, as well as deliver IT services to the business more efficiently and effectively. By eliminating proprietary physical equipment and moving deployment to the cloud, vCPE enables both faster time to market for new value-added services and significant cost improvement in service delivery.

In the 5G CHARISMA project, we have presented full environment starting from CPE and going to MANO managing VNFs (also known as vCPE side).

Figure 91 provides an illustration of the respective business model. It is noted that the roles/actors of ICT/Network Equipment Vendor, and Retailor are mostly in red boxes, and Operators, ISPs, and VNOs mostly in dashed boxes. End Customers can be involved in both device purchasing and functions usage or even managing (as an example, Parental Control).

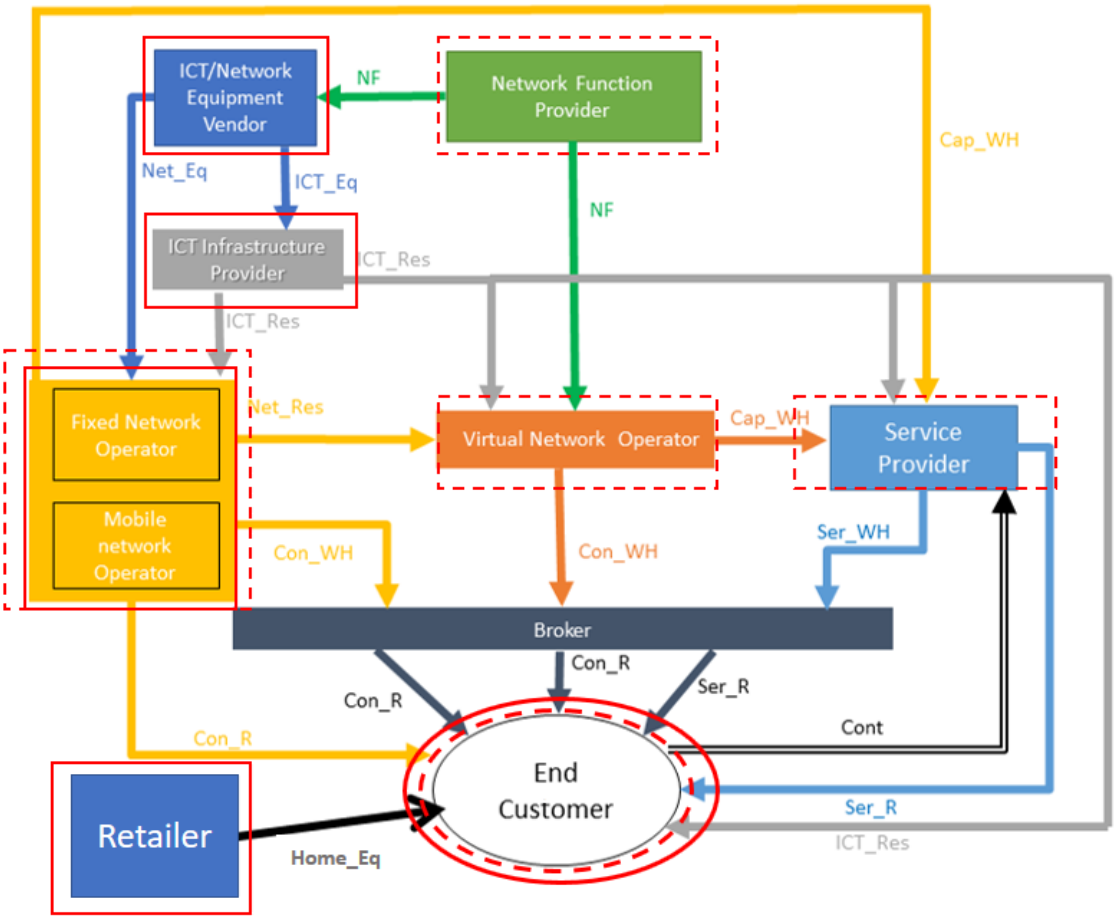

Figure 10: vCPE business model relationships

ICT Infrastructure Providers and Network operators support the compute, storage and network resources for the operational need and for VNOs. In terms of vCPE, this translates to data center resources or Network and Compute nodes with instantiation of the vCPE functions like NAT, Parental Control. Also, can be provided more layers, which may provide Functions sharing between VNOs, e.g. optimizing configuration for the traffic profile of VNOs. The business model introduces an additional interface between VNOs, which represents the reuse of same functions by different owners.

Table 21 below presents the economical aspects identified for the vCPE peering business model. The costs and revenues have a volume nature, in that they depend on the *amount* of service provisioned. In our case, this may have different interpretations including the volume of content served over the peering link, number of functions running and customer satisfaction of SLA performed. In consequence, this calls for detailed monitoring and accounting, based on which the corresponding revenues and costs are determined. By accelerating and virtualizing the network service ISPs, NOs, VNOs facilitate the increase of revenue. The vCPE model mostly is attractive to reduce CAPEX and OPEX for Operators, expedite new Service integration, and improve Customer Experience.

Table 6: Revenue Streams and Cost Drivers for the vCPE peering business model

Actor	Role	Revenues		Costs	
		Interface	**Stream**	**Interface**	**Stream**

Retailer	Device Retailer	Hoem_Eq	Sells devices to end users	Not Specified	Build Distribution Channel
	Device Seller	Dev_R	Sells devices to end users	Not Specified	Buy CPE devices from manufacturers
					Build Distribution Channel
End Customer	End Customer	Cont	Buy content, service, traffic from Service Providers	Con_R	Purchase connectivity
				Ser_R	Purchase vCPE services
				Dev_R	Purchase user equipment
Fixed / Mobile Network Operator	Connectivity Provider	Con_R	Sells connectivity services to End Customers	Net_Eq	Buys CPE and Server equipment from ICT/Equipment Vendor
		Con_WH	Sells connectivity service to Brokers/End Customer	ICT_Eq	Rents ICT Infrastructure p/v resources from ICT Infrastructure provider
		Net_Res	Rents vCPE resources to Virtual Operator		
ICT Equipment Vendor	Device Manufacturer	Net_Eq	Sells CPR+Server Equipment to Fixed/Mobile Network Operator	Not Specified	Buy/Construct CPE+Server Equipment
		ICT_Eq	Sells CPE Equipment to ICT Infrastructure provider	Not Specified	Buy/Construct Equipment
				NF	Buys/rent vCPE Network Functions for the equipment
ICT Infrastructure	ICT Infrastructure	ICT_res	Rents ICT vCPE resources to	ICT_Eq	Buys vCPE Equipment from

Provider	Provider		Operators, End Customers or Service Providers		ICT Equipment Vendor
Network Function Provider	Network Function Provider	NF	Sells vCPE network functions to Equipment Vendor or Virtual Network Operator or End Customer (OTT – SDWAN)	Not Specified	Development of vCPE Network Functions
Service Provider	Service Provider	Ser_WH	Sells services to Brokers/End Customer	Cont	Reuse content from End customers
		Ser_WH	Sells Services to End Customer	ICT_Res	Rents ICT resources from ICT Infrastructure provider
				Cap_WH	Rents network capacity from Network Operators
				Not Specified	Cost of developing Services
Virtual Network Operator		Cap_WH	Get capacity from Service Providers	NF	Buys Network Functions
		Com_R	Sells connectivity services to End Customers	ICT_Res	Rents ICT resources from ICT Infrastructure provider
		Com_WH	Sells connectivity service to Brokers/End user	Net_Res	Rents vCPE Network Resources from Fixed or Mobile Network Operator

4.4. Multi-tenancy

Open of the main objectives for Telekom Slovenije in the CHARISMA project is the concept of open access 5G infrastructure. This enables a 5G network operator to efficiently plan and share network and infrastructure resources, and achieve higher utilisation of those resources.

One of the main drivers behind the multi-tenancy objective is the emerging IoT (Internet of Things) and in general "Internet of Everything" market, and how to scale and provision hardware and network resources, and finally negotiate and guarantee the SLA negotiated with customers.

The business model focuses on the concept of multi-tenancy as technique that enables infrastructure providers to efficiently allocate network and infrastructure resources to other business customers. Those business customers may be:

- Other virtual telecom services providers, e.g. MVNOs – Mobile Virtual Network Operators;
- Dedicated service operators providing specific critical services to end users, e.g. eHealth;
- Enterprise internal services, e.g. providing network resources for smart grids.

The infrastructure provided to each VNO (Virtual Network Operator) is based on a chain of VNFs (Virtual Network Functions) that represent the end-to-end functionality as requested by the VNO. The management layer fetches the virtual infrastructure template from the virtual infrastructure catalogue. The VNFs are created and orchestrated, and infrastructure and network resources allocated according to the selected SLA (service level agreement).

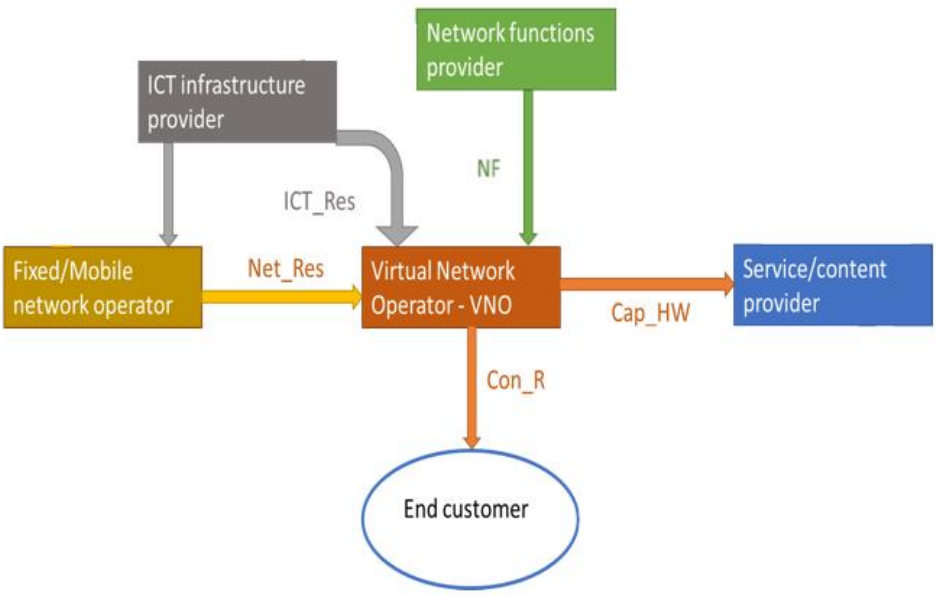

Figure 11: Multi-tenancy model relationships

Automation of the provisioning process briefly described above enables network and infrastructure operators to achieve faster times to market, and promptly react to new requirements as specified by business needs. The physical infrastructure is translated into virtual infrastructure slices, and this also enables virtual operators to preform automatic sizing of their virtual infrastructure. More resources may be added in a much more efficient manner, in the case of increasing traffic. On the other hand, slices may also

be downsized dynamically in a more efficient fashion, in the case where fewer physical resources are required, and these then allocated to slices requiring higher throughputs.

Table 7: Revenue Streams and Cost Drivers for the multi-tenancy business model

Actor	Role	Revenues		Costs	
		Interface	**Stream**	**Interface**	**Stream**
End Customer	End Customer	Con_R			Purchase connectivity
					Purchase services
Network Operator	Connectivity Provider	Net_Res	Rents network resources to Virtual Operator	Con_R	Providing and upgrading network service
Infrastructure Provider	Infrastructure Provider	ICT_res	Rents infrastructure resources to Virtual Operators, End Customers or Service Providers		Purchase new infrastructure
Network Function Provider	Network Function Provider	NF	Sells network functions Virtual Network Operator	Not Specified	Development of Network Functions
Service Provider	Service Provider	Ser_Res	Sells Services to Virtual Operator	Cap_WH	Service development
Virtual Network Operator		Con_R	Sells connectivity and services to End customers, or internal consumers	ICT_Res	Rents infrastructure resources
					Purchase connectivity
					Rent network resources
					Rent services

5. Conclusions

This CHARISMA deliverable D5.5 “Business model analysis report” has provided a study into the potential innovative 5G business models that the CHARISMA architecture is enabling. CHARISMA has as its technical objectives, the target of improving the networking functionalities that 5G architectures can offer – with the expectation that these will also enhance the commercial and socio-economic success of such a 5G deployment. In this regard, CHARISMA is focused on the support of the service scenarios in the field of caching, and in particular, the support for the cache peering business relationship between VNOs, using caching not only for acceleration of accessing the network for content, but also to create new business opportunities both for operators and content providers. Also, the use of vCPE is allowing service providers to apply the broader advantages of NFV to customer-facing deployments. vCPE simplifies the complex management of the network infrastructure and the services reducing the OPEX. The business model focuses on the concept of multi-tenancy as a technique that enables infrastructure providers to efficiently allocate network and infrastructure resources to other business customers. This new business model also opens the way to the IoT and scales the hardware and network resources, guaranteeing SLAs with customers. vCache as a service, opens the door to new business opportunities for content providers, storing copies of retrieved content a serving them to users upon similar request and lowering the traffic in the network for operators.

All these functionalities lie in the objective of the Open Access network that the CHARISMA project is proposing. This enables network operators to efficiently plan and share network and infrastructure resources, and achieve a higher techno-economic utilisation of those resources. Indeed, a full techno-economic analysis of the CHARISMA architecture is therefore currently now being undertaken, and will be reported in the final deliverable D5.6 of the work package WP5.

Low Latency improves both end-to-end connectivity performance, as well caching download speed improving the QoE for customers. Here, caching opens an entirely new space of 5G business opportunities for both operators and content and service providers.

In the Security aspect, CHARISMA implements a holistic management platform, combining cloud, network slicing, SDN and NFV technologies while focusing on the delivering end-to-end security across all layers of the converged and virtualised open access network.The operators need new revenue streams, while end-users need a better quality of experience. The operators need to optimize the bandwidth and secure the access but not necessarily increasing the required investment. This is the point where the new business model proposed by 5G CHARISMA makes commercial sense: sharing the infrastructure lowers the investment, achieves better performance with vCaching and therefore the user experience, and all of this via an end-to-end virtualised security approach.

To provide a broader commercial context for the successful implementation of the 5G CHARISMA business models, we have also analysed the telecommunications market by taking as reference five different EU countries: France, United Kingdom, Greece, Slovenia and Spain. In each country, this report analyses several parameters such as: penetration, annual revenue per operator, and portability, etc., and has compared each one with the average of the European Union.

Regarding the coverage of LTE/4G, France has a coverage of 77.5%, while for the United Kingdom the LTE/4G coverage is 97.8%, Greece is 79.8%, in Slovenia it is 99%, and in Spain its around 80%. The deployment of high-speed connections in the mobile context is already very high, and according to the number of lines and data consumption the use of mobile connections is also continuing to grow each year.

When considering only the fixed connections, not all countries have the same deployment scale; indeed, highlighting France and Greece, these are countries where the analysis indicates that they have the lowest NGA access penetration, well behind the EU average. From the data that have been presented, we can see that people therefore have a greater facility to access a high-speed connection using the mobile infrastructure than the fixed infrastructure. The commitment to 5G will enable improvements in the coverage and speed of mobile access, allowing end-users to consume all kinds of services through a mobile connection, as if they were connected to a fixed connection, but with the advantage that they have ubiquitous and seamless access from anywhere.

All the countries selected for this 5G market analysis already exceed the average in most of the analysed parameters. In the analysis, we have also seen that in every country the number of people connected to the Internet has grown every year, even while the revenue for each service, in most of these countries, has actually been declining each year.

Thus, in overall summary CHARISMA features the important new business model functions of open access, low latency and security, and in this deliverable we have described how these may enable the emergence of new 5G business models and commercial opportunities particularly in the European context.

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Acronyms

Acronym	Definition
5G	5th generation mobile network
4G	4th generation mobile network
ARCEP	Autorité de Régulation des Communications électroniques et des postes (Regulatory authority for electronic communications and post office)
B2B	Business to Business
BSS	Business Support System
CAPEX	Capital Expenditures
CDN	content delivery network
CNMC	Spanish National Markets and Competition Commission
CPE	Customer Premise Equipment
CS	Circuit Switched
CSP	Carrier Service Providers
DESI	Digital Economic and Society index
DOCSIS	Data Over Cable Service Interface Specification
EU	European Union
FTTx	Fibre to the X
GDP	Gross Domestic Product
HSDPA	High Speed Downlink Packet Access
IoT	Internet of Things
IPTV	IP Television
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
LTE	Long Term Evolution
M2M	Machine to machine
MVNO	Mobile Virtual Network Operator
NGA	Next generation access
OFCOM	The Office of Communications
OPEX	Operating Expense
OTT	Over The Top
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
QoS	Quality of Service
SLA	Service Level Agreement
UMTS	Universal Mobile Telecommunications System
US	United States
TCO	Total cost of ownership
v-CPE	virtual Customer Premises Equipment

VNF	Virtual Network Function
VoIP	Voice over IP
xDSL	x Digital Subscriber Line

Appendix

7. Market Analysis of Five Selected EU States

In this Appendix we review the emerging 5G market in five different European Union countries, focusing on the penetrations of the fixed and mobile communications, and the existing deployed infrastructure to achieve these penetrations. Portability bundle of services and the revenue earned by operators and by services are discussed. Finally, a comparison between each country and the whole of the EU in aspects such as coverage, distribution of fixed broadband lines by speed, fixed and mobile penetrations, and active NGA lines are discussed.

7.1. France

France's population is almost 66 million inhabitants that accounts for around 1% of the total world population and ranks in in the 22th position in the world by population. France account for 13% of the EU population and occupies 14.6% of the total EU area. The average density in France is 100 people per square kilometer. The total area is 632,833 square kilometers and there are 30 million households (Table 8).

Table 8: France general characteristics[17]

Area (land)	632,833 km^2
Population	65.8 Millions
Households	29.9 Millions
Person per Household	2.2
Rural proportion	15.6%

7.1.1. Key Macroeconomic Indicators in France

After a marginal positive growth rate in 2014 the French economy began to slowly grow in 2015 with an average GDP of 1.1%. The GDP in France is expected to increase in a modest growth of around 1.7% in 2017. The unemployment rate is stabilized around 10% at 2017 while the inflation rate has increased mainly because of an increase in the energy prices. The decision of the UK to leave the EU is expected to hold back exports from France.

Table 9: Key macroeconomic indicators for France [17]

KMI	2011	2012	2013	2014	2015	2016	2017
GDP annual variation (economic growth %)	2.1	0.2	0.7	0.2	1.1	1.3	1.7
GDP in € billion	2,058	2,086	2,118	2,134	2,183		
Registered unemployment level (%)	9.2	9.8	10.3	10.3	10.5	10.5	10.3
GDP per capita (€)	32,632	32,290	33,272	33,379	33,990		
Inflation rate (HICP)	2.4	1.4	0.8	0.1	0.3	0.6	1.3

7.1.2. The France in comparison with EU

According to data provided by the EU [18], France ranks in the 16th place of in the DESI (Digital Economy and Society Index) 2016, staying behind the EU average in connectivity and use of Internet categories. Broadband coverage is increasing in France and is above the average EU rates for fixed broadband coverage, but is behind the EU average in NGA broadband coverage (Figure 12) [19]. 71% of French households subscribe to fixed broadband Internet (with the average EU rate to be 28%) and 15% of these subscriptions are connected to speeds over 30Mbit/s (EU average is 30%). Mobile broadband subscriptions are 73% (with EU average to be 75%) that ranks France in the 11th place. The number of users that have never used Internet is 11% in France (and 16% in EU).

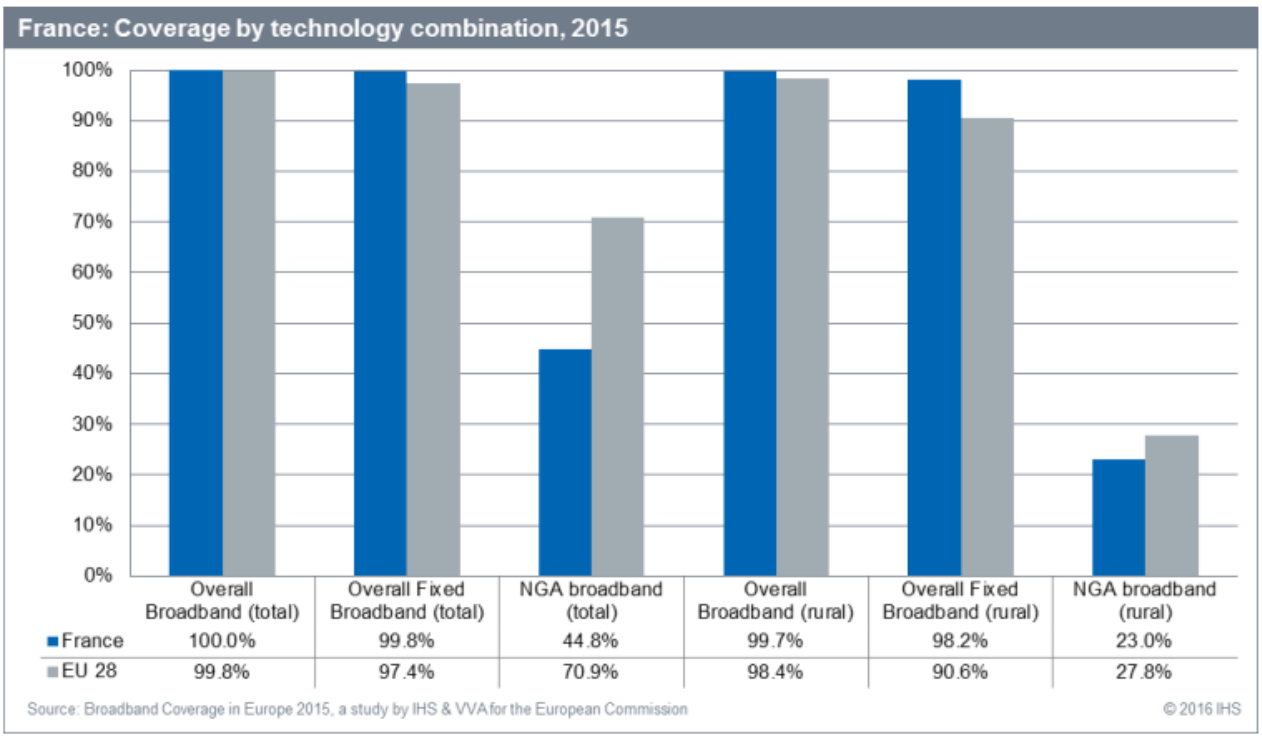


Figure 12: Broadband coverage (France, 2015)

7.1.3. The French telecoms market

France is one of the largest telecom markets in Europe. In the mobile sector, there are four major players that have market shares of around 90% and a set of MVNOS that covers the rest of the 10% of subscribers. In the fixed market, the biggest player remains the incumbent Orange that offers a mix of solutions that include DSL cable and fiber technologies. Orange is one of the biggest fiber network operators in France and has announced plans to reach a 60% coverage by 2022.

According to data provided by ARCEP [20] the retail telecom market in France has annual revenues around 36 Billion Euros. The next figure shows the revenues per quarter from fixed and mobile services. The proportion shows 47% of the revenues come from the fixed services, 40% from mobile services and the rest is associated with other services.

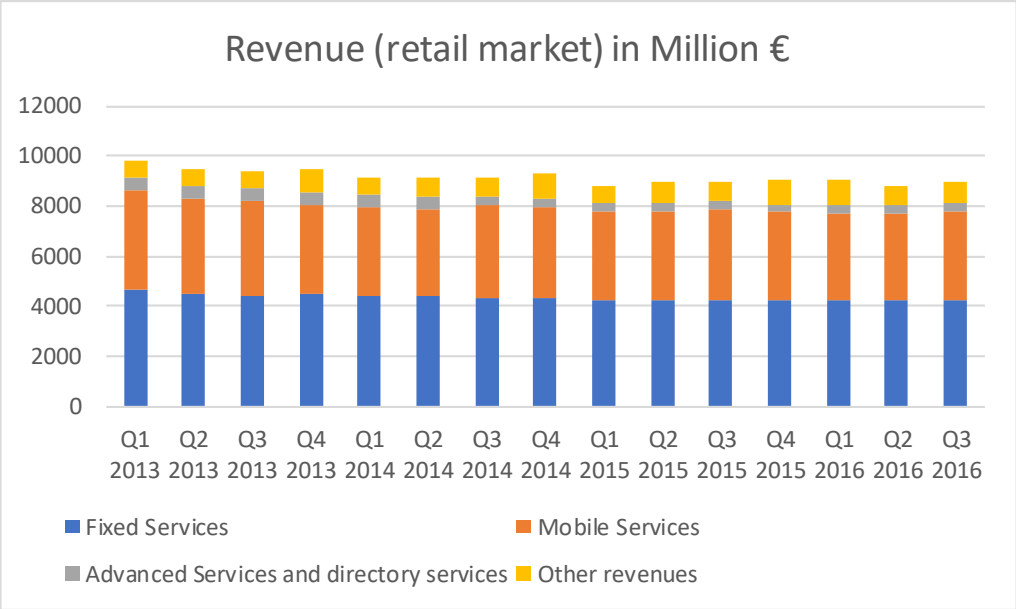


Figure 13: Revenues per quarter in the French telecoms market

7.1.3.1. Fixed Market

The broadband market in France is continuing to evolve; the total number of broadband subscriptions (Figure 14), at the end of 2016, were around 27.5 million subscriptions. Out of them there are 5 million users subscribed to a very high-speed internet (connections over 30Mbps), of which 1.9 million are FTTH subscribers (connections over 100Mbps) according to the latest data from ARCEP (September 2016). This evolution is based on the heavy investments in high speed broadband networks; almost 15 million houses are covered by these, of which around 7 million can get access from FTTH networks. France cable operators are now using DOCSIS 3.0 and cover almost 30% of all households.

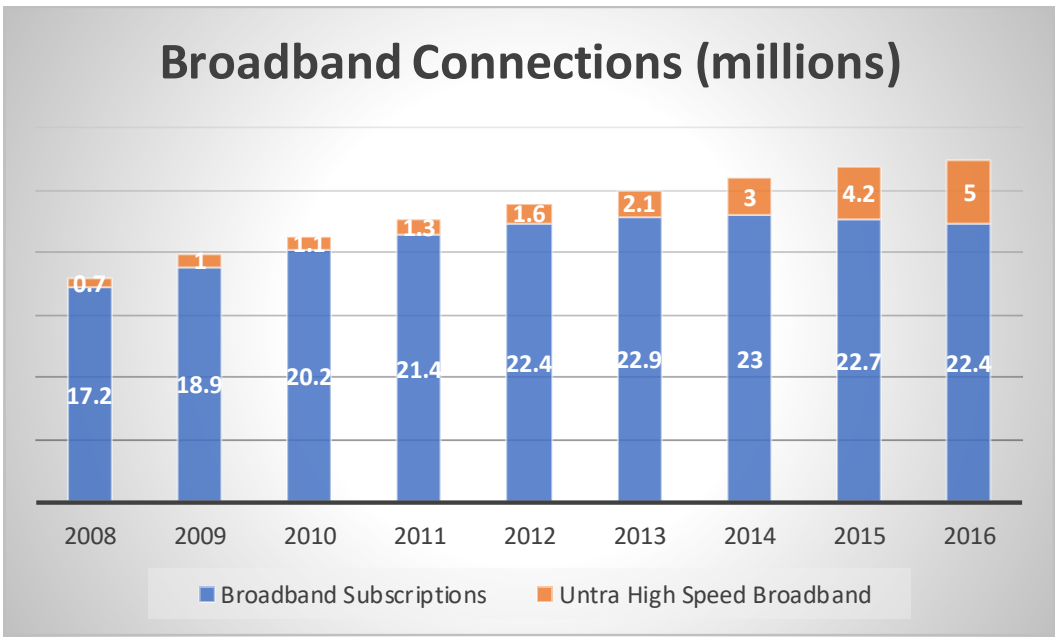


Figure 14: Broadband connections evolution in France

The next table shows the coverage of networks that offer speeds over 30 Mbit/s in France.

Table 10: Fixed broadband coverage in France

	At least 30Mbit/s	At least 100Mbit/s
Number of houses covered	15.4 Millions	11 Millions
Cable coverage	8.8 Millions	7.8 Millions
FTTH coverage	6.9 Millions	6.9 Millions
VDSL2 coverage	5.5 Millions	-

The take up of subscriptions over 30 Mbps is 15%, which is almost half of the EU average [21]. Most of the connections are in the range of 10 to 30 Mbps (around 80%).

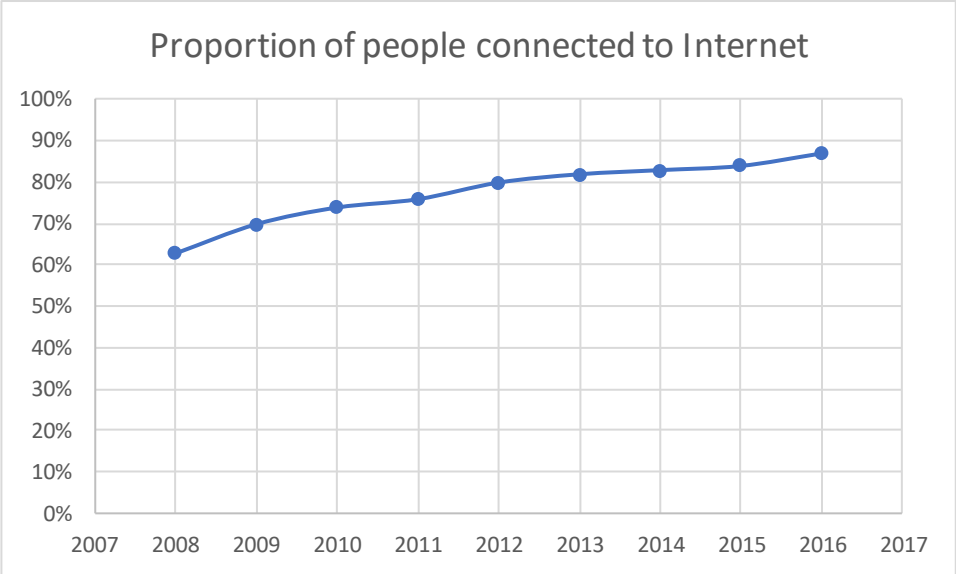


Figure 15: Proportion of people connected to Internet

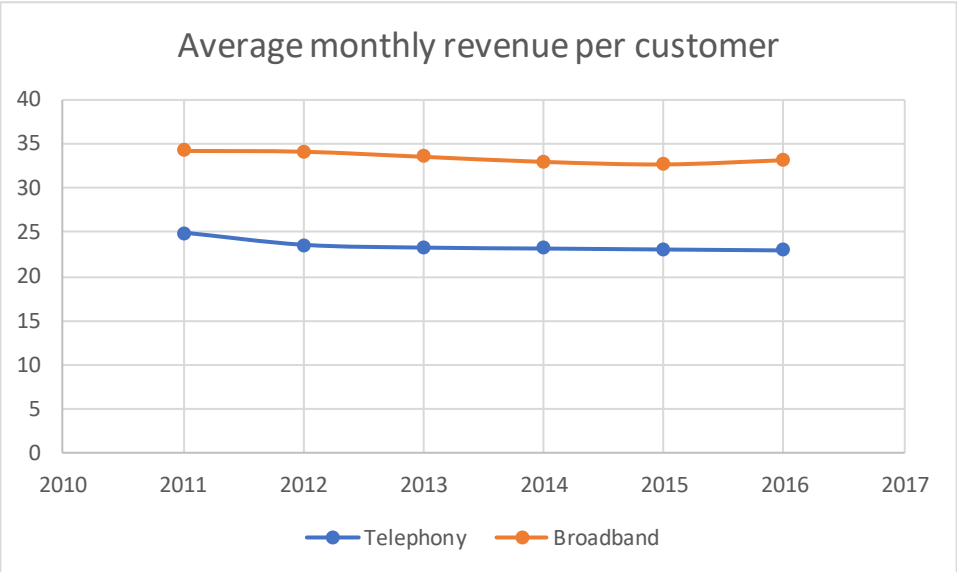


Figure 16: Average monthly revenue per customer (fixed networks)

The average monthly revenue per customer is slowly declining as shown on Figure 16 and at the end of 2016 was 23€ for telephony services and 33.2€ for broadband services. The overage income spent on standalone fixed broadband connections is 0.91%, while for triple play connections it represents 1.17% of the total household income.

The next figure illustrates the evolution in the number of subscriptions to TV services over xDSL. It includes those subscriptions that are part of a bundle packet or are standalone subscriptions.

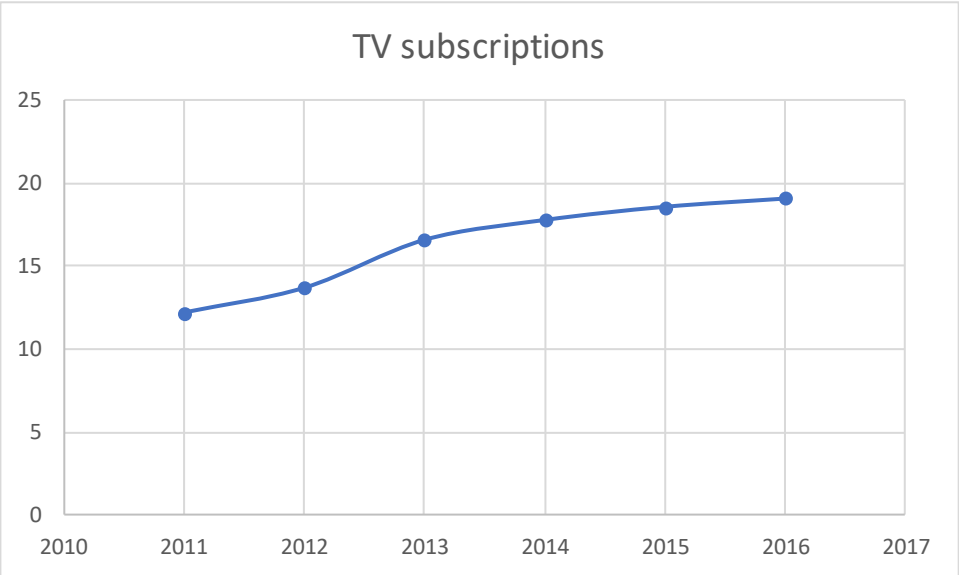


Figure 17: Subscriptions to TV services (with Internet access)

7.1.3.2. Mobile Market

Mobile subscriptions are continuing to grow in the France market, as illustrated in Figure 18, and there was a total of 83 million subscriptions in 2016. The split out shows that 60.8 million are associated with contracts, 11.6 are prepaid contracts and 10.9 are Machine-to-Machine SIM cards.

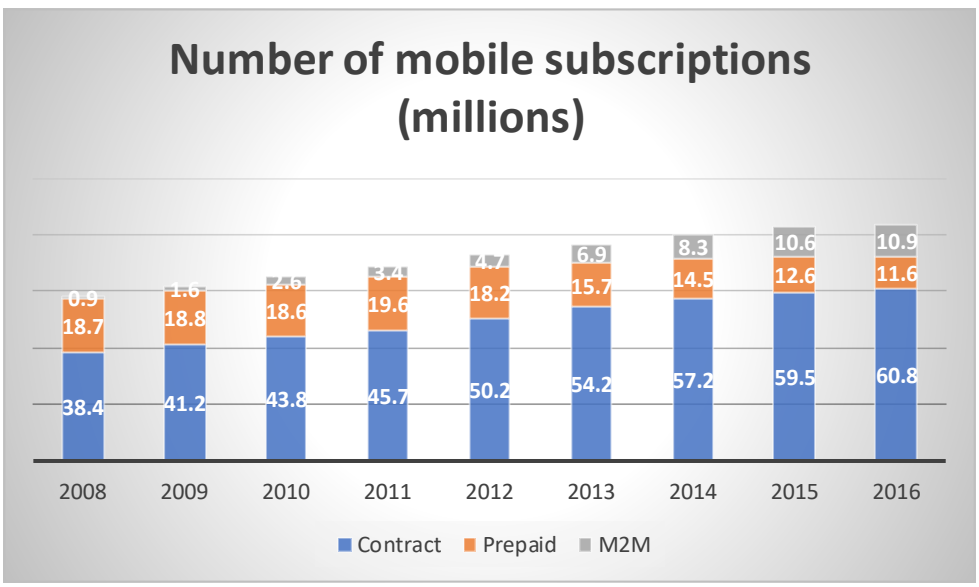


Figure 18: Mobile connections evolution in France

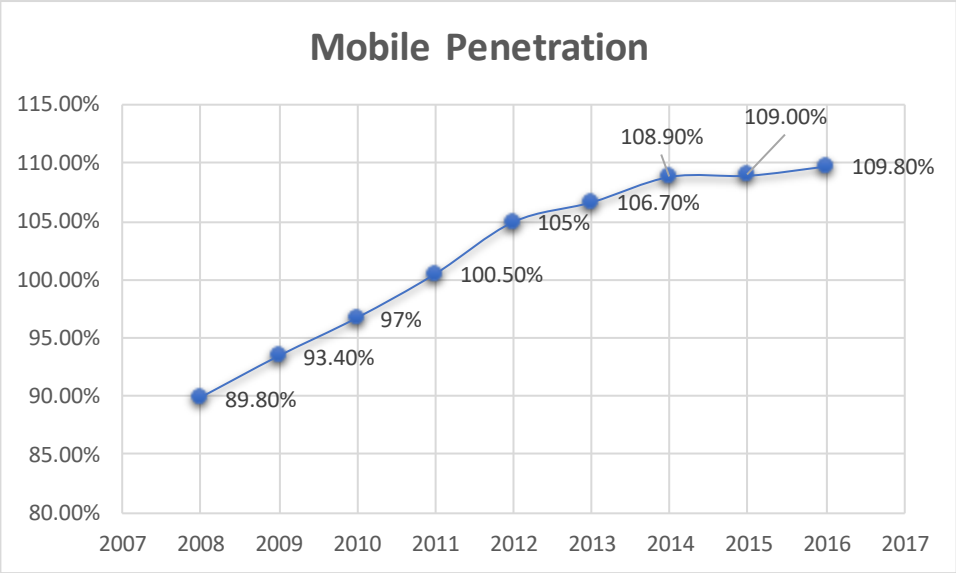


Figure 19: Mobile Penetration in France

Figure 19 shows the evolution of mobile penetration in France market, it has continuously grown since 2008, passing the milestone of 100% in 2011, and in 2016 was around 110%.

The biggest operator in France mobile market is Orange, which accounts for around one third of the total subscriptions, followed by SFR, Free and Bouygues. 10% of subscribers are associated with MVNOs (Figure 20).

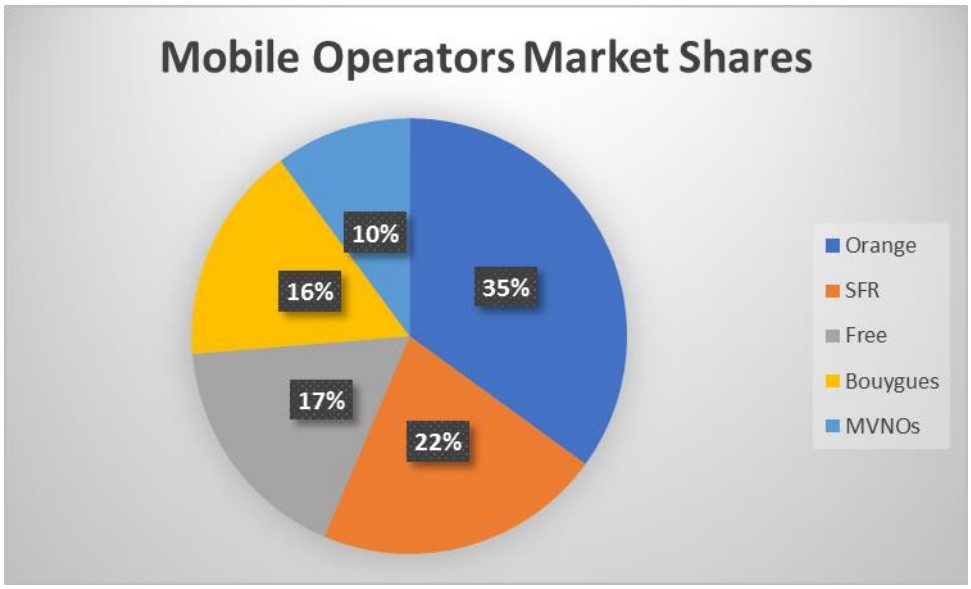


Figure 20: Mobile operators market share in France

The evolution of MVNO market share over recent years is illustrated in the next figure.

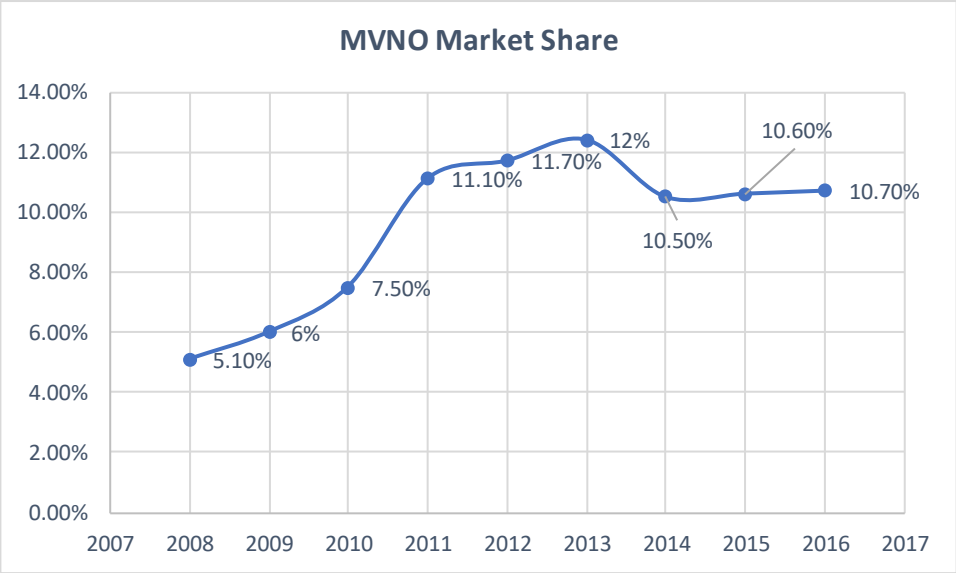


Figure 21: MVNOs market share in France

The penetration of mobile phones and smartphones is illustrated in the next figure.

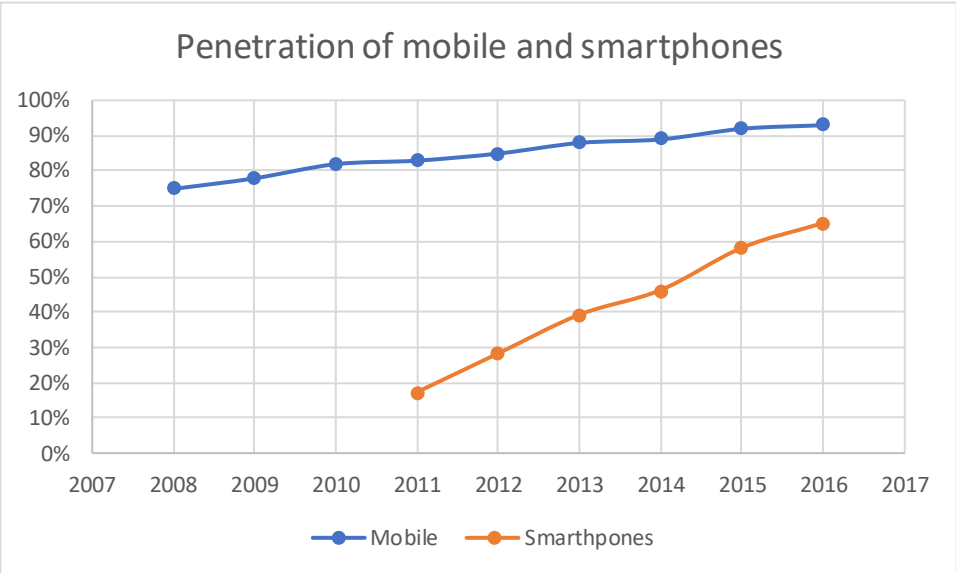


Figure 22: Penetration of mobile phones and smartphones

Orange and SFR have deployed the first LTE networks in 2012, followed by Bouygues at 2013. LTE coverage has reached 77.5% of total households in 2015, staying behind the EU average that is almost 86%. Table 11 shows the number of households covered by LTE and HSPA (end of 2016).

Table 11: Coverage of French households, at end of 2016

	LTE	HSPA
Households	23.2 Millions	29.8 Millions

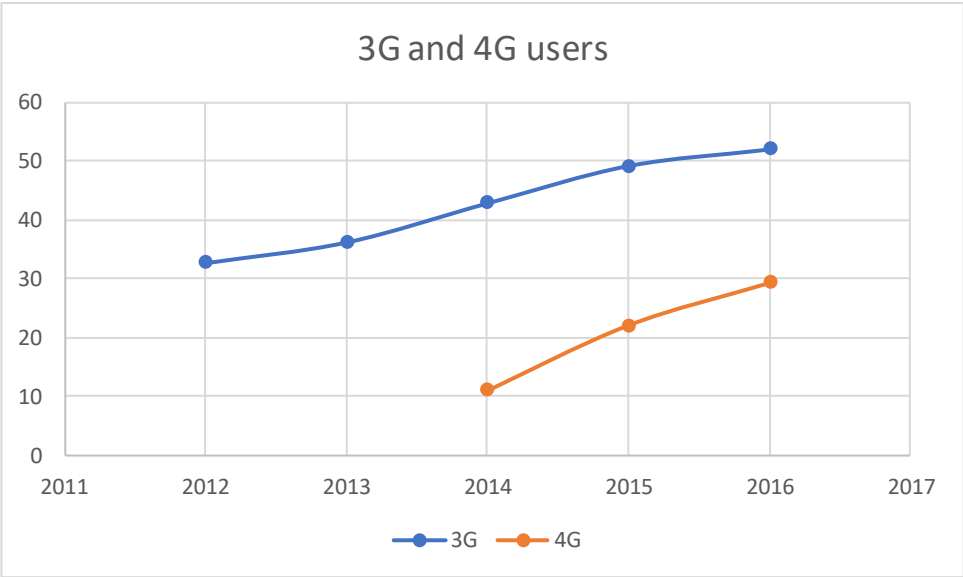


Figure 23: Number of 3G and 4G users in France

52 million users are using the 3G network, while the number using the 4G network is growing and has reached 30 million in 2016.

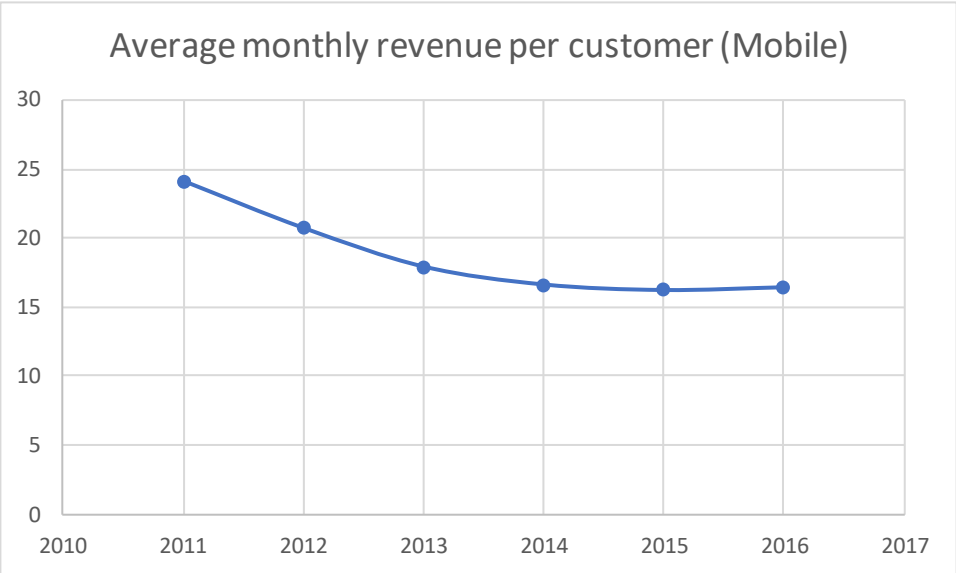


Figure 24: Average monthly revenue per customer (mobile) in France

The average monthly revenue per mobile customer has been declining over the last five years and at the end of 2016 was 16.4€ (Figure 24).

The monthly outgoing voice traffic continuous to growth, but at a much slower rate over the last two years. In 2016 each user generated 191 minutes of traffic (Figure 25). The number of messages sent monthly from users with a contract was 285 in 2016, while users with prepaid subscriptions sent 58 messages per month. The average calculation gives a value of 250 (Figure 26).

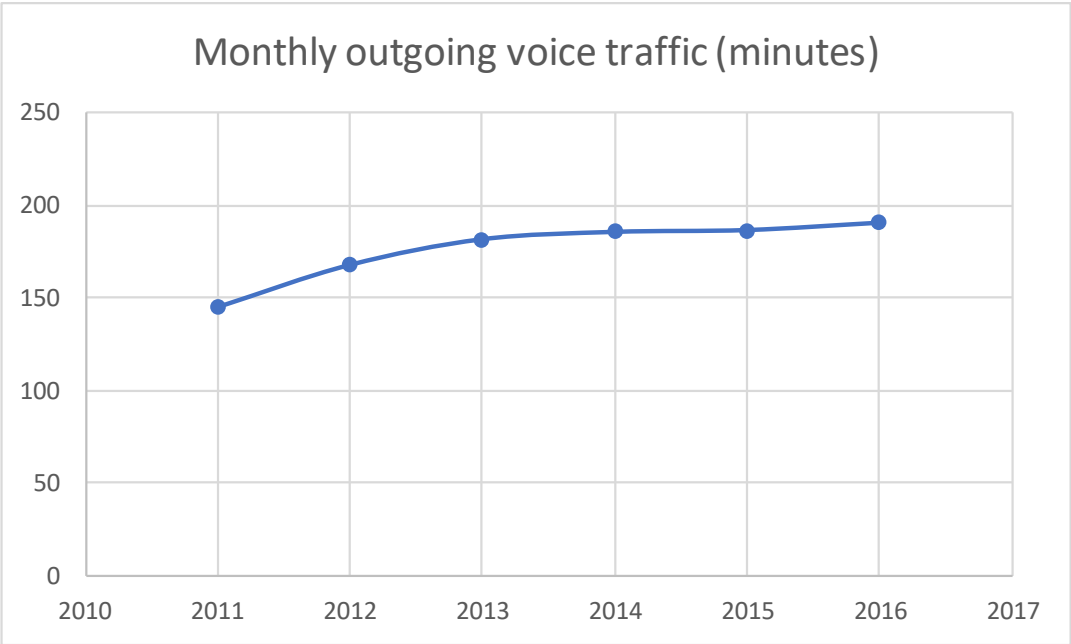


Figure 25: Monthly outgoing voice traffic in France

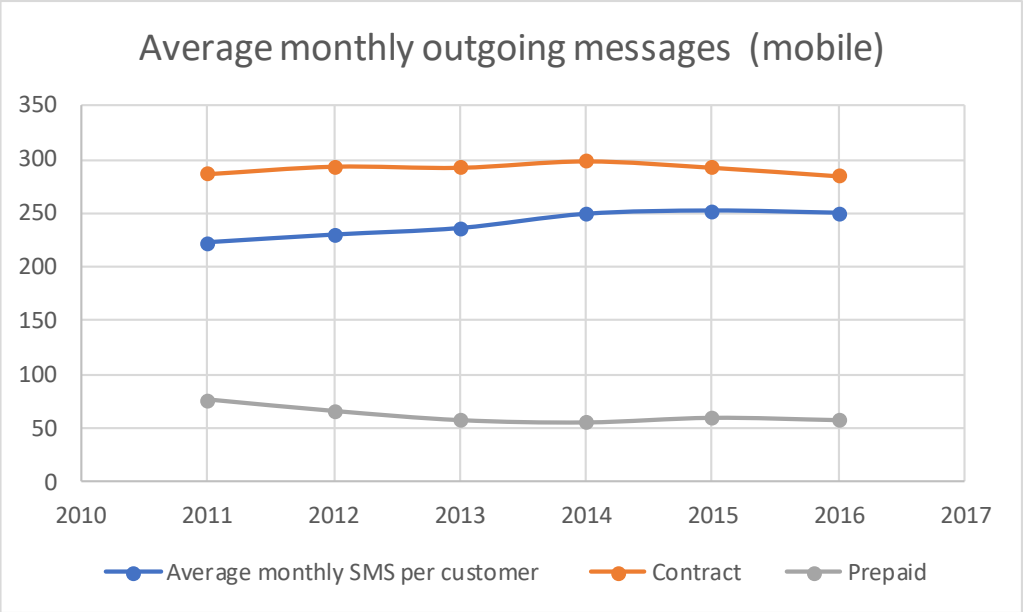


Figure 26: Average monthly outgoing messages (mobile) in France

The monthly data traffic per mobile customer continues to growth at a high rate, and at the end of 2016 was 1,334 MB, representing an increase of 64% over the previous year (Figure 27). The analysis shows that contract customers consume on average 1,565 MB of data and the pre-paid customers only 136 MB.

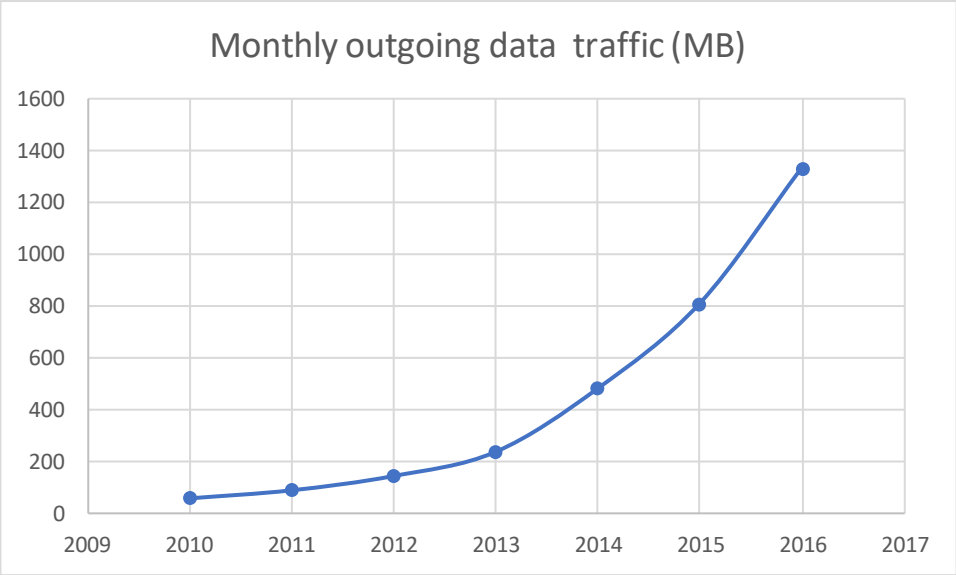


Figure 27: Monthly outgoing data traffic in France

7.2. UK

The United Kingdom has a total area of 248,514 square kilometres and a population of 64 million according to the 2016 data. The core of the population is located in the major cities, and the rural proportion is below 9%. The total number of households is 27.7 million with an average of 2.3 people living in each household. Table 12 summarises the general characteristics of UK.

Table 12: UK general characteristics[22]

Area (land)	248,514 km^2
Population	63.9 Millions
Households	27.7 Millions
Person per Household	2.3
Rural proportion	8.6%

7.2.1. Key Macroeconomic Indicators in UK

The United Kingdom [22] has the 4th largest GDP in the world and is the second biggest economy in Europe (behind Germany) in 2015. The annual growth of GDP for 2015 was 2.2% and the unemployment rate was at 5.3%. The general macroeconomic factors for UK are presented in the next table.

Table 13: Key macroeconomic indicators for UK[22]

KMI	2011	2012	2013	2014	2015	2016	2017
GDP annual variation (annual growth %)	1.5	1.3	1.9	3.1	2.2		
GDP in $ billion	2,611	2,655	2,721	3,002	2,858		
Registered unemployment level (%)	8.0	7.9	7.5	6.1	5.3		

GDP per capita (PPP $)	36,441	37,475	39,066	40,755	41,813		
Inflation rate (HICP)	4.5	2.8	2.6	1.5	0.0		

7.2.2. The UK in comparison with EU

The United Kingdom is one of the countries with the higher broadband coverage in the EU, the overall NGA coverage at 2015 at 90% was almost 20% higher than the average EU. In rural areas, the coverage is almost 50%, again with a difference of over 20% from the average EU number. UK comes third after Luxembourg and Netherlands in fixed broadband take-up with 85%, while the average EU28 is 72%. In mobile broadband UK ranks 7th and is above the EU average level [18], [19]. UK ranks 6th in EU in the DESI Index.

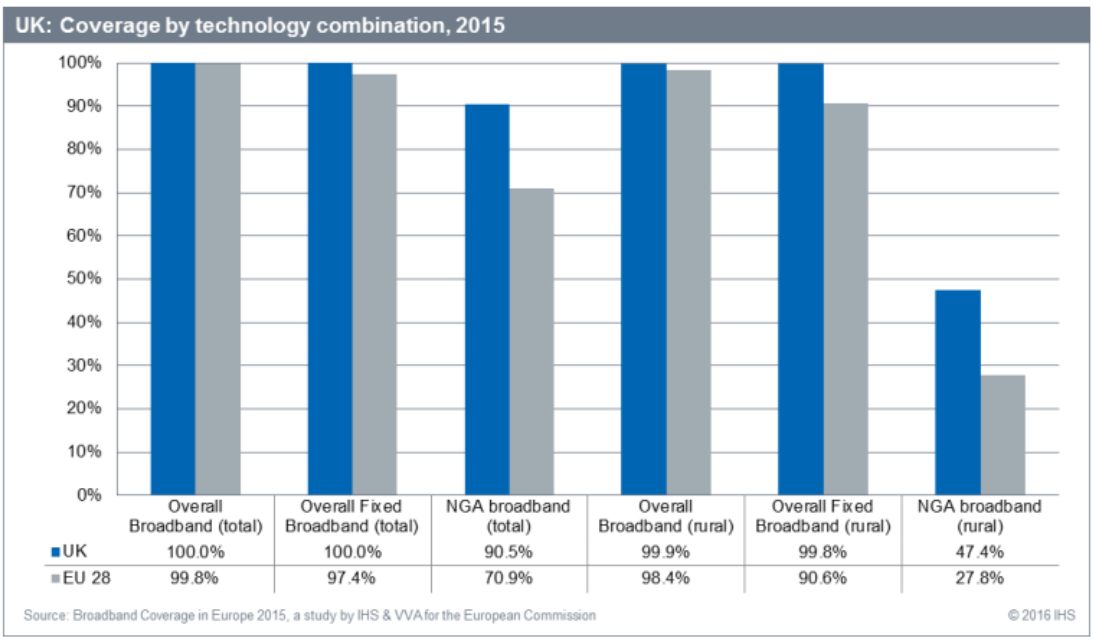


Figure 28: UK broadband coverage

7.2.3. The UK telecoms market

The total telecommunication revenues increased by £0.2 billion (retail and wholesale fixed and mobile voice and data services) in 2015 at £37.5 billion, and were the largest among all European countries, while the television related revenues (£14 billion) were ranked second (Germany was the first). The television industry faced an increase in revenues of 3% in 2016. The revenues by those industries are presented in the next figure. The average monthly spend per household on telecoms increased by 3% and represents 3.5% of the total expenses of each household. The data in the next figures are provided by OFCOM [23].

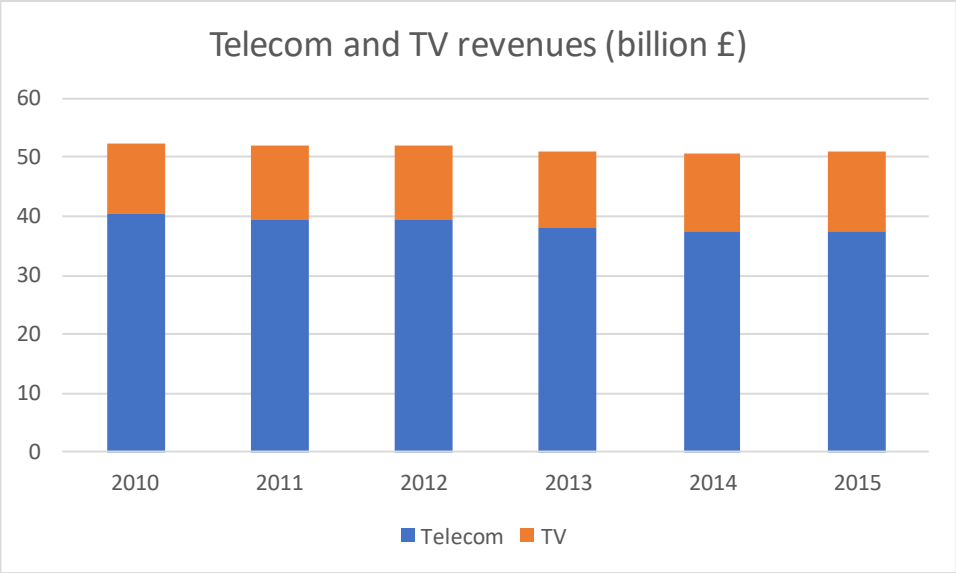


Figure 29: UK telecom and TV revenues

7.2.3.1. Fixed Market

British Telecom (BT) is the incumbent operator and has covered 23 million households with VDSL technology in 2015, allowing a high broadband coverage and competitive operators to sell commercial NGA services through BTs network.

The total number of fixed lines decreased to 33.3 million in 2015 (around 1%), while the fixed broadband connections are 24.7 million, with 9.2 million of them having speeds over 30 Mbit/s (Figure 30). From 2010 to 2015 there was a decline of around 2 million to the business connections, but these are compensated by the increase in the residential lines. This increase in the residential lines is due to the increase of fixed broadband take-up.

The UK has one of the biggest broadband coverage in Europe, achieving 90.5% coverage of total households in 2015. In Rural areas, the coverage is around 47%. The UK broadband market is dominated by DSL technology, with the most dominant technology for NGA being VDSL that has a coverage of almost 83%. Other broadband technologies in the UK market include cable networks (DOCSIS 3.0) with a coverage of 47%, and FTTP with only 1.5%.

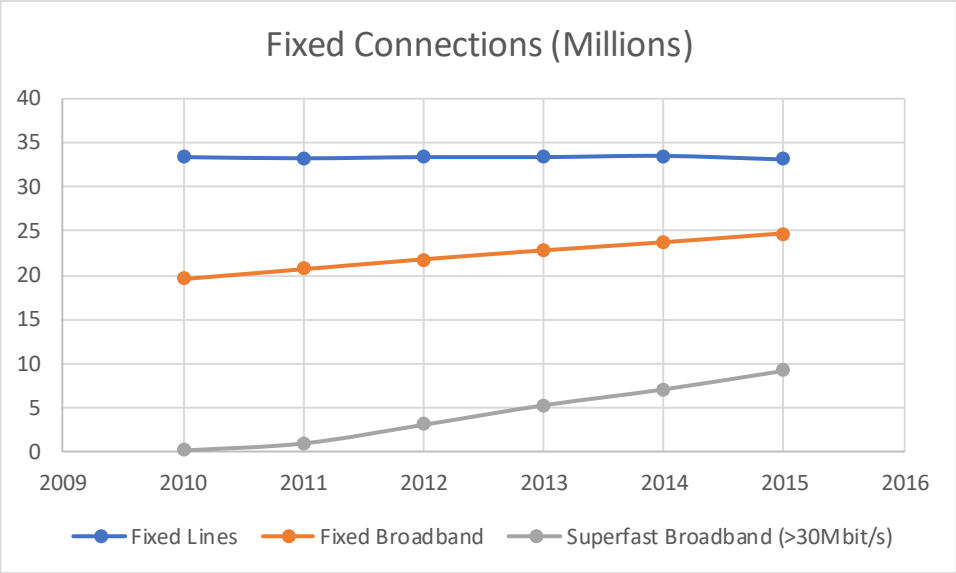


Figure 30: Number of fixed connections in UK

The rate of households with fixed telephony is at 86% (at 2016), the same as with the broadband take up (Figure 31).

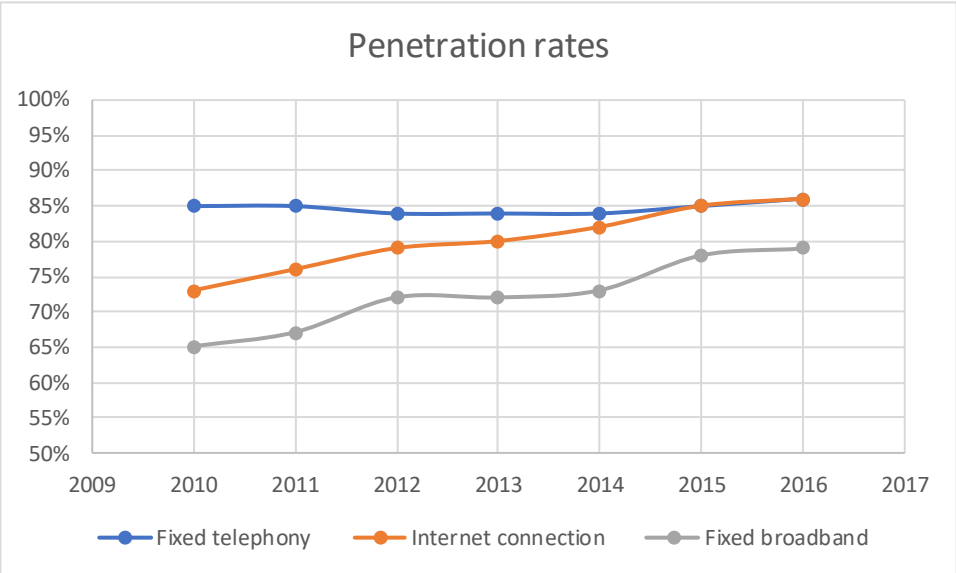


Figure 31: Penetration rates of telecom services in UK

The next figure illustrates the market shares of the major telecom operators that provide fixed broadband access. BT has almost one third of the market followed by Sky (23%) that continues to increase its market share. Virgin Media (19%) and TalkTalk (13%) each lost one percent as compared to their market shares the previous year.

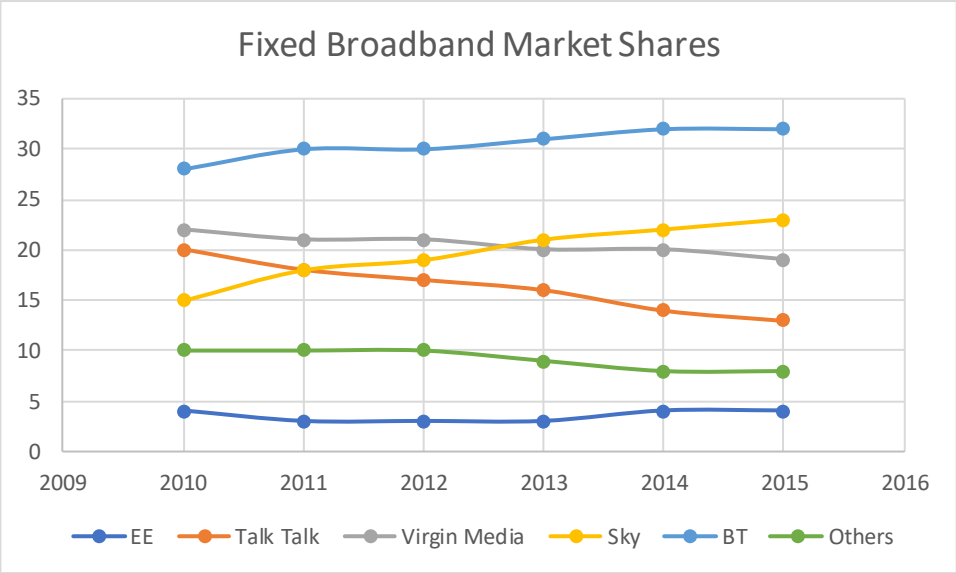


Figure 32: Fixed Broadband Market Shares in UK

Fixed revenue continues to increase with a total growth of 12% from 2010 to 2015. Almost all of this growth is related to the increased take-up of fixed broadband services. The main reason for this increase is the migration of users to high-speed connections that has an average cost of £10 higher than the standard broadband services. At the end of 2015, 37% of all fixed line broadband connections have advertised speeds of over 30 Mbit/s (Figure 33). In the UK, the overage income spent on standalone fixed broadband connections is 1.29% for connections up to 30 Mbps, and 1.79% for connections with speeds higher than 30 Mbps. In triple play connections, the percentages are 1.90% and 2.34% of the total income for connections below and over 30Mbps, respectively.

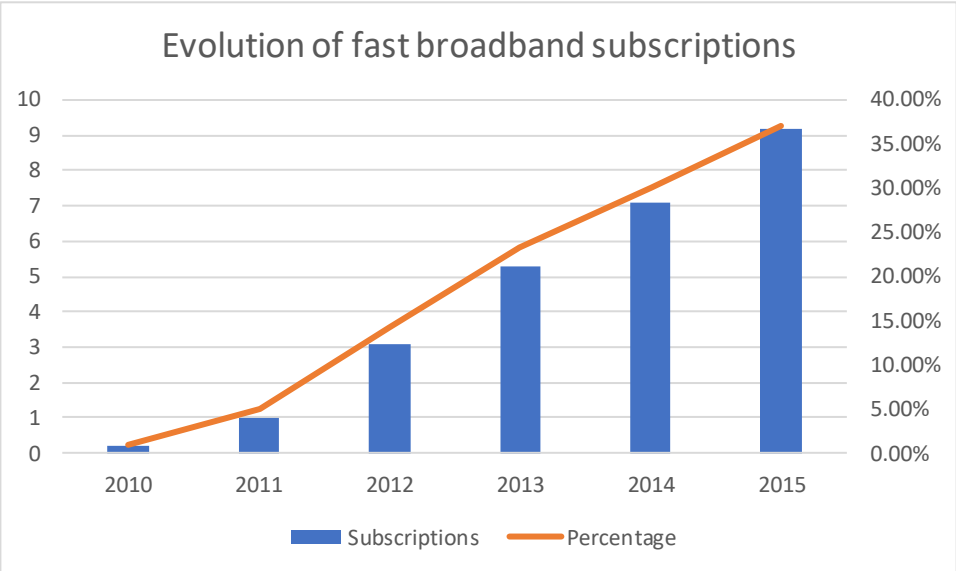


Figure 33: Fast broadband subscriptions in UK

The average monthly fixed broadband data usage continuous to evolve and in 2015 was at 82 GB (Figure 34), an increase of 40% over the previous year. This increase is associated with the growing popularity of high data consuming video services.

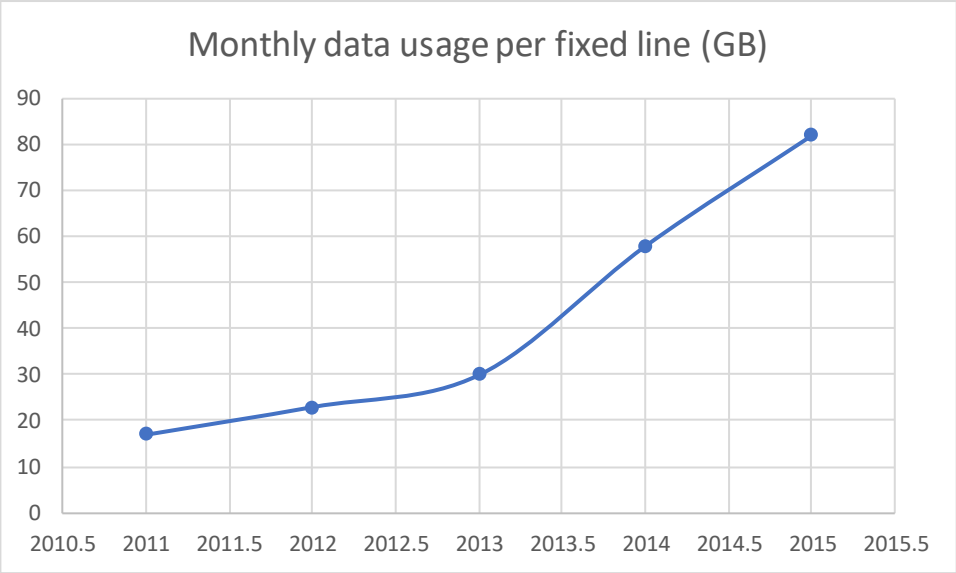


Figure 34: Monthly data usage per fixed line in UK

7.2.3.2. Mobile market

In the mobile sector, all 4 major operators (Vodafone, EE, Three and 02) provide LTE services. From the middle of 2016 over 99% of all UK households are covered by a 2G or 3G network of at least one operator. The coverage of 4G, which is still in the phase of being deploying by the four major mobile operators, is at 97.8%. The market shares of the mobile operators (Figure 35) are presented in the next figure. EE has the biggest number of subscriptions (29%) followed by O2 (27%) and Vodafone (19%). UK has a high number of MVNOs that have a total market share of 15%.

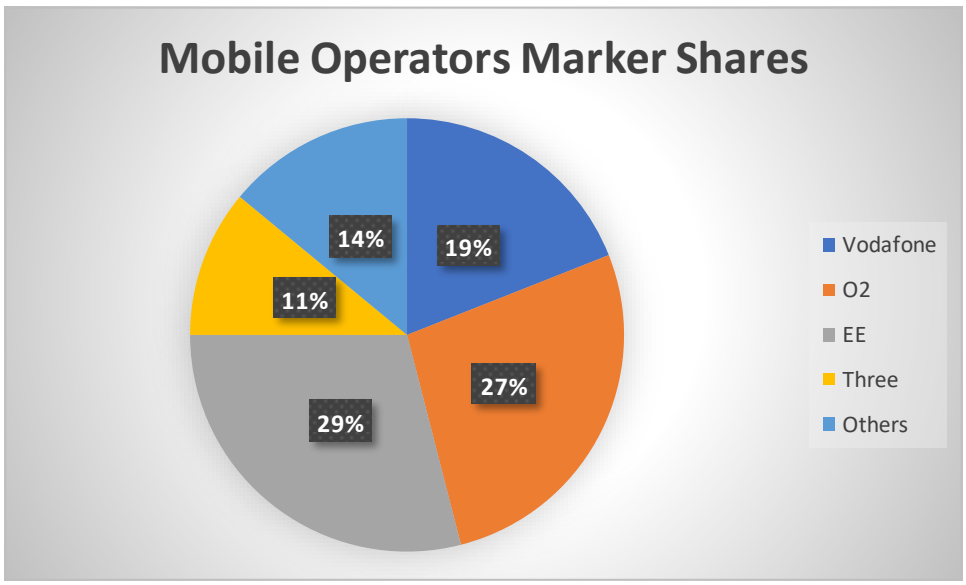


Figure 35: Market shares of mobile operators in UK

The total number of mobile subscriptions was 91.5 million in 2015, if we also include dedicated mobile data and M2M connections. This was an increase of 1.5 million connections as compared to the previous year's results.

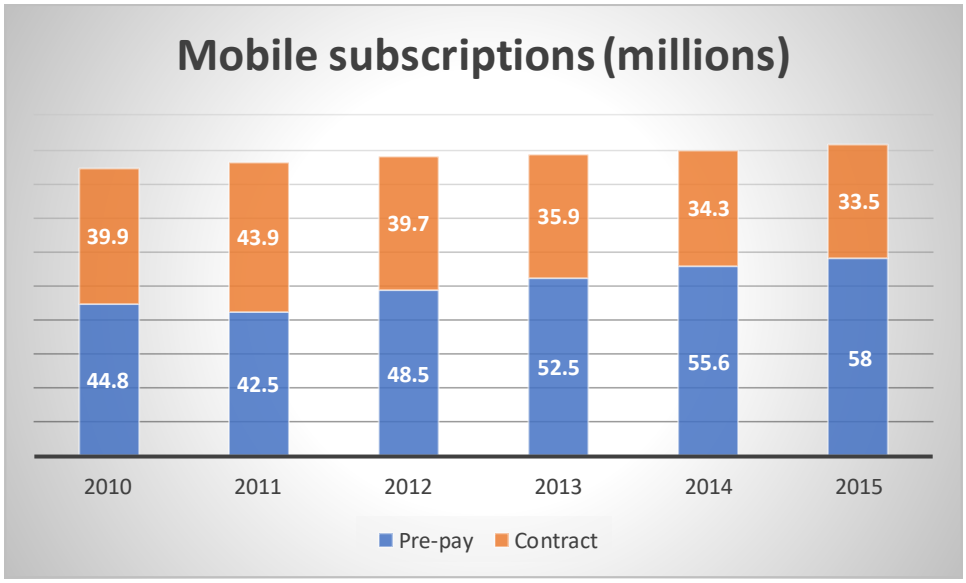


Figure 36: Mobile subscriptions in UK

Contract subscriptions continue to increase and are 64% of the total mobile subscriptions (Figure 36).

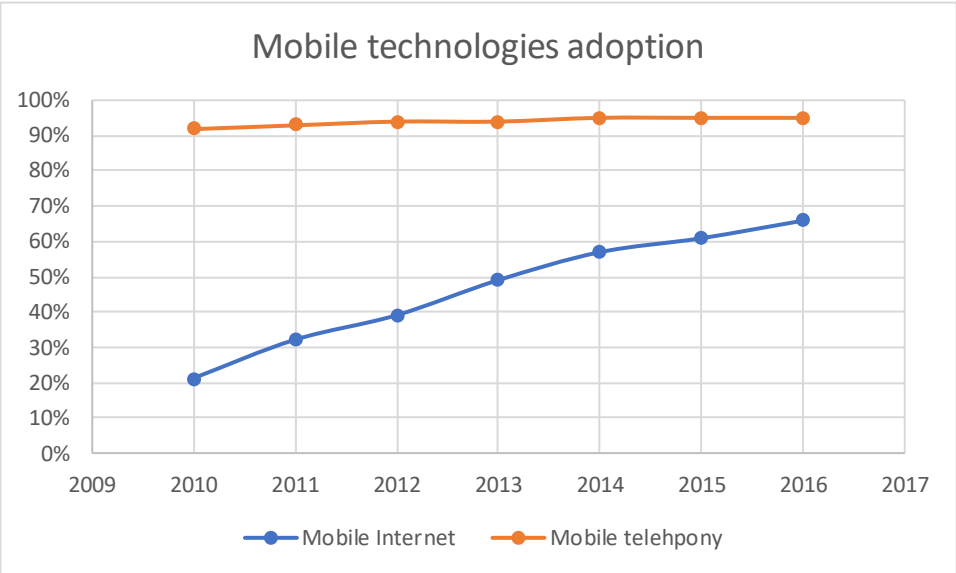


Figure 37: Mobile technologies adoption in UK

In Figure 37 an increase over the last five years in the adoption of mobile Internet is seen, and at the end of 2016 almost two thirds of the population are using it. This is closely related to the increase in the proportion of users that use smartphones. A percentage of 48% of all mobile users have a 4G subscription.

The average monthly revenue per subscriber for mobile services continues to decline and is £15; the erosion being lower on pre-paid (£4.75) and higher on contract subscriptions, which faced a fall of 4.4% and is at £22.1 (Figure 38).

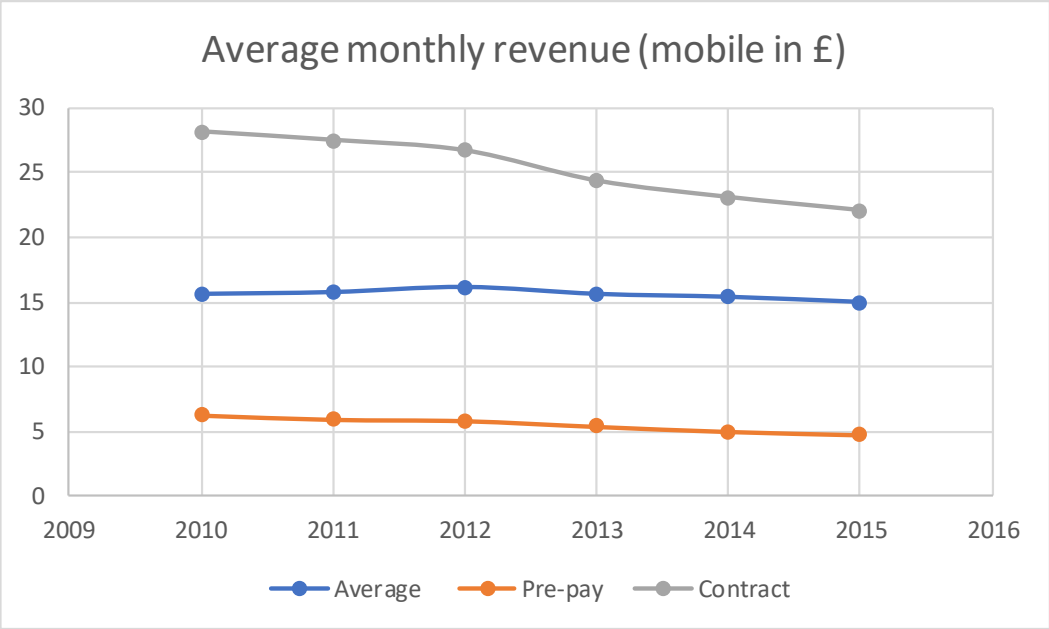


Figure 38: Average monthly revenue (mobile) in UK

Contract mobile customers produce each month 219 minutes of traffic, while pre-paid customers only reach 55 minutes. The average mobile user generates 151 outgoing traffic minutes per month (Figure 39).

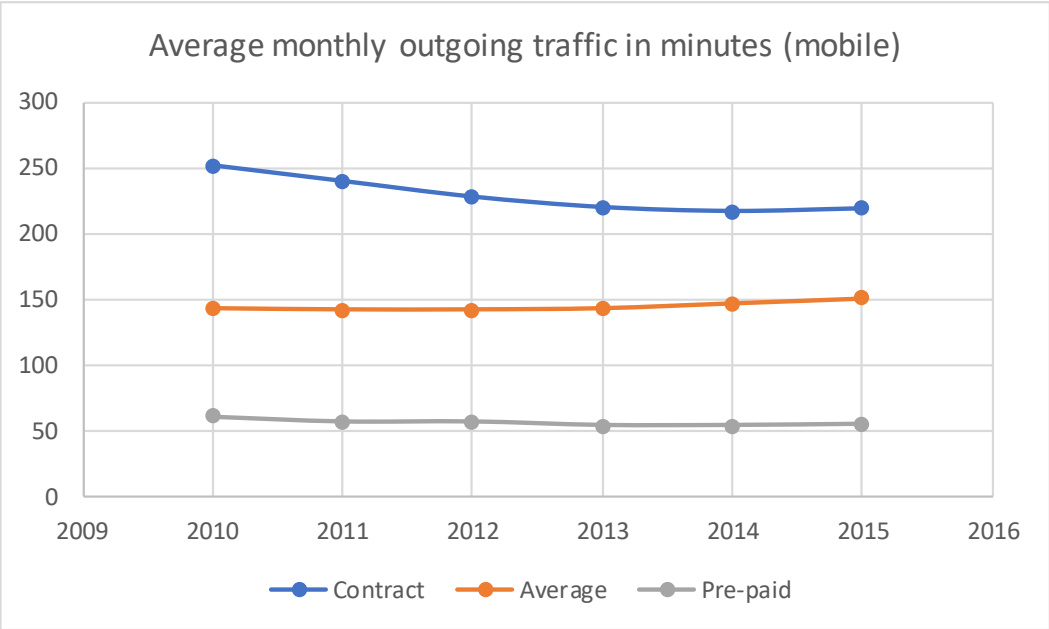


Figure 39: Average monthly outgoing traffic (mobile) in UK

Each contract subscriber sends 150 messages per month, while for pre-paid subscribers this number is reduced to 46. The average number of messages per month is 107 (Figure 40).

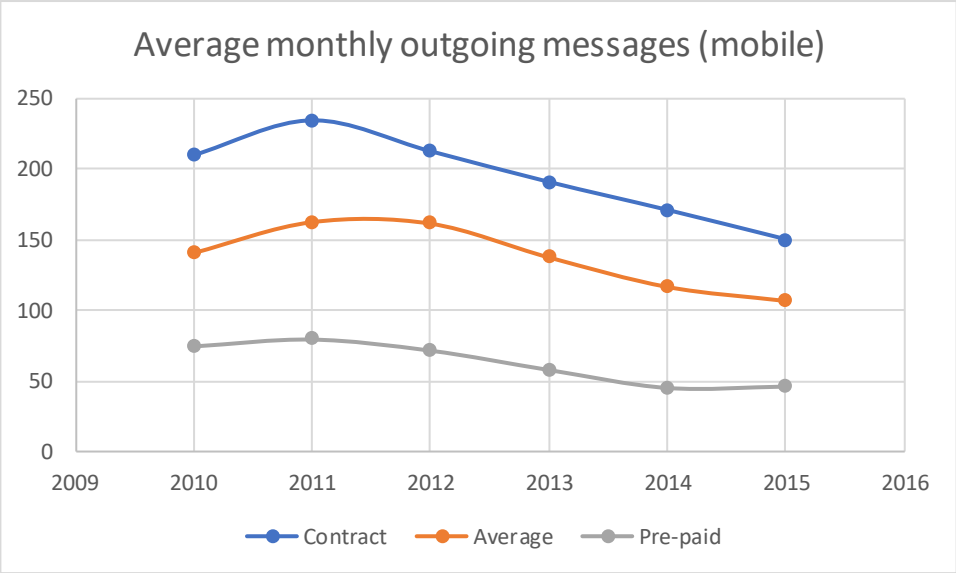
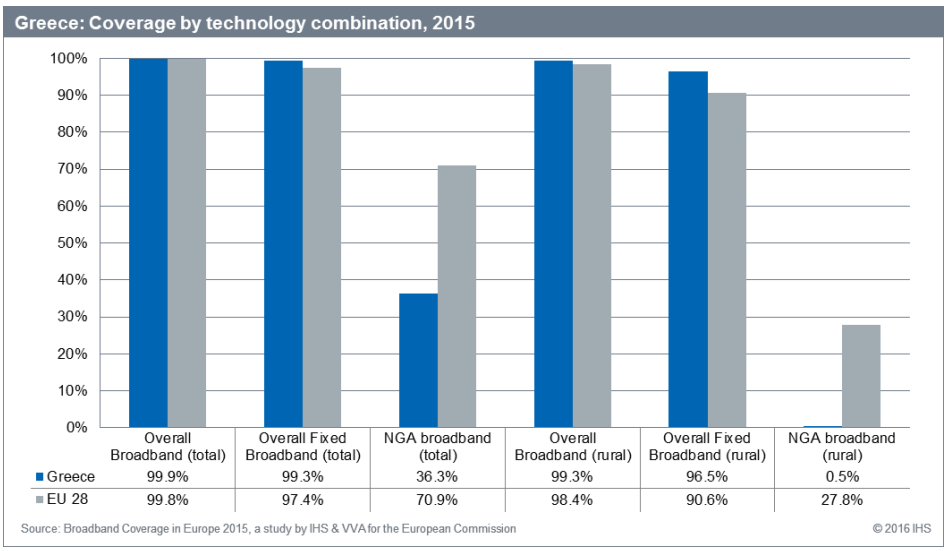


Figure 40: Average monthly outgoing messages (mobile) in UK

7.3. Greece

7.3.1. The Greek Sector in the European context

In 2015 Greece reported overall and fixed broadband coverage levels that exceeded the EU 28 average, but it continues to lag behind the vast majority of the EU countries in terms of NGA coverage [24]. Even though total NGA coverage grew by 2.3 percentage points during the first six months of 2015, high-speed broadband services were only available to 36.3% of Greek households.



	Overall Broadband (total)	Overall Fixed Broadband (total)	NGA broadband (total)	Overall Broadband (rural)	Overall Fixed Broadband (rural)	NGA broadband (rural)
Greece	99.9%	99.3%	36.3%	99.3%	96.5%	0.5%
EU 28	99.8%	97.4%	70.9%	98.4%	90.6%	27.8%

Figure 41: Overall broadband coverage in Greece (2015)

DSL networks covered nearly all households (99.3%) in Greece, unchanged from previous years. The incumbent, OTE, has been heavily investing in upgrading its DSL network, such that in the first six months of 2015, VDSL coverage grew by 2.3 percentage points to 36.1%, but still remained below the EU average of 41%.

With regards to mobile broadband technologies, HSPA remained at its 2014 near universal coverage level of 99.3%. LTE, on the other hand, recorded the most significant coverage increase amongst all technologies, with coverage increasing by almost 10 percentage points and reaching 79.8% of households. This increase can be attributed to the continued LTE roll-out by Cosmote (OTE's mobile branch) and Vodafone Greece and a newly launched Wind Hellas' LTE network.

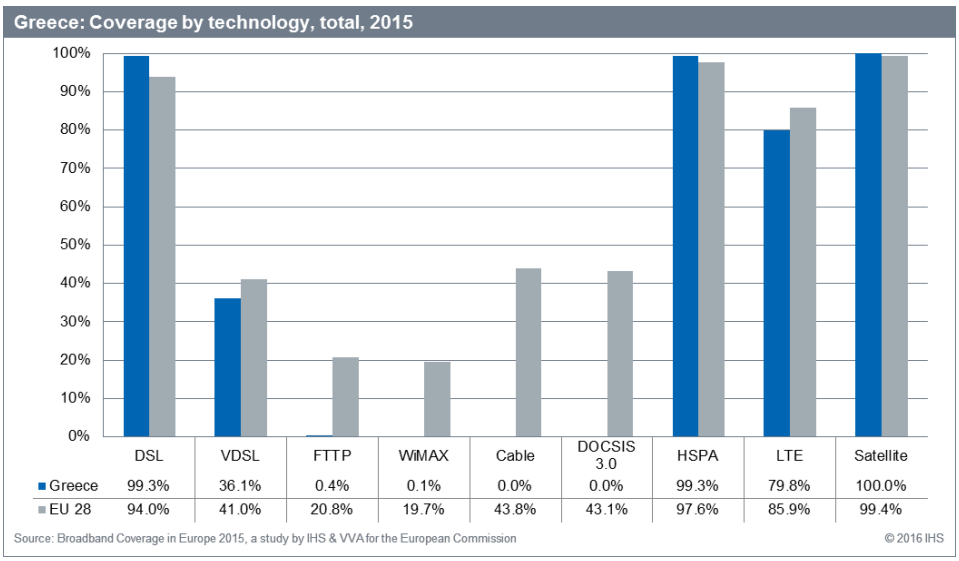


Figure 42: Broadband coverage by technology in Greece (2015)

Rural LTE coverage increased at broadly the same pace as the national coverage, with 32.3% of rural homes passed by LTE networks, representing a 9.2 percentage point increase as compared to 2014.

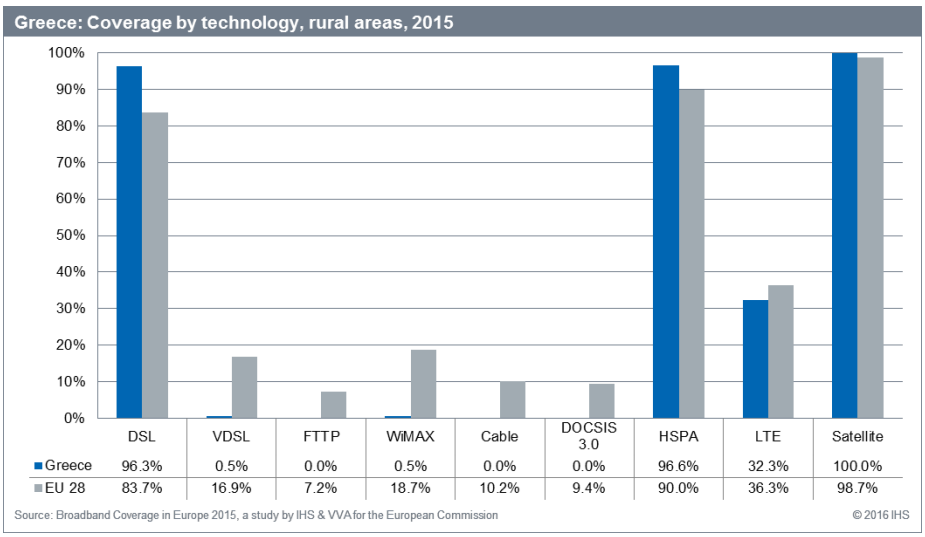


Figure 43: Broadband coverage by technology in rural areas of Greece (2015)

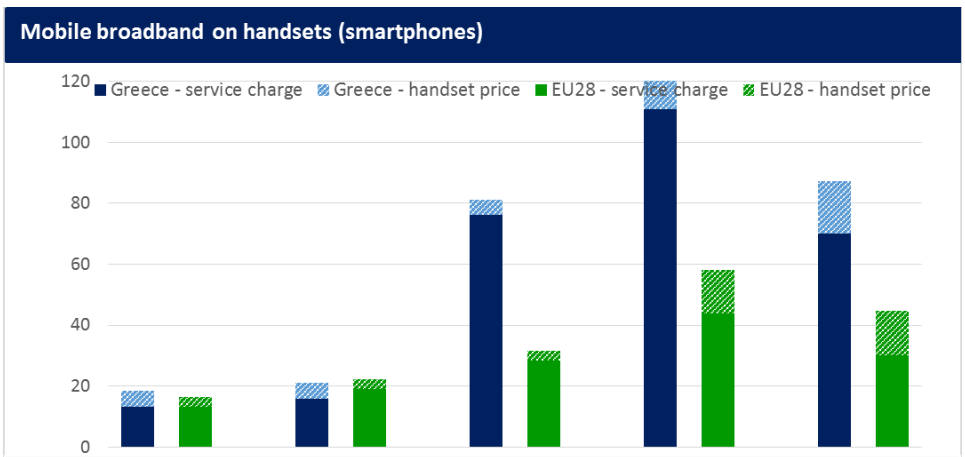
In the next figure a consolidated view of the broadband technologies in Greece and a comparison with the EU 28 is depicted [24].

Statistic	National
Population	10,903,704
Persons per household	2.5
Rural proportion	20.3%

	Greece 2015		Greece 2014		Greece 2013		EU28 2015	
Technology	Total	Rural	Total	Rural	Total	Rural	Total	Rural
DSL	99.3%	96.3%	99.3%	96.3%	99.2%	97.7%	94.0%	83.7%
VDSL	36.1%	0.5%	33.8%	0.5%	26.7%	0.0%	41.0%	16.9%
FTTP	0.4%	0.0%	0.4%	0.0%	0.4%	0.0%	20.8%	7.2%
WiMAX	0.1%	0.5%	0.1%	0.4%	0.0%	0.2%	19.7%	18.7%
Cable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	43.8%	10.2%
DOCSIS 3.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	43.1%	9.4%
HSPA	99.3%	96.6%	99.3%	96.6%	99.5%	96.5%	97.6%	90.0%
LTE	79.8%	32.3%	70.2%	23.1%	54.8%	11.8%	85.9%	36.3%
Satellite	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.4%	98.7%
Overall broadband	99.9%	99.3%	99.9%	99.3%	99.9%	98.8%	99.8%	98.4%
Overall fixed broadband	99.3%	96.5%	99.3%	96.4%	99.6%	97.8%	97.4%	90.6%
NGA broadband	36.3%	0.5%	34.0%	0.5%	26.9%	0.0%	70.9%	27.8%

Figure 44: Broadband coverage in Greece (2015)

Regarding mobile broadband service and handset prices, shown in the next figure, except for the two lowest usage profiles on handsets, prices in Greece are systematically more expensive than the average prices in EU28 (around 60% more expensive on average, excluding handsets and equipment and including voice and SMS for the handset offers) [25]. The difference is however much less pronounced for the 5GB and 10GB offers. For these high usage profiles, prices in Greece are only about 10 to 15% more expensive than the EU 28 average.



MB	102.4	512	1024	2048	2048
Min	60	200	600	1800	200
SMS	100	140	225	350	140
Handset	Basic	Basic	Basic	Advanced	Advanced

Figure 45: Greece: mobile broadband on handsets (2015)

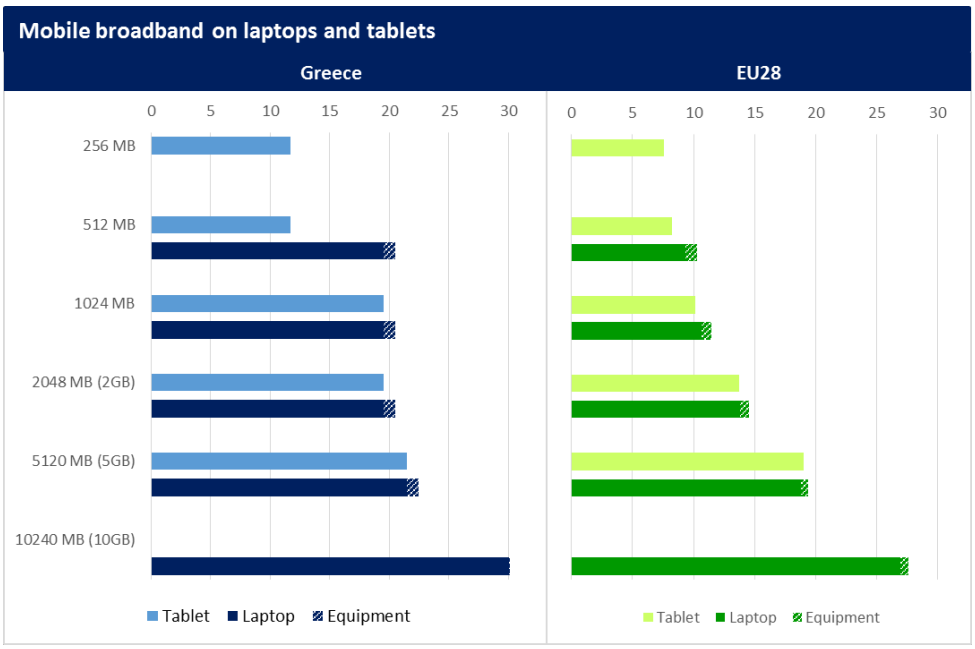


Figure 46: Greece: mobile broadband on laptops and tablets (2015)

7.3.2. National Broadband Coverage and Future Plans

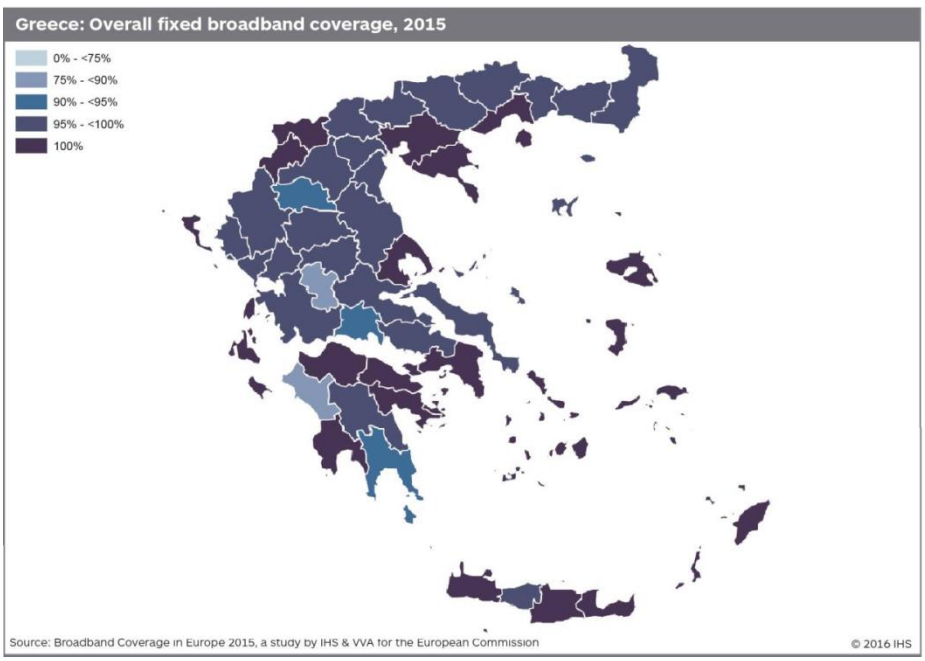


Figure 47: Overall fixed broadband coverage in Greece (2015)

Most regions recorded fixed broadband coverage rates exceeding 98% [24]. Two clear exceptions were Ileia and Evrytania, which were the only two regions with fixed coverage rates lower than 90%. It is also worth noting that the Greek island regions (such as Zakynthos, Lefkada, or Kerkyra) offer complete or almost complete fixed broadband coverage, while more variation was observed in mainland regions.

NGA coverage was more varied, with most regions recording coverage levels between 20% and 50%. NGA coverage exceeded 50% in only four regions (Evros, Xanthi, Rodopi and Serres) with no regions reporting

NGA coverage of less than 10%. The most substantial increase in NGA broadband coverage (4.4 percentage points) was reported in Attiki.

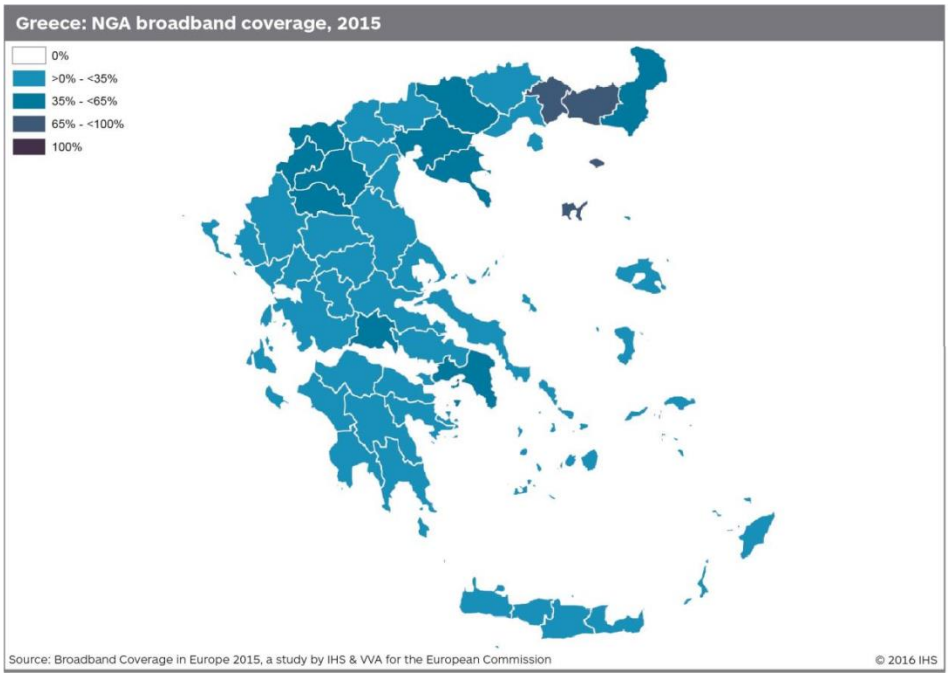


Figure 48: NGA broadband coverage in Greece (2015)

The National Broadband Plan NGA 2014-2020 [26] is the key document guiding national policy for the development of broadband infrastructure and digital economy. The plan has two long-term objectives in line with the Digital Agenda targets:

- Universal availability of 30 Mbps access by 2020;
- Availability of 100 Mbps connections to at least 50% of households by 2020.

The plan also includes specific steps aimed at achieving the objectives and closing coverage gaps between urban and rural areas with the help of fibre-optic networks, such as reduction of investment cost, simplification of administrative procedures and coordination of NGA networks deployment.

7.3.3. The Greek Telecommunications Market

The Greek telecommunications market (fixed and mobile) during 2015 was at a constant shrinking phase with investment, as a percentage of the turnover, being significantly limited [26]. It is worthwhile to note that the telecommunication sector has been seriously affected by the economic downturn, and the telcos are in a particularly unfavourable position, with restricted cash options for new investments. Having been strongly affected by the harsh economic environment, in general, and having received loans that cannot be served, they have started to discuss redemption and merge scenarios.

The main players in the Greek Telecom Market at the 2015 point of time were:

- OTE-Cosmote Group
- Vodafone-HOL
- Wind
- Forthnet
- Cyta-Hellas

With the exception of investment by the OTE Group (in VDSL and 4G), by Vodafone (in 4G) and Wind (in 4G), the remaining providers have practically frozen their investment activities (limiting themselves to low cost investment, mainly for the provision of VDSL services through the Central Offices).

OTE is the only provider that has invested in infrastructure for the provision of NGA services through VDSL technologies through the street cabinet, providing such services both to the retail and wholesale market. It must be noted that while in ADSL and VDSL, provided through the Central Office, actual speeds are, in general, lower than the theoretical ones; in VDSL, through the street cabinet, actual speeds are not much different from the theoretical ones, at least in urban environments, where distances from the street cabinet are small. Despite the fact that the relevant regulatory framework exists, which would allow other providers to engage in joint installation on a cabinet level, none has implemented any such infrastructure so far.

The market share of broadband connections at the end of 2015 Q1 was as follows [26]:

Table 14: Market share of broadband connections in Greece (2015)

OTE	44.1%
Forthnet	17.7%
HOL	15.4%
Wind	13.1%
Cyta	9.0%
On Telecoms	0.8%

Regarding fixed telephony, the number of operators has been constantly reducing since 2006, whereas the number of mobile operators has remained almost fixed, as shown in the following table:

Table 15: Number of operators in Greece [27]

Operators	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fixed telephony	13	14	14	14	11	11	11	9	8	8	6
Mobile telephony	4	4	4	3	3	3	3	3	3	4	4

7.3.4. Financial Data for the Greek Telecommunications Market

In 2015, the Greek telecommunications industry turnover reached 4.5 billion euros [27]. OTE's turnover has increased by 1.6% due to an increase of the revenues from fixed and mobile telephony services.

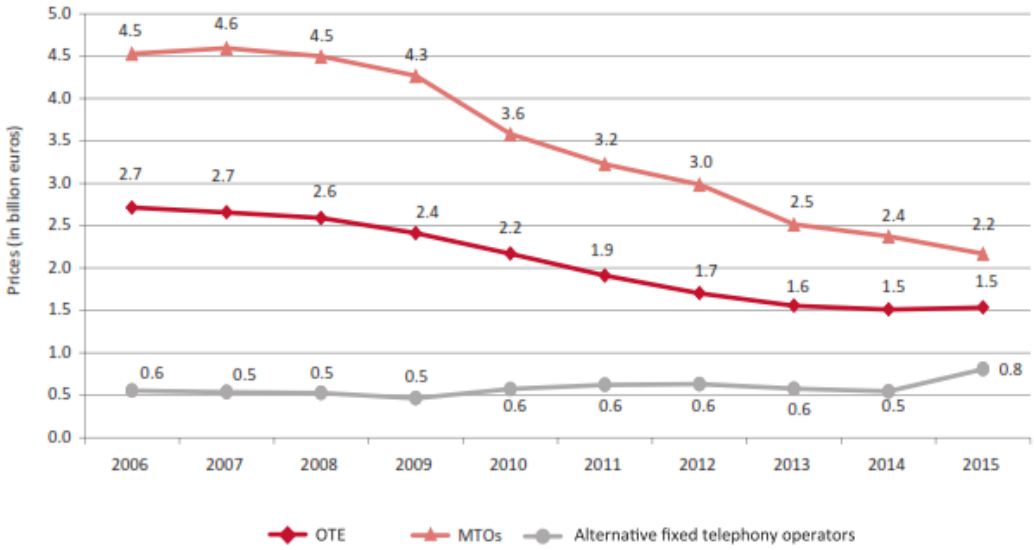


Figure 49: Turnover of fixed & mobile telephony operators in Greece

Regarding the largest fixed and mobile telephony operators, their investments represent 5% to 20% of the value of their total revenues, as shown in the following figure.

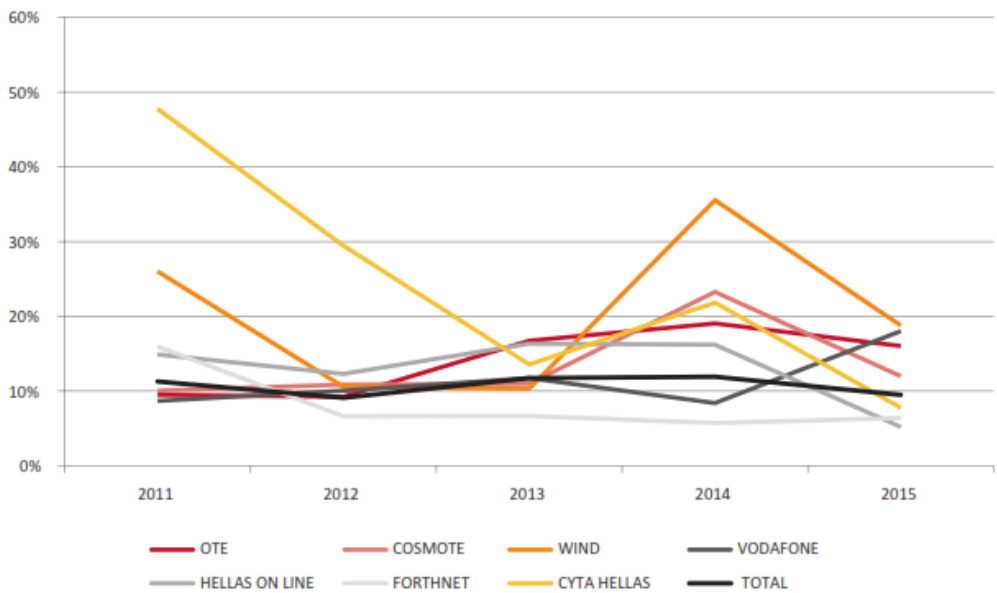


Figure 50: Investments / Turnover ratio in Greece

The profits before interest, tax and amortisations (EBITDA) of the major fixed and mobile telephony operators decreased by 12% in 2015 as compared to 2014. It is worth mentioning that compared to 2008 and taking into account the outcome of mergers and acquisitions, the EBITDA profitability index was decreased almost by half, from approximately 2 to 1.1 billion euros as shown in the next figure.

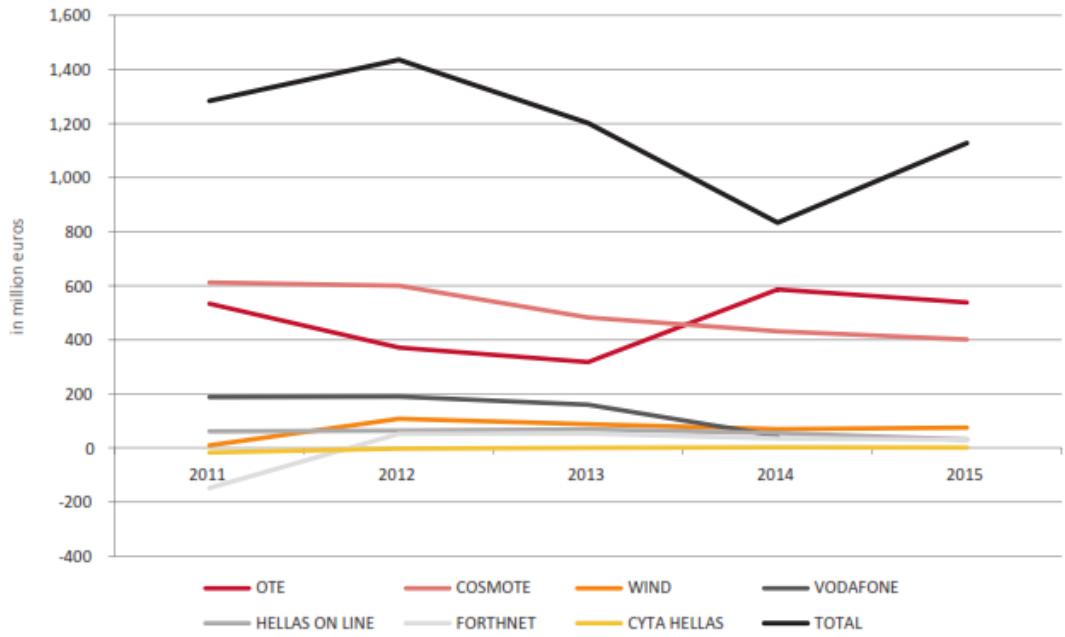


Figure 51: Earnings before interests, taxes, depreciation and amortization (EBITDA) in Greece

7.3.5. Fixed Communications

In December 2015, the number of access lines to the public telephone network at a fixed location was 4,748,802 (43.7% penetration over the general population), as compared to 4,758,271 in December 2014 marking an additional small decrease of 0.3% and an overall decrease of 14% compared to the end of 2005 (5,518,683). These lines include OTE's Managed VoIP, PSTN and ISDN lines as well as those of the alternative operators.

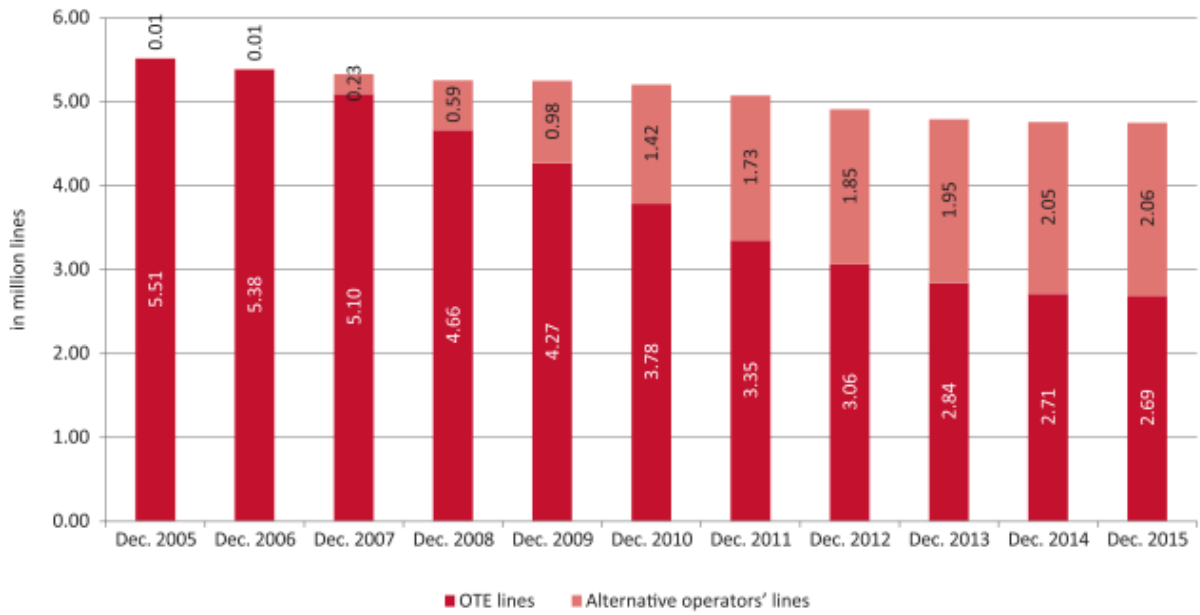


Figure 52: Progress of fixed telephony lines in Greece

The duration of the fixed to mobile calls increased for the second consecutive year (12.8% in 2015 and 6.3% in2014), as shown in the following figure.

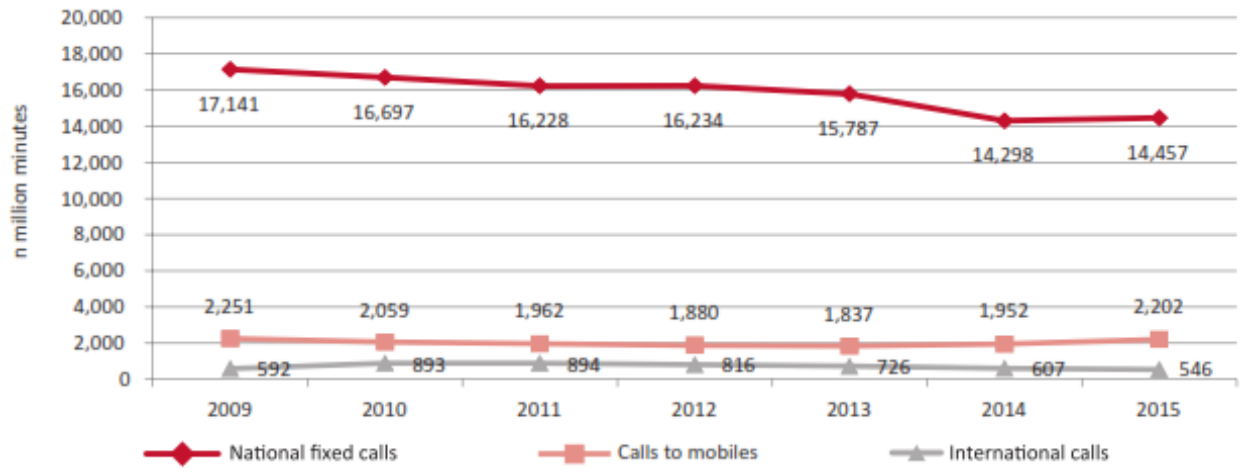


Figure 53: Fixed outgoing traffic for the main call types in Greece

In 2015, the retail revenues from rendering telephony and Internet services at a fixed location were 1.4 billion euros, decreased by 3.5% compared to 2014.

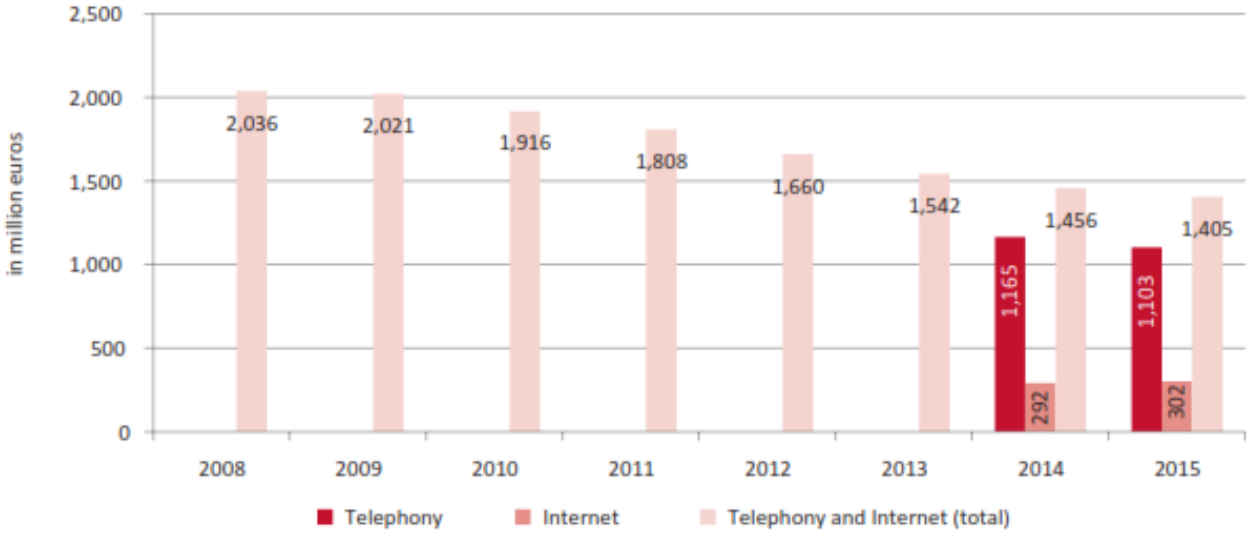


Figure 54: Retail revenues from the provision of telephony and Internet services at a fixed location in Greece

7.3.6. Mobile Communications

In 2015, the total mobile telephony subscriptions slightly dropped by 0.8% to 15.4 million at the end of the year compared to 15.5 million subscriptions at the end of 2014. Conversely, the number of active subscriptions/connections increased by 3.5%, from 12.1 to 12.6 million connections.

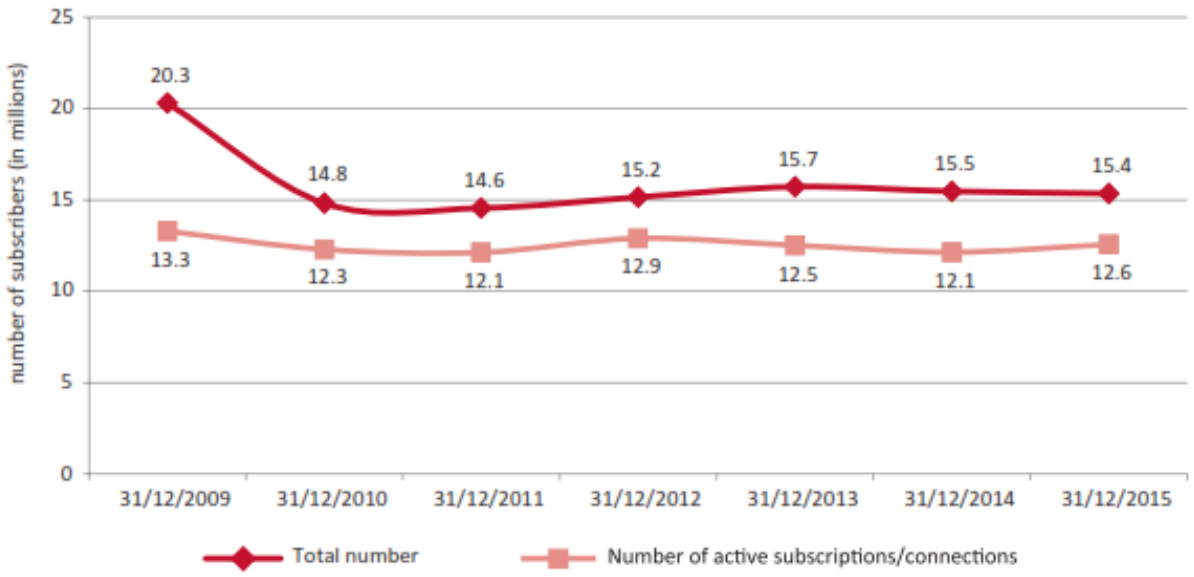


Figure 55: Mobile telephony connections/subscriptions in Greece

Both post-paid and pre-paid connections remained roughly at the same levels of 2014 (4.2 million post-paid subscribers and 11.2 million pre-paid users). The number of active pre-paid connections increased by 5.4%, from 7.9 million at the end of 2014 to 8.4 million at the end of 2015. Regarding the MTO's shares over the total number of subscribers, COSMOTE's share slightly increased (from 44.5% at the end of 2014 to 45.2% in 2015), VODAFONE's share rose considerably (from 30.4% to 35.1%), while WIND's share dropped proportionately from 25% to 19.5%.

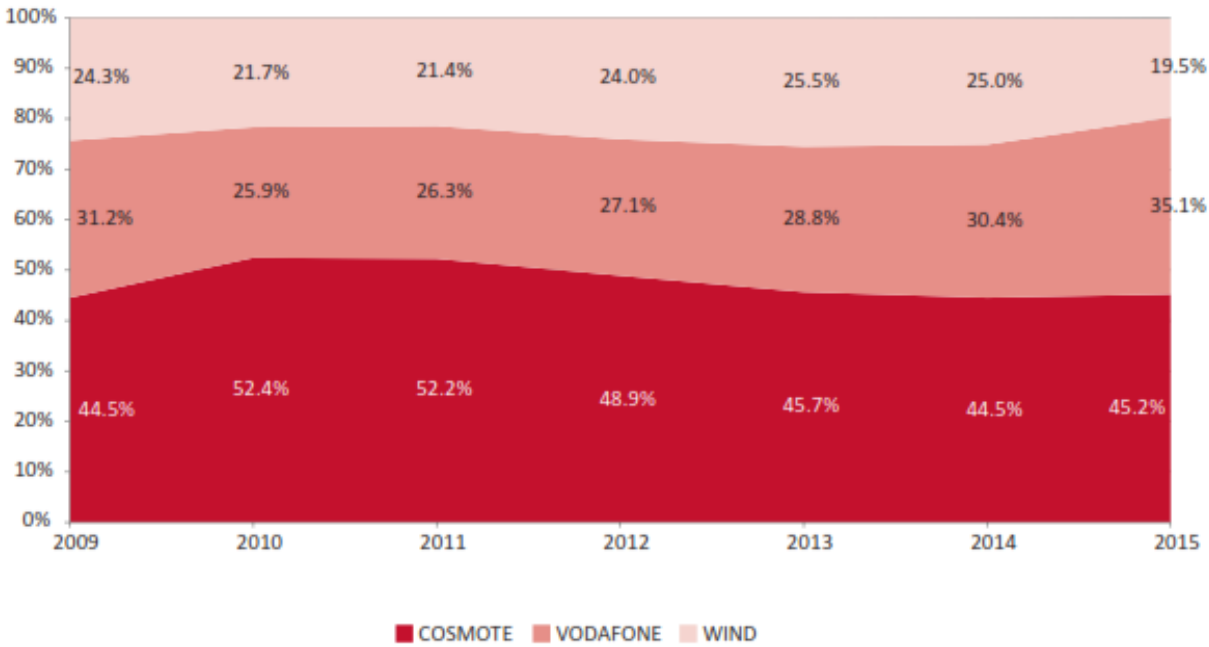


Figure 56: MTOs' market shares over the number of mobile telephony connections in Greece

In 2015, data services via mobile telephony networks increased significantly by 69%, reaching 35.9 billion MB compared to 21.2 billion MB in 2014. The majority of data was transferred via mobile phones (73%), while the remaining 27% was transferred via other portable devices using datacards.

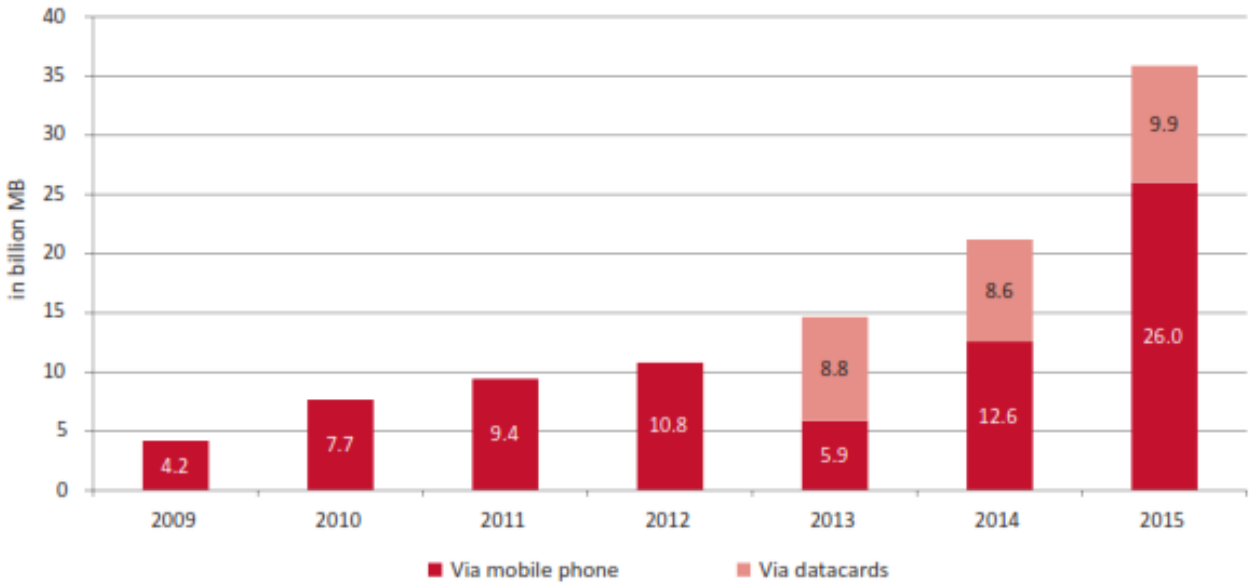


Figure 57: Total number (MB) of data services in Greece

It is worth mentioning that the average use of data services from mobile phones in 2015 jumped to 485 MB per month during the second semester of the year compared to 397 MB per month in the first semester.

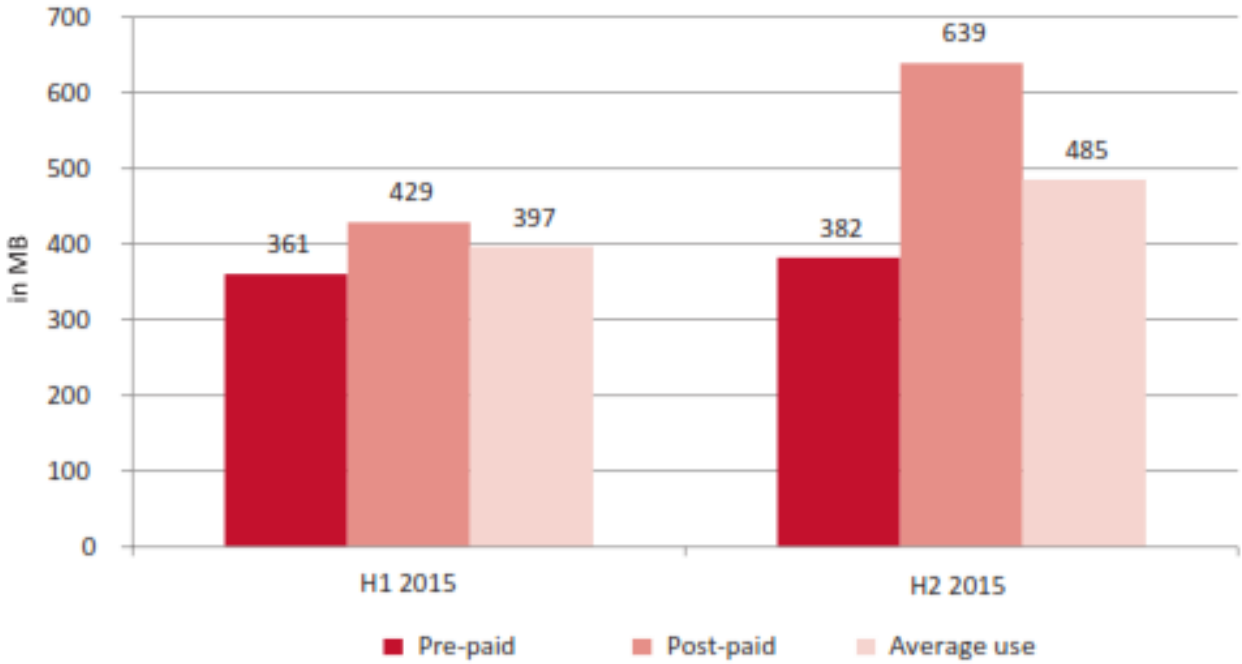


Figure 58: Average use of data via mobile phones in Greece in 2015

In 2015, the mobile telephony retail revenues (post-paid and pre-paid) decreased slightly by 4.7% and amounted to 1.66 billion euros (as compared to 1.74 billion euros in 2014).

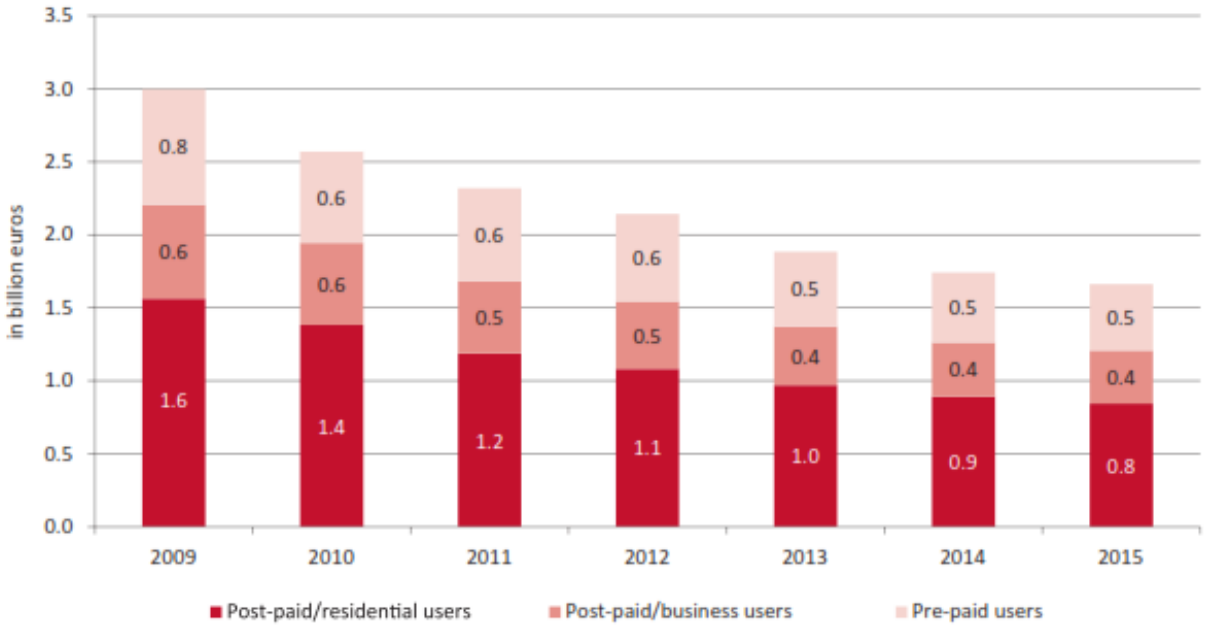


Figure 59: Mobile telephony retail revenues in Greece

Finally, the average annual revenue per post-paid and prepaid user for 2015 was 287 euros (down by 3.6%) and 56 euros (down by 6.2%) respectively.

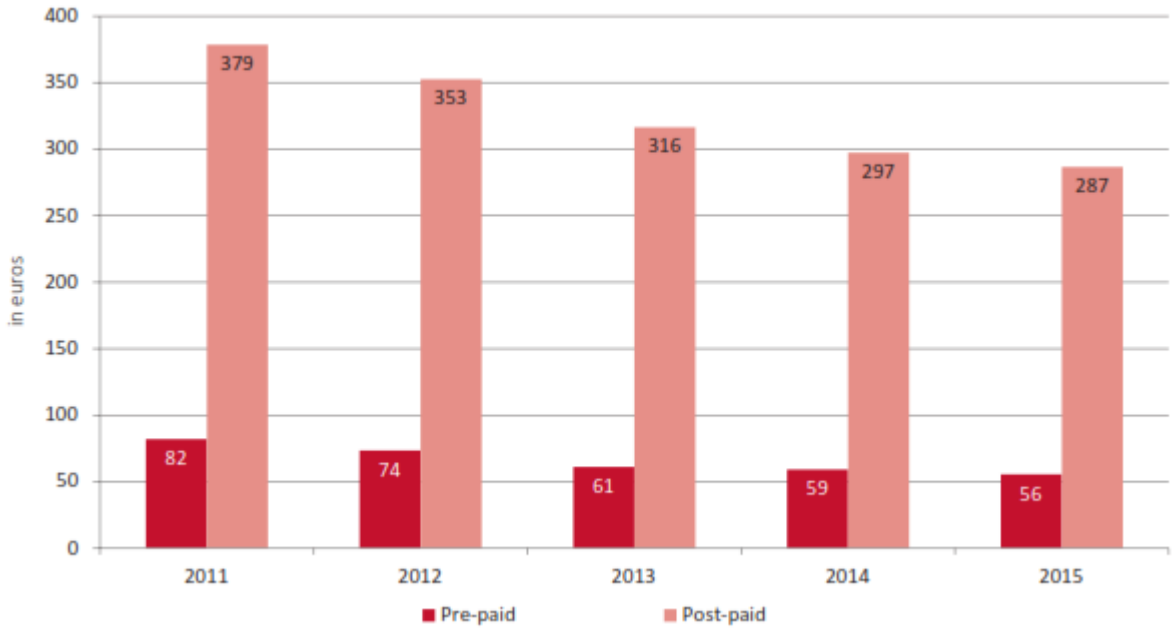


Figure 60: Average revenue per mobile user in Greece

7.4. Slovenia

7.4.1. Key Macroeconomic Indicators in Slovenia

International institutions expect economic growth in the euro area to maintain its pace. The UK's decision to leave the EU (Brexit) has not significantly affected business results or the stability of the financial market

thus far. The forecast for the domestic environment assumes that the economic policies planned, including fiscal consolidation, will continue. Given the improved situation in the banking system, we have also assumed that there will be a rebound in bank lending to the corporate sector, as well as a further increase in the importance of nonbanking and internal sources of funding. All this will support Slovenia's further economic growth, which has strengthened in recent quarters and become broad-based.

The autumn forecast for GDP growth in 2016 and the two years that follow envisages a continuation of favourable economic trends; GDP growth dynamics will be marked primarily by government investment related to the absorption of EU funds. The forecasts for GDP growth are 2.3% in 2016, 2.9% in 2017 and 2.6% in 2018. Exports will remain the key driver of economic activity over the entire forecasting period. They will continue to be fuelled by not only the expected growth in foreign demand, but also competitiveness gains in the tradable sector. Economic growth is becoming broad-based as the contribution of domestic consumption gradually rises. Household consumption is therefore expected to increase significantly in 2016, with a marked improvement in labour market conditions and a high level of consumer confidence, and these positive trends will also continue in 2017 and 2018.

KMI	2012	2013	2014	2015	2016	2017	2018
GDP (real growth %)	-2.7	-1.1	3.1	2.3	2.3	2.9	2.6
GDP in € million (current prices)	36,003	35,917	37,332	38,570	40,004	41,416	42,885
Registered unemployment level (%)	12.0	13.1	13.1	12.3	11.2	10.2	9.5
Labour productivity (GDP per employee)	-1.8	0.0	2.6	1.2	0.4	1.5	1.5
Inflation (at the end of the year)	2.7	0.7	0.2	-0.5	1.1	1.4	1.5
Inflation (annual average)	2.6	1.8	0.2	-0.5	0.1	1.4	1.5
Private consumption (real growth %)	-2.5	-4.0	2.0	0.5	2.3	2.2	2.0
State consumption (real growth %)	-2.2	-2.1	-1.2	2.5	2.0	1.3	0.7

Table 16: Key macroeconomic indicators in Slovenia

Favourable labour market trends will persist, but they will be increasingly characterised by demographic change. In 2016 employment continues to rise, not only in most private sector activities but also in the public sector owing to the relaxation of hiring restrictions. Given the improvements to the indicator for expected employment, employment growth should be significantly higher in 2016 (at 1.9%) than in 2015.

Nominal growth in average earnings will hover around 2.0% in 2016 and the next two years; it will rise steadily in the private sector, but will slow down in the public sector.

Although consumer prices will rise in the next two years, inflation will remain relatively low. In 2016 average consumer prices will remain unchanged, mainly due to the influence of the low price of oil. The impact of energy prices on the total price decline is gradually easing. Core inflation is rising slightly, fuelled by the higher prices of services, while the average prices of non-energy goods remain unchanged.

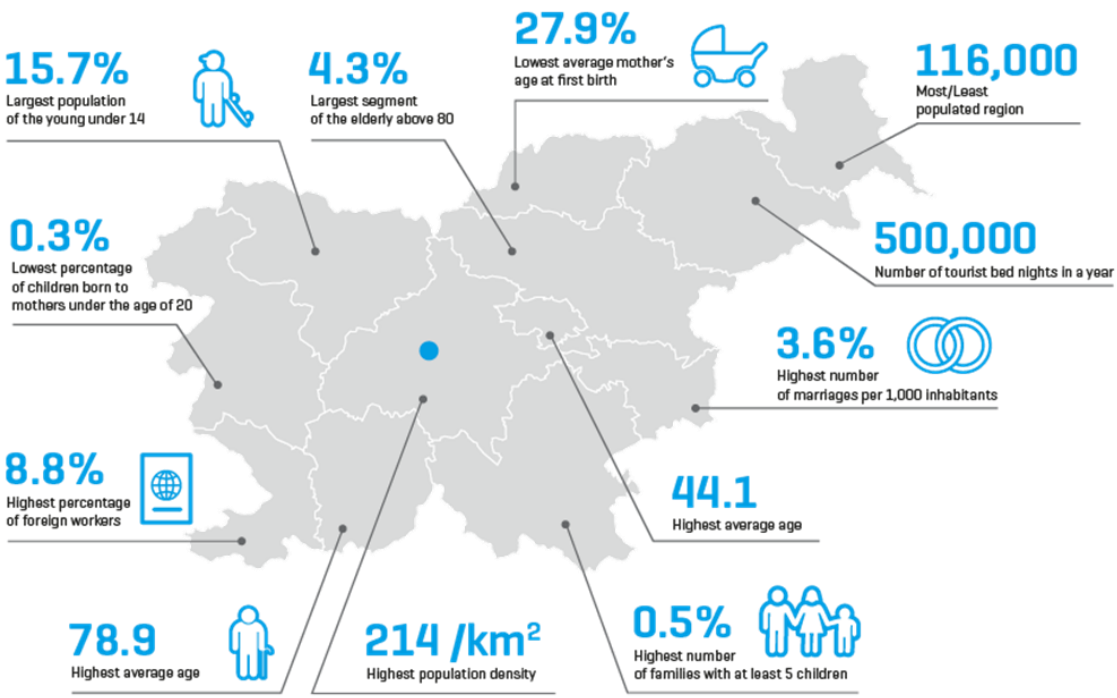


Figure 61: Features by region in Slovenia

The key risks to the central scenario of IMAD's Autumn Forecast arise from the international environment; the risks associated with the domestic situation are less pronounced and more balanced than in previous forecasts. To a greater extent than in previous forecasts, the risks relate to the narrower international environment, particularly the effects of Brexit. Global challenges remain, which are partly geopolitical and these are reflected in the uncertainty regarding future migration flows; however, for the most part, these challenges are increasingly associated with the different speeds of recovery of the largest world economies and thus the expected different directions of economic policy actions taken. The risks in the domestic environment are less pronounced and more balanced than in previous forecasts. The prospects regarding the future absorption of EU funds and hence the volume of government investment are particularly uncertain. On the upside, however, an improvement to Slovenia's competitive position in the years to come could lead to stronger growth in exports and private investment than assumed in the baseline scenario. Upside risks also predominate in terms of final consumption and stem primarily from favourable developments on the labour market.

7.4.2. The Slovenian sector in the European context

Revenues on the European telecommunications market were down again in 2014. Forecasts indicate a continued fall in revenue. However, the decline will slow after 2014 and revenues will stabilise by 2016.

A decline in revenues is forecast for the telecommunications market until 2016 due to declining revenues from mobile services (–3.5%) and fixed services (–8.2%). The aforementioned decline will be offset by growth in Internet services (+3.2%) and pay TV services (+4.3%). The mobile telephony segment (telephony and SMS) is having the most significant impact on the fall in revenue overall due to regulation and

aggressive competition. The decline in revenue is expected to slow, primarily due to the easing of regulatory policy and growth in fixed broadband connections.

The analysts and consultants of Analysis Mason (source Analysis Mason, 2014) are forecasting a drop in revenues from telecommunication services in Western Europe until 2019. The aforementioned fall will be driven primarily by a decline in revenues from mobile telephony, SMS, fixed telephony and mobile broadband access. They are forecasting the highest growth for M2M devices and mobile data transfer on mobile phones. Fixed broadband access and pay TV services will achieve somewhat lower growth.

Declining revenues from services is also forecast for Central and Eastern Europe until 2019. Similar to Western Europe, the highest growth is being forecast for M2M devices and mobile data transfer on mobile phones. In contrast to trends in Western Europe, growth in revenues from mobile broadband access services is forecast for Central and Eastern Europe.

EUR billion	2010	2011	2012	2013	Forecast 2014	2015	2016	Growthrate13–16
Mobile telephony and data transfer	**113.8**	**109.9**	**103.2**	**93.5**	**88.7**	**85.5**	**84.1**	**–3.5%**
Mobile telephony	79.9	72.0	63.5	53.8	48.1	43.9	40.9	–8.7%
Mobile data transfer	33.9	37.9	39.7	39.7	40.6	41.6	43.2	2.8%
SMS	18.0	18.3	17.4	15.4	13.7	12.3	11.1	–10.3%
Mobile data transfer	15.9	19.6	22.3	24.3	26.9	29.3	32.1	9.7%
Fixed telephony and internet services	**88.7**	**86.2**	**84.4**	**82.4**	**80.8**	**79.6**	**78.9**	**–1.5%**
Fixed telephony	45.4	42.0	39.3	36.4	33.2	30.5	28.2	–8.2%
Internet services	43.3	44.2	45.1	46.1	47.6	49.1	50.7	3.2%
Pay-TV	**22.9**	**23.7**	**24.6**	**25.5**	**26.6**	**27.8**	**28.9**	**4.3%**
Total revenues (with pay-TV)	**225.4**	**219.8**	**212.2**	**201.5**	**196.1**	**192.9**	**191.9**	**-1.6%**

** Germany, France, United Kingdom, Italy, Spain, Netherlands, Belgium and Portugal.*
Source: Arthur D. Little, Exane BNP Paribas estimates, March 2014

Table 17: Forecast of telecommunications sector revenues: Eight Western European (source: Analysis Mason, 2014) countries

7.4.2.1. Moderate growth in fixed broadband connections market

The number of broadband connections continues to rise in the EU, although the annual growth rate is low and has stabilised between 1% and 1.3%.

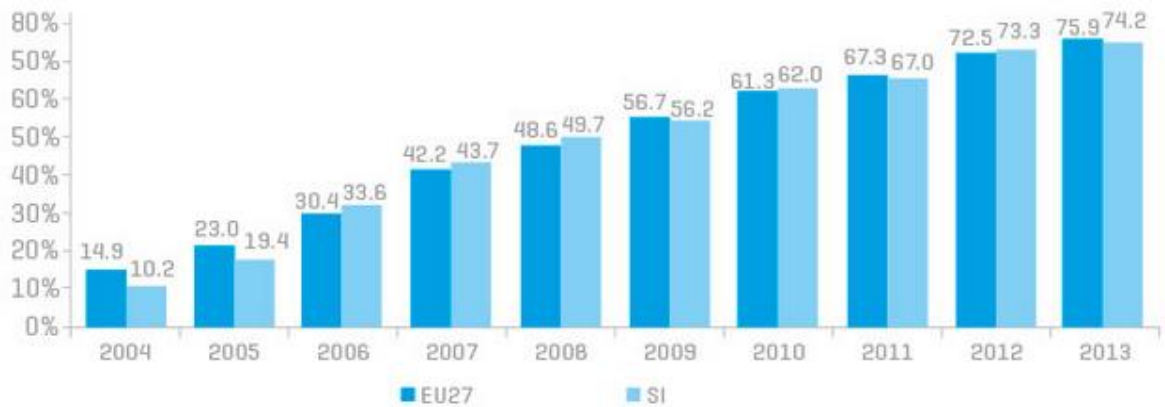


Figure 62: Penetration rates of household broadband Internet access in Slovenia and the UE-27

Net growth in the revenues of new operators has outstripped the growth recorded by incumbent operators for the last eight years. Major changes in the overall market share of new operators are not expected due to low market growth. Incumbent operators still account for 42% of all fixed broadband Internet access connections. With a 35% market share in the third quarter of 2014, Telekom Slovenije is below the average of incumbent EU operators.

According to figures from the European Commission (January 2014), Slovenia is below the EU average of 27% in terms of household broadband penetration, while growth in the previous period was also lower and below the EU average. This is also true for connections with higher transfer speeds, i.e. in excess of 10 Mbps. The prices of high-speed fixed broadband Internet access services are falling in all EU member states, while prices in Slovenia are among the highest.

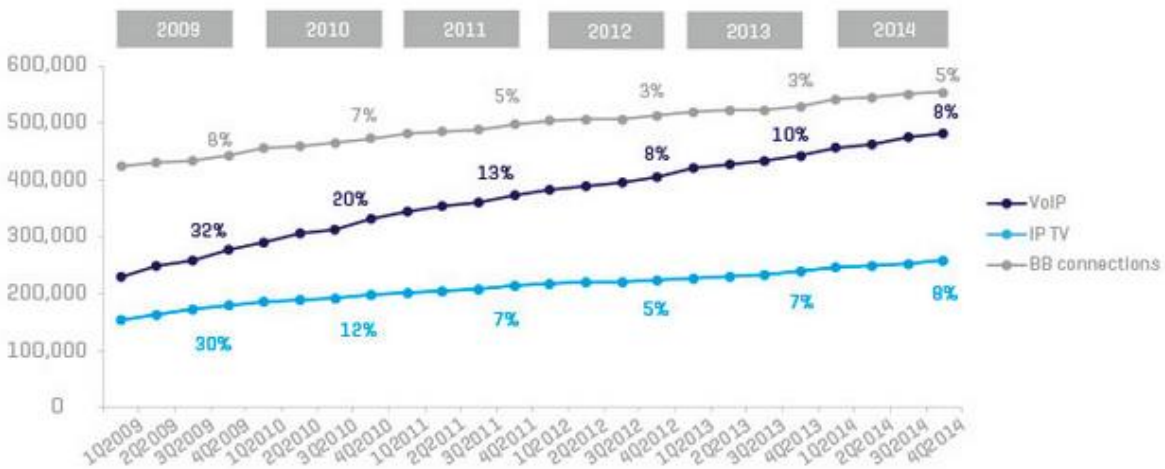


Figure 63: Growth in the fixed broadband services market in Slovenia

7.4.2.2. Growth in mobile broadband access

Mobile broadband access is the fastest growing segment of broadband services, although growth has slowed slightly. It is used for the most part as an alternative form of access to the Internet and does not represent a replacement for fixed access. More than 30% of EU households have the latter, while only 8% have only mobile access. The majority of mobile broadband subscriptions are used on smart phones, followed by tablets and laptop computers.

According to forecasts by Analysis Mason, the European mobile broadband internet market will be characterised in the future primarily by growth in mid-screen devices (tablets and e-readers) and by a decline in large-screen devices (desktop and laptop computers, and netbooks).

Packages with leased data transfer services account for the highest proportion in Slovenia, followed by standard packages with voice services and data packages intended for use on other devices.

7.4.2.3. Development of fibre optic connections for higher speeds

Slovenia still ranks among the leading countries in Europe in terms of household fibre optic access penetration (FTTx), and stands above the EU average in this regard, although that rate is growing faster in other countries. Broadband FTTx connections accounted for 21.8% of all broadband connections in Slovenia at the end of 2014, as compared with 6% in the EU (January 2014).

Telekom Slovenije provides the fibre optic network with the highest level of quality, reliability and security of services. Users were provided with SiOL Internet services with speeds of up 1 Gb/s on the fibre optic network in 2014.

7.4.2.4. Growth in the pay TV market

Digital IPTV services and multimedia content (video-on-demand, HD content, interactive TV content and internet television) continue to record growth. IPTV accounts for 45.6% of all TV connections in Slovenia (Q4 2014) and continues to grow. Cable TV is also recording growth in connections, primarily on account of the number of digital connections. At 52.9% (Q4 2014), the Telekom Slovenije Group holds the highest share of the IPTV market. According to AKOS figures, 71.4% of Slovenian households have pay TV (Q4 2014).

According to forecasts by Analysys Mason, the pay TV market in Western Europe is expected to grow by 21% from 2013 to 2019, with growth in OTT (over-the-top) and IPTV services contributing most to overall growth. Cable TV will remain the leading technology in the pay TV market, although it is expected to decline by 4.4% until 2019. Pay TV household penetration will exceed 64% in Western Europe over the same period.

OTT services for households will grow, primarily as a second TV receiver, as users will wish to reduce TV costs. A total of 3.2% of households in Western Europe will use OTT as their primary receiver by 2019, while 47.7% will use the aforementioned technology as their secondary receiver.

7.4.2.5. Growth in mobile voice telephony compared with fixed telephony

More than two thirds (68%) of EU households have fixed telephony. According to forecasts by Analysis Mason, the fixed telephony penetration rate (residential users) will fall to 62% in Europe by 2019. With a fixed telephony penetration rate of around 76%, Slovenia stands above the European average, although that rate is in constant decline. In the mobile segment, Slovenia has the lowest per capita penetration rate of active mobile telephony users in the EU (112.8% in 2014), giving it sufficient room for further development. The penetration rate in Slovenia is constantly rising.

7.4.2.6. Rising proportion of package services, in particular triple play and quadruple play

With the aim of maintaining existing customers and attracting new customers, European operators are offering more varied packages that combine fixed telephony, the internet, TV and mobile telephony (quadruple play). The popularity of such packages is on the rise, while the number of independent broadband access connections is falling.

Slovenia is also recording growth in all packages, most notably in quadruple play. The main reasons lie in affordability and the fact that these packages are the newest on the market. With the most advanced network, Telekom Slovenije also has great potential for further growth in this segment.

Table 18: Proportion of households with services (TS)

January 2014	Slovenja	EU28
Proportion of households with mobile telephone access	94 %	92 %
Proportion of households with a fixed telephone connection	76 %	68 %
Proportion of households with broadband internet access	67 %	60 %
Proportion of households with internet access via mobile telephone	52 %	52 %

7.4.3. The Sector in Slovenia

7.4.3.1. Penetration

Traditional CS voice telephony market share is declining, on the other hand the IP-telephony share is increasing. Fixed access penetration in Slovenia is above the European average (75% of Slovenian households). The penetration rate will continue to grow. Fast Internet (at least 30Mbps) presents about 22% of connections.

Digitalisation of cable infrastructure and pocket sales (IPTV) will be among the most significant growth generators on the pay TV market in the next 5 years (until 2021).

In 2015 Slovenia had a 114% penetration rate of active mobile telephony users.

Mobile Internet is the fastest growing segment in the mobile services market. With its 49.7% penetration rate Slovenia's penetration rate is below the EU average (75.3% penetration), however it is on the increase.

Table 19: Telecom Slovenia penetration

Telecommunications services penetration rate in Slovenia in 2015		
Fixed telephony	88 %	Households
Fixed internet	75 %	Households
Pay TV	71 %	Households
Mobile services	114 %	Population
Mobile internet	50 %	Population

7.4.3.2. Fixed and mobile telephony market

The fixed telephony income is expected to decrease in the residential and business segment. Especially the business segment is subject to migration towards mobile technologies and other alternative communication options.

At the end of third quarter of 2016, the market share of VoIP was 77% and is constantly growing. On the other hand, classical fixed telephony share is 26% and declining.

Mobile telephony segment has the third lowest penetration of active users in EU; that is at 114%. The current trend inside the mobile telephony segment is for the transition of users from prepaid to post-paid accounts. Amongst the post-paid accounts, Slovenia has one of the highest shares comparing to EU average.

Subsequently, network traffic is following the trend, with an increase of traffic in mobile and VoIP networks and a decrease in fixed telephony traffic. In the third quarter of 2016, the share of fixed traffic represented only 12% of the whole traffic.

Trends expectations are the following:

- Enhanced data speeds and new business opportunities with 4G.
- LTE services increase growth in handset data spend.
- Fixed–mobile traffic substitution will continue.
- Converged services for all segments in both residential and business/corporate market.
- Growth in the areas of mobile business, multimedia solutions and mobile TV.

- New opportunities in mobile applications, telemetry (M2M) market and „connected home".
- Machine-to-Machine SIMs account for an increasing proportion of mobile SIM cards

7.4.3.3. Mobile broadband access

Mobile broadband access is mostly used as an extra access and not as a replacement of the fixed broadband access. In 2015, 8.1% of households in the EU used exclusively mobile broadband access (4.2% in 2010.) In Slovenia this share is 3.1%

Mobile broadband represents a fast growing segment of the broadband market. More than 60 % of all active mobile SIM cards use mobile broadband. The majority of mobile broadband subscriptions are used on smartphones, followed by tablets and notebooks.

7.4.3.4. Fixed broadband access

The fixed broadband access segment is experiencing slow growth, that was 3% at the end of the 2015, and the focus is on retaining customers and upgrading the access network. The Slovenian market is still very low as regards fast broadband access above 30 Mbps. There is therefore still potential for further growth in the fixed broadband market. Fixed access is an important part of network investment strategy, and in Slovenia fast broadband access, with speeds of at least 30 Mbps, represents 22%.

7.4.3.5. Portability

Portability allows a user to change their service provider without having to change their telephone number. This possibility, which eliminates the drawbacks that users would otherwise encounter, makes it easier to change operator.

Number portability was introduced in Slovenia in 2006 for both fixed and mobile telephony. Operators are required to use a central portability database, recording all the phases of number portability. At the end of 2016, eleven years after number portability was enabled in Slovenia, there were total of 939,027 mobile numbers and 648,200 fixed number portability records in Slovenia for last ten years.

The table below shows the number of portability records for fixed and mobile numbers on a yearly basis.

	Mobile	Fixed	Total
2010	70,331	61,923	132,254
2011	75,499	55,969	131,468
2012	73,557	62,910	136,467
2013	90,902	65,022	155,924
2014	103,799	76,517	180,316
2015	118,380	42,750	161,130
2016	195,555	76,801	272,356

Table 20: Mobile and fixed portability by year – gfngf source NPCH.si

7.4.3.6. Bundles

Operators in the Slovenian market offer two major bundles: triple and quad play. The triple play bundle consists of broadband internet access, IPTV and fixed VoIP telephony. Additionally, the quad play bundle consists of mobile service that is mobile telephony and mobile broadband access. Slovenia has bundled-offer household penetration of 64 %, which is the highest in the EU (50%). Prices of triple play bundles have gone down by 24 % since 2012.

7.4.4. Revenue

The service revenue in Slovenia keeps falling year after year. In the year 2014, service revenue totalled 998 million €. Peak service revenue was reached in 2011 with 1,050 million €. The service revenue forecast up to the year 2021 is negative and expecting to drop, with the forecast value for 2021 being 842 million €.

7.4.4.1. Service Revenue

Industry revenue includes interconnection, but excludes separately billed equipment charges. The sum of service revenue is considered for mobile services, fixed services and Pay TV. IPTV revenue can be considered both a fixed service revenue and a pay-TV revenue, but is only counted once in this metric.

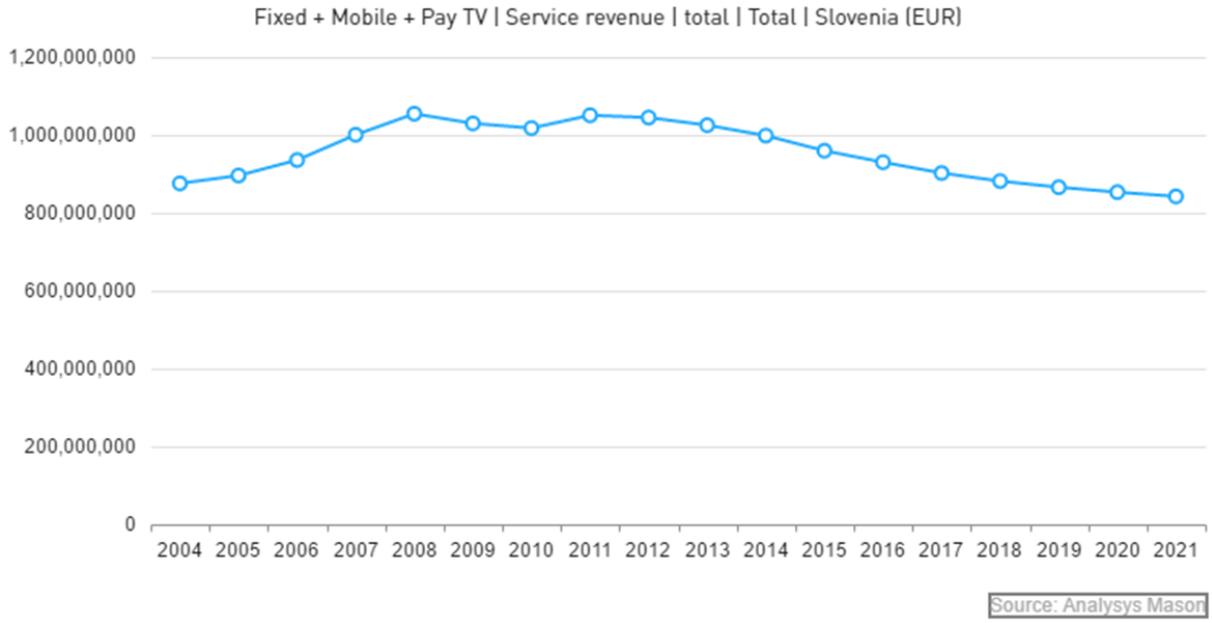


Figure 64: Service Revenue for Slovenia – source Analysys Mason

7.4.4.2. Retail Revenue

Industry retail revenue excludes interconnection and separately billed equipment charges. The sum of retail revenue is considered for mobile services, fixed services and Pay TV. IPTV revenue can be considered both a fixed service revenue and a pay-TV revenue, but is again only counted once in this metric.

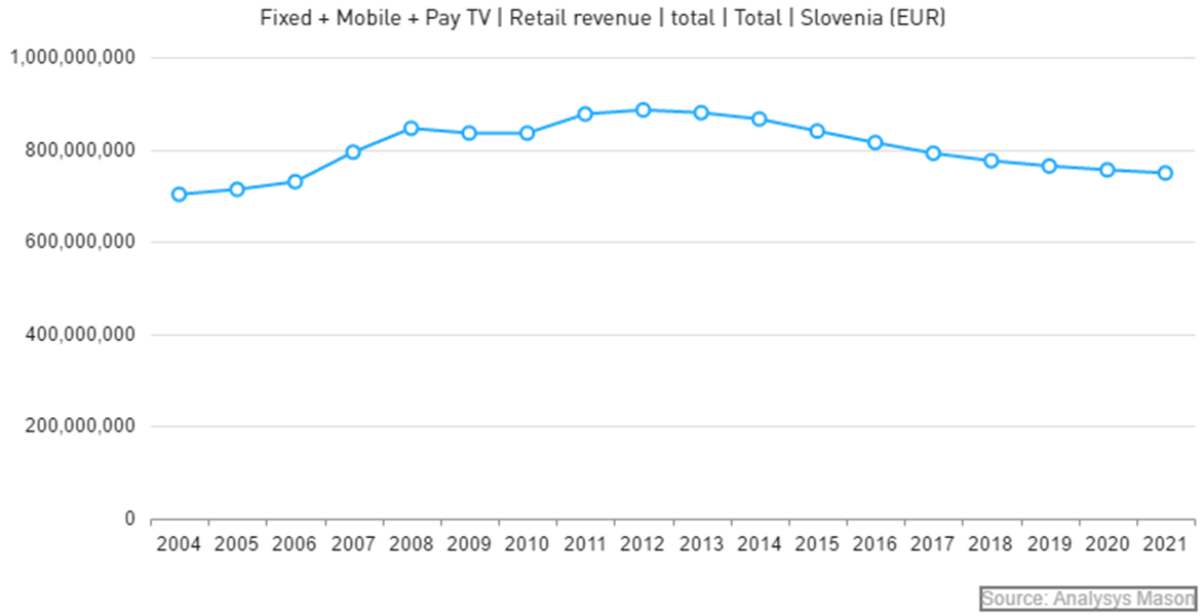


Figure 65: Retail Revenue for Slovenia – source Analysys Mason

7.4.5. Operator shares

Four major telecommunications operators providing telephony services, Internet services and pay TV operate in the Slovenian telecommunications market. Additionally some minor alternative operators exist, covering certain business specifics and/or certain geographical regions. The major operators are shown in following tables along with their major services offered.

Service/Operator	Telekom Slovenije	SiMobil	Telemach	T2
Fixed Telephony	Yes (PSTN, ISDN, VoIP	Yes (VoIP)	Yes (VoIP)	Yes (VoIP)
Fixed Internet	Yes	Yes	Yes	Yes
Pay TV	Yes (IPTV, Cable)	Yes (IPTV)	Yes (Cable)	Yes (IPTV)
Mobile services	Yes	Yes	Yes	Yes
Integrated IT services	Yes	Yes	No	No

Table 21: Major operators in Slovenian Communication Market and services offered

Telekom Slovenije is the dominant player in all market segments except in Pay TV segment. In the Pay TV segment the IPTV players are dominant and trying to gain the share from cable operators.

Alternative operators are gaining shares due to the aggressive pricing policy, that cannot be followed by Telekom Slovenije due to regulatory limitations and its constant investment in infrastructure and services.

Operator/Service	Mobile services	Pay TV	Fixed Internet	Fixed Telephony
Telekom Slovenije	47 %	28 %	34 %	53 %
Telemach	16 %	30 %	25 %	22 %

Operator/Service	Mobile services	Pay TV	Fixed Internet	Fixed Telephony
T-2	4 %	16 %	19 %	12 %
SiMobil	30 %	8 %	12 %	7 %
Others	3 %	18 %	10 %	6 %

Table 22: Operator market shares by service in Slovenia

Maturity and thus a saturation of Slovenian telecommunications market brings high

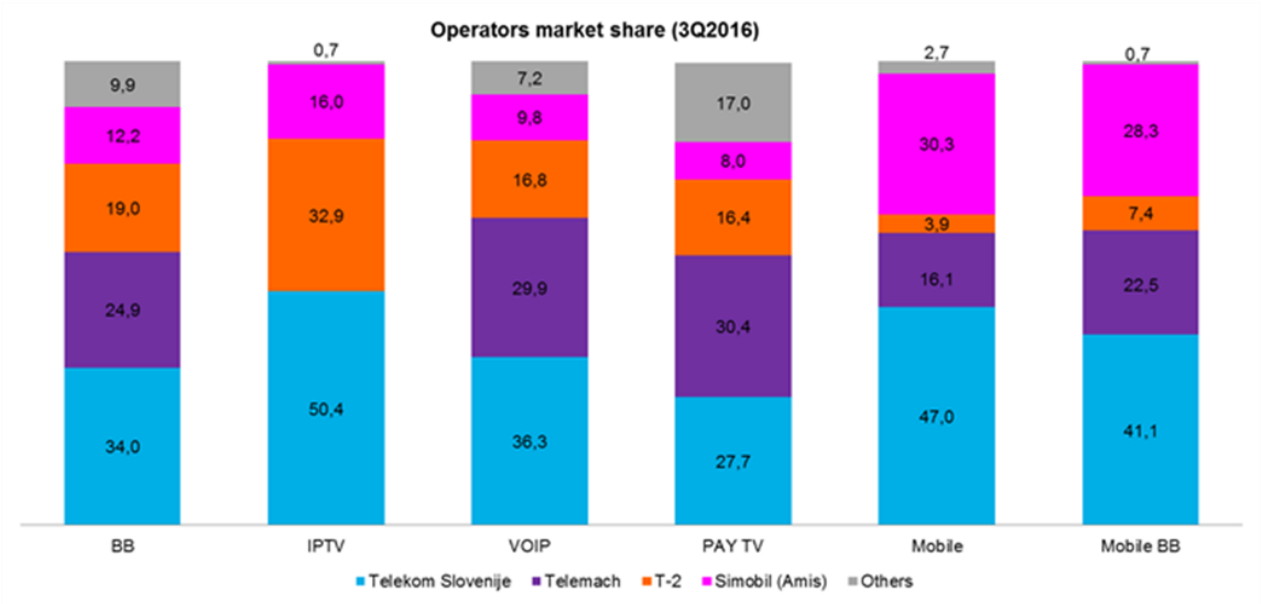


Figure 66: Operator shares by service in Slovenia, 3Q2016

7.4.6. Installed NGA connections by operator

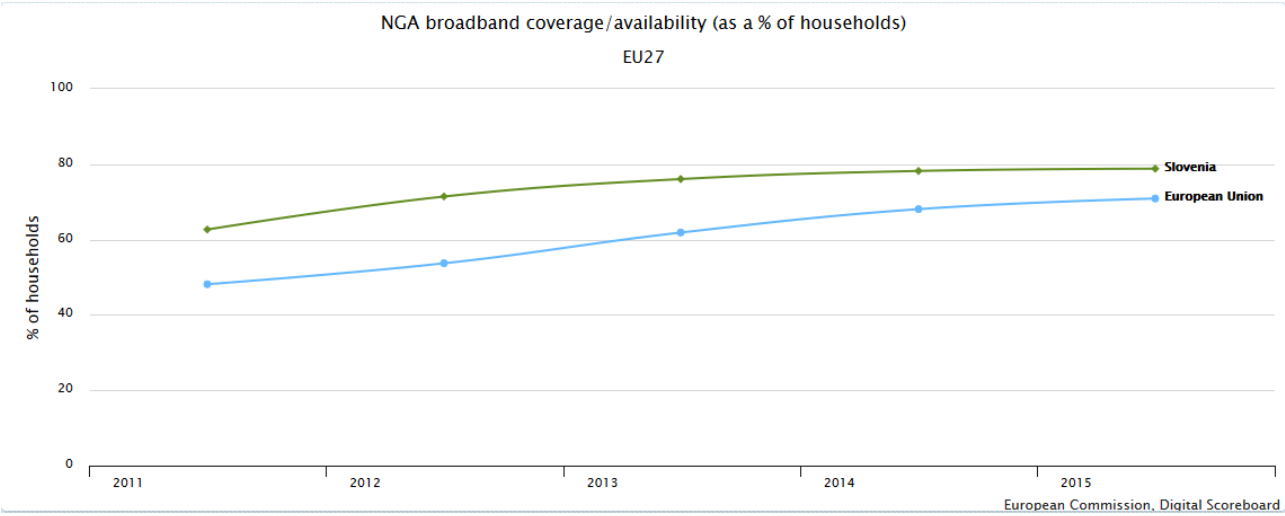


Figure 67: Slovenian NGA broadband coverage/availability - Source – EU DSM Digital Scoreboard

Coverage is a supply indicator defined as the percentage of households living in areas served by NGA. Next Generation Access includes the following technologies: FTTH, FTTB, Cable Docsis 3.0, VDSL and other superfast broadband (at least 30 Mbps download)

7.4.7. Mobile network

In Slovenia, three major operators cover the country with the mobile network. All of them offer 2G, 3G and LTE mobile technologies. Average coverage by technology is above 90% of population. As of late 2014, major operators have started rolling out LTE-A (Advanced) that enables much higher network capacity and bandwidth of up to 300 Mbps. Currently the LTE-A coverage is limited to major urban areas such as Ljubljana and Maribor. The detailed coverage by technology and operator is presented in the following table.

	2G	**3G**	**LTE**
Telekom Slovenije	100 % (99,7)	90 %	97 %
SiMobil	99 %	99 %	98 %
Telemach	98 %	99 %	86 %

Table 23: Mobile network coverage by operator and technology

It is expected that the major operators will continue investing in LTE and LTE-A, and increase coverage in the coming years, since the market is highly competitive.

The following maps show the actual coverage and the distribution of base stations across the country. The maps show the 3G and LTE coverage offered by the major operators.

7.4.7.1. 3G coverage in Slovenia

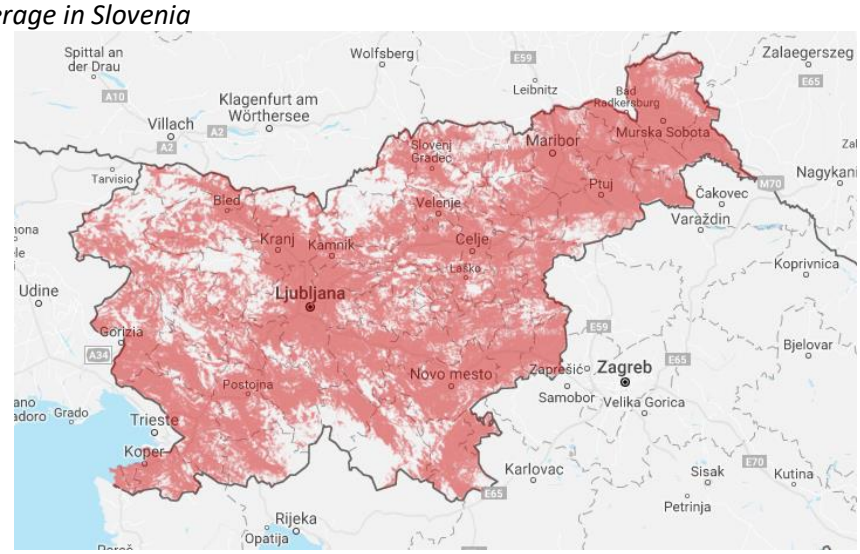


Figure 68: Telekom Slovenije 3G coverage – source Telekom Slovenije

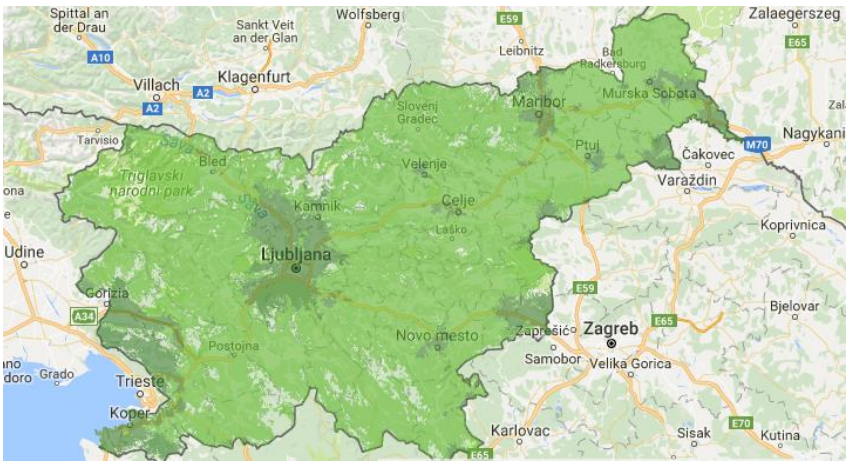


Figure 69: SiMobil 3G coverage – source SiMobil

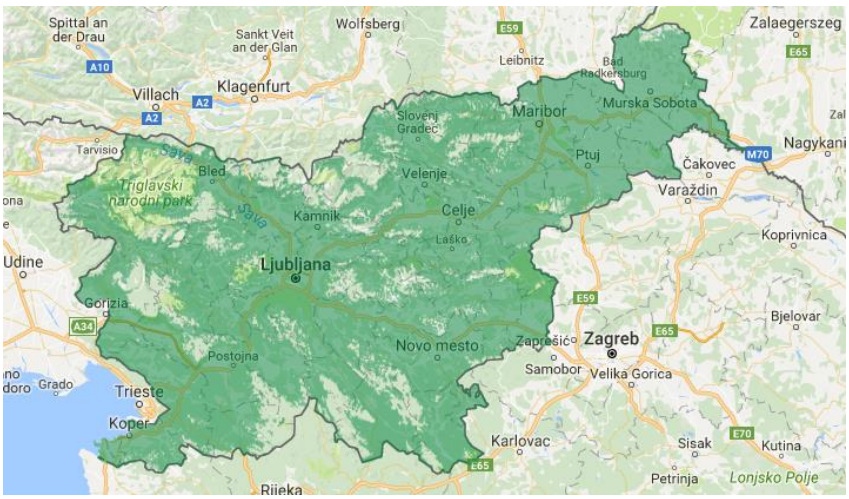


Figure 70: Telemach 3G coverage – source Telemach

7.4.7.2. LTE coverage in Slovenia

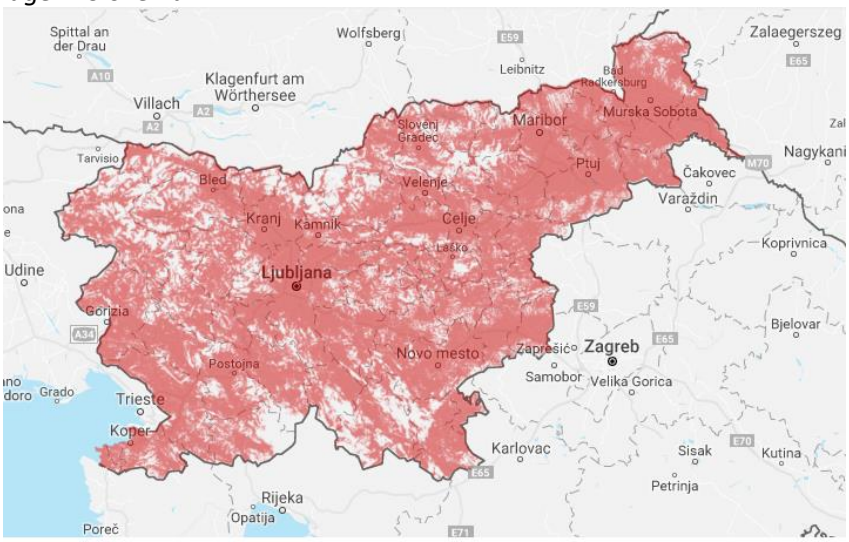


Figure 71: Telekom Slovenije LTE coverage – source Telekom Slovenije

Figure 72: SiMobil LTE coverage – source SiMobil

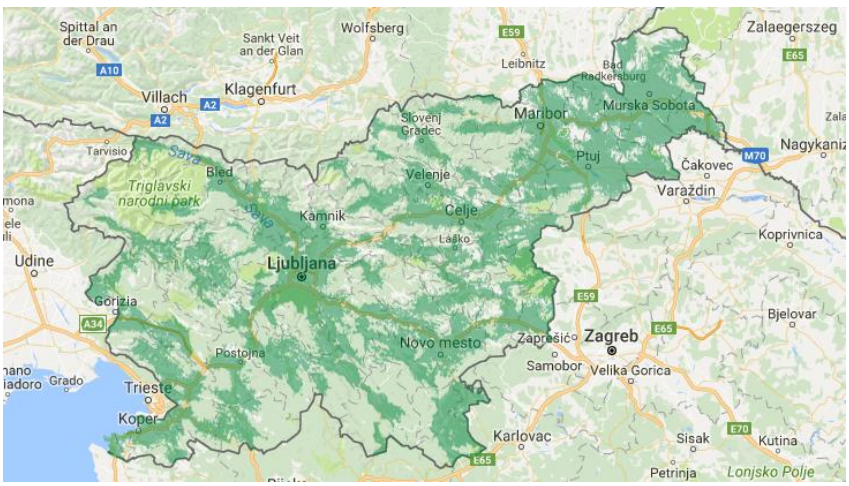


Figure 73: Telemach LTE coverage – source Telemach

7.4.8. Population with access to next-generation networks (UMST/HSDPA)

With the exception of some rural areas, the coverage and availability of the country with 3G technologies is as high as 99%. The 3G coverage comparison between EU countries and Slovenia is depicted in the following figure.

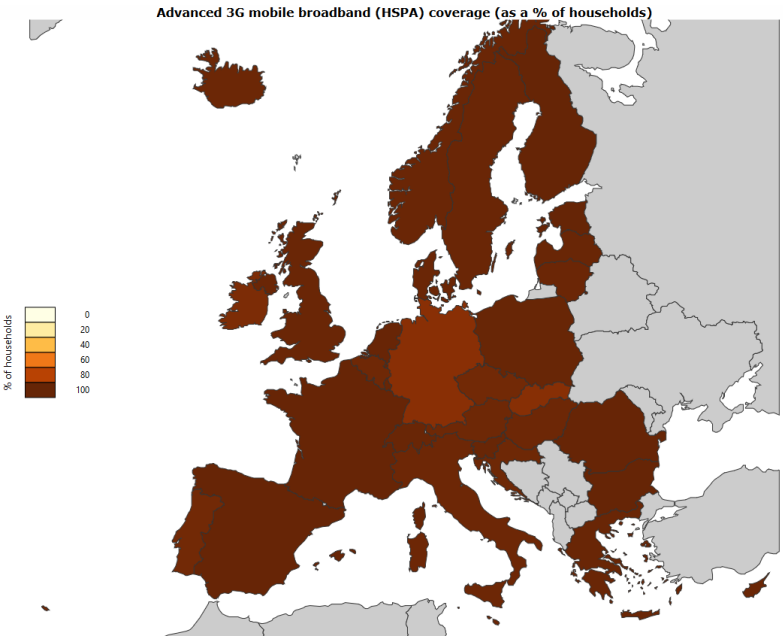


Figure 74: 3G coverage in 2015 Source: EU DSM Digital Scoreboard

7.4.9. Population with access to fourth-generation networks (LTE)

With the exception of some rural areas, the coverage and availability of the country with LTE technologies is as high as 99%. The LTE coverage comparison between EU countries and Slovenia is depicted in the following figure.

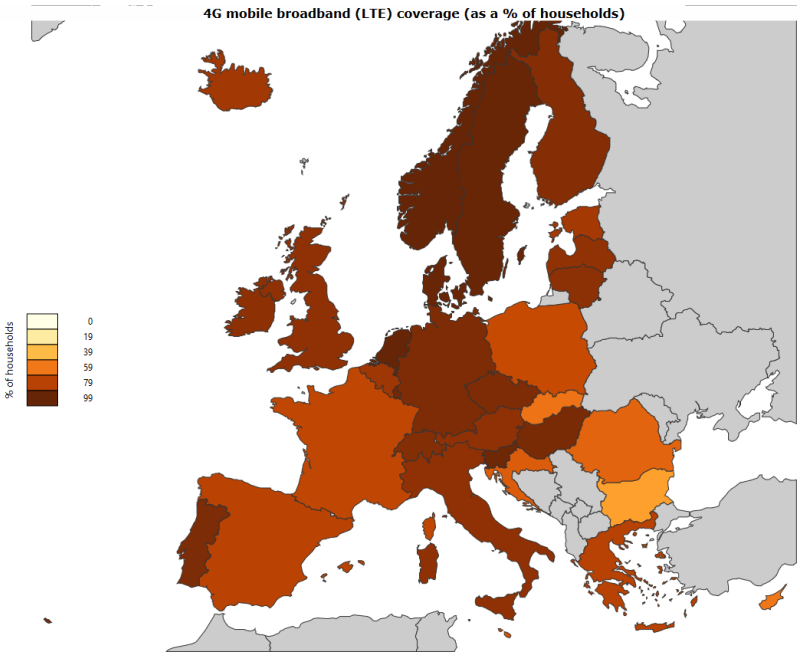


Figure 75: LTE coverage in 2015 Source: EU DSM Digital Scoreboard

7.5. Spain

7.5.1. The Spanish Sector in the European context

Economic recovery gained strength in 2014, both in the EU (28) and in Spain, with real growth in GDP of 1.4% in both cases. Furthermore, inflation (measured on the basis of year-on-year CPI growth) was relatively low in the EU (28), at 0.6%, and slightly negative in Spain, at -0.2%.

In this slightly more favourable economic context than that of previous years, worldwide revenue from telecommunications fell by 0.9% and, in Europe, by 3.5%, slightly less than in 2013 (5.1%) (IDATE). The European Commission (EC) estimates there has been a fall of 6.6% in telecoms sector revenue in Europe since 2010.

In Spain, sector revenue fell by 6% and prices dropped sharply by up to 6.1%, following a trend contrary to that of EU (28) prices, which fell less than in 2013. Both the EU (28) and Spain have seen several consecutive years of falls in prices and revenue. Despite this, a significant factor in Spanish telecommunications markets in 2014 was the strong growth in investment, with year-on-year growth of 30% due mainly to the extensive rollout of fixed next generation networks.

The need to finance heavy investment and the sustained fall in revenue facing the European sector were two of the factors leading to the market consolidation processes initiated in 2013. In 2014, mergers and acquisitions between operators of the same market segment, for example, Telefónica Deutschland-E-Plus in Germany, Hutchinson 3G-Telefónica in the UK or Liberty Global-Ziggo in the Netherlands, and between operators whose main business targeted different segments were initiated or completed.

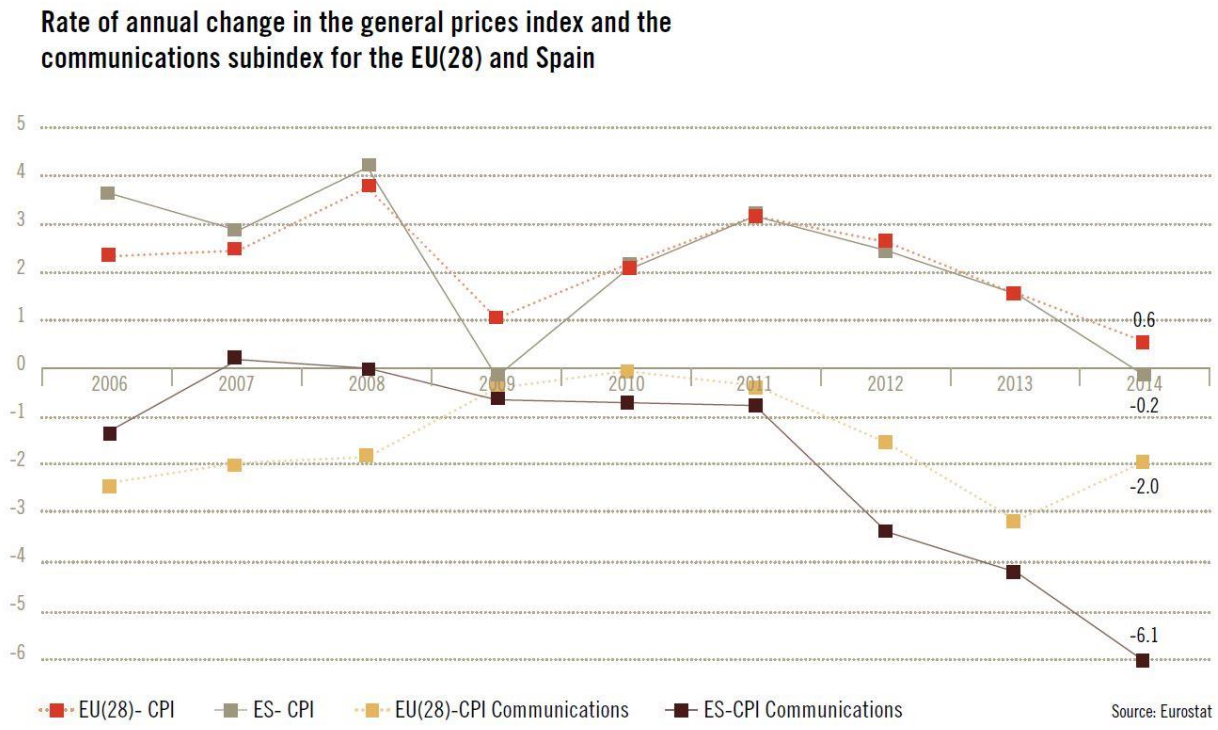


Figure 76: Rate of Annual Change in the General Prices (Spain)

In fact, in Spain there have been significant combinations of the latter type. Firstly, between fixed segment and mobile segment operators, such as the acquisition of Ono's assets by Vodafone in 2014 or the acquisition of Jazztel by Orange, approval of which by the EC in 2015 was conditional on various divestments of fixed network assets. These transactions arose from operators' need to strengthen their

chances of competing in the Spanish market, which is characterised by strong convergence, demonstrated by the fact that 41.4% of fixed voice lines and 61.7% of fixed broadband lines were subscribed in fixed and mobile service bundles. Also, in 2015, the Spanish National Markets and Competition Commission (CNMC) placed conditions on the acquisition of DTS by Movistar. Through this acquisition, the long-standing operator consolidated its audiovisual content offering. These services allow operators to differentiate their offerings and mitigate the fall in revenues from the traditional segments, which are more homogeneous and provided in a more competitive context.

BROADBAND

The development of broadband and, in particular, fast and ultra-fast broadband, is considered a key factor for European economic recovery and an improved quality of life for EU citizens. The European Digital Agency is one of the seven pillars of the Europe 2020 strategy, which aims to achieve sustainable and sustained growth in EU countries. In 2010, the Agency established ambitious broadband connectivity and use objectives for Europe and, from 2015, will be implemented with the execution of the European Digital Strategy, published in May 2015, through which it aims to create a European digital market encompassing companies and consumers of different countries.

In 2014, the penetration of broadband in the EU continued to rise, both fixed broadband (at a year-on-year rate of 4.4%) and mobile broadband, at a year-on-year rate of 12.4%. According to CNMC data, in Spain both services grew somewhat faster, at 6.9% and 16.9%, respectively.

In fact, the approval of Law 9/2014, the General Telecommunications Act, in May 2014 means a simplification of licensing and municipal administrative authorisations for rolling out networks and provides rights of occupation in the public and private domain. For example, the law requires the provision of access under non-discriminatory and transparent conditions to the infrastructure of the so-called 'utilities'. This law eliminates obstacles to the rollout of new electronic communications networks to help achieve the objectives of the European Digital Agenda; universal access to broadband at 10 Mbps in 2017, at 30 Mbps in 2020 and also the objective that 50% of Spanish households will have a connection speed higher than or equal to 100 Mbps by 2020.

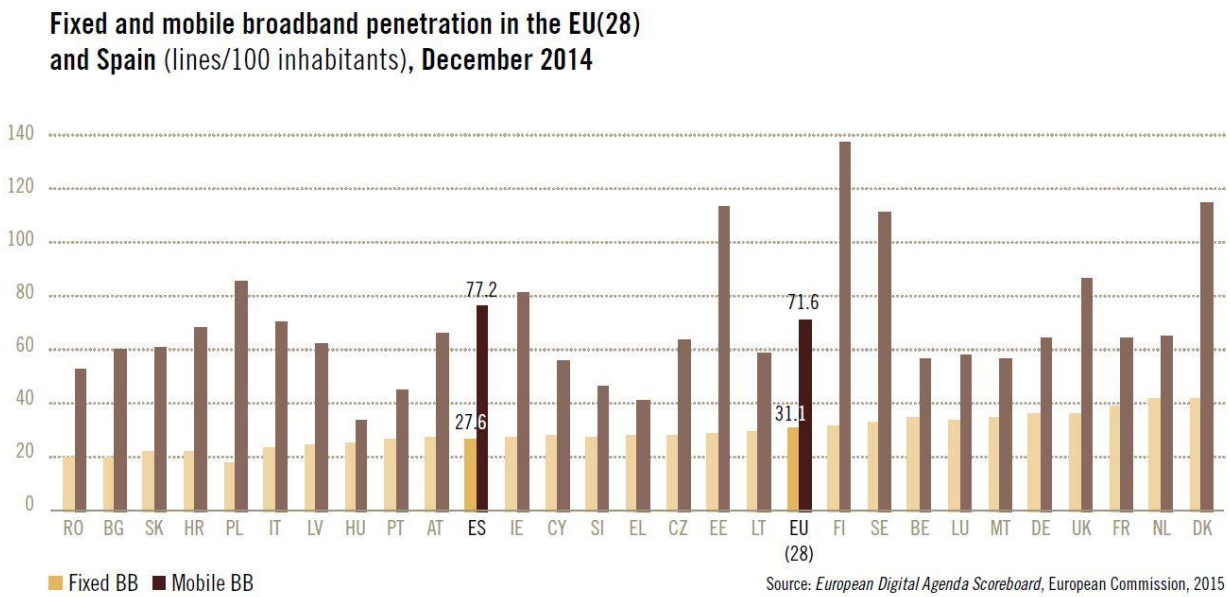


Figure 77: Fixed and mobile broadband Penetration (Spain)

In 2014, the percentage of lines with a speed equal to or higher than 100 Mbps in Spain was 10.8%, 1.8 times higher than that recorded at the end of 2013. In Europe the percentage of lines whose speed exceeded 100 Mbps was 8.7%. Progressively, the rollout of fixed next-generation access networks, which allow speeds of over 30 Mbps, has enabled the marketing of higher-speed services and with relative success. In Spain, 23.4% of fixed broadband lines had speeds of over 30 Mbps, while in the EU (28) that percentage was slightly higher: 25.8%.

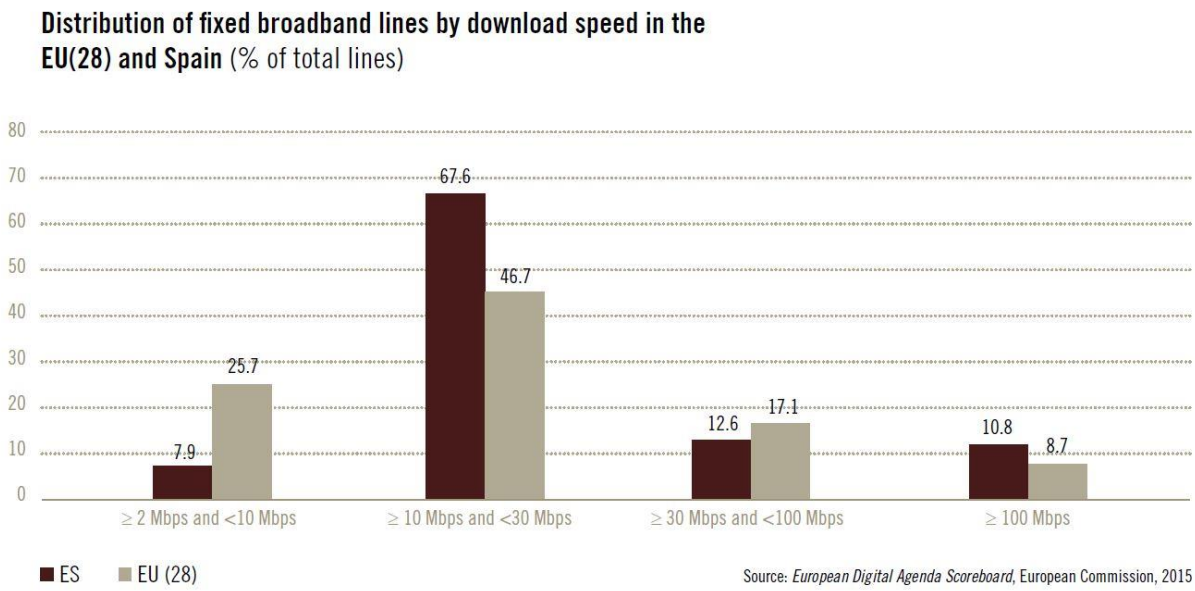


Figure 78: Distribution of fixed broadband lines (Spain)

The broadband services are provided over traditional copper (xDSL) which supports 70% of broadband lines in EU and Spain, and over different networks such as cable networks using the DOCSIS 3.0 standard (17% in Spain), but also over fibre networks (FTTH and FTTN which in 2014, accounted for 8% of active broadband lines in the EU (12% in Spain)

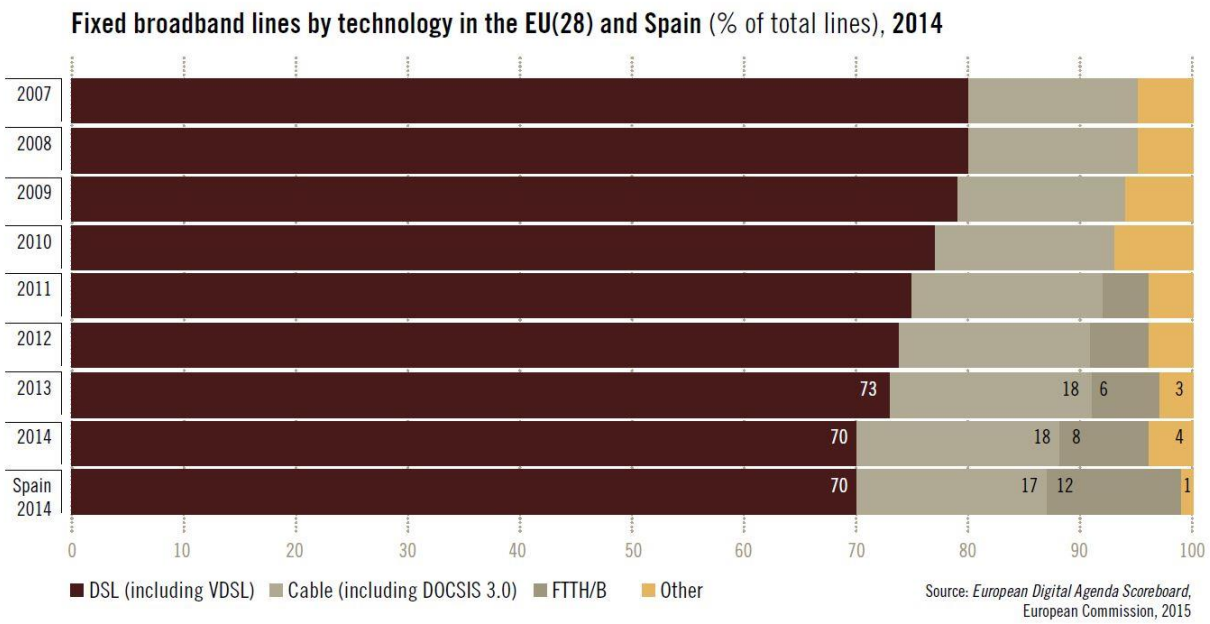


Figure 79: Fixed broadband lines by technology (Spain)

Of these three networks, fibre networks were the only networks whose active connections grew in Europe in 2014, growing from 6% of the total in 2013 to 8%. The total number of xDSL lines is gradually falling as customers opt for higher-speed offers, or simply because the operating cost for operators is lower with these networks, due to which some prefer to migrate their customers to the new networks even if they do not currently request services with more bandwidth.

In the EU (28), 31% of fixed broadband lines were active NGA lines, a figure slightly lower than that of Spain, 33%.

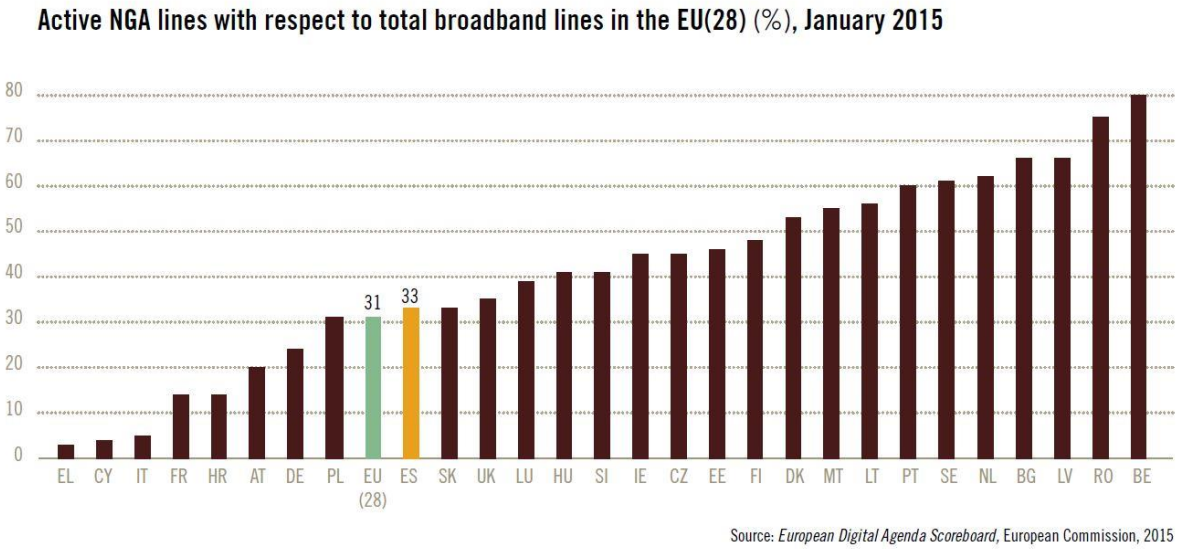


Figure 80: Active NGA lines (Spain)

7.5.2. The Sector in Spain

7.5.2.1. Penetration

All end-services increased their penetration rate in 2014. The biggest rises in this indicator were for pay television (not included in mobile television) and mobile broadband services, with year-on-year growth rates of 31.1% and 16.9%, 80 respectively. The growth in pay television subscribers (1.2 million) was due to IP television, sales of which grew gradually during the year, mainly due to Movistar's various marketing campaigns promoting this service by bundling it with other telecommunications. Thus, the percentage of pay television lines bundled with other services grew by 11 percentage points and 69.7% of these bundles with pay television were of the quintuple-play type, i.e. they involved subscribing to this service together with fixed and mobile telephony and broadband services.

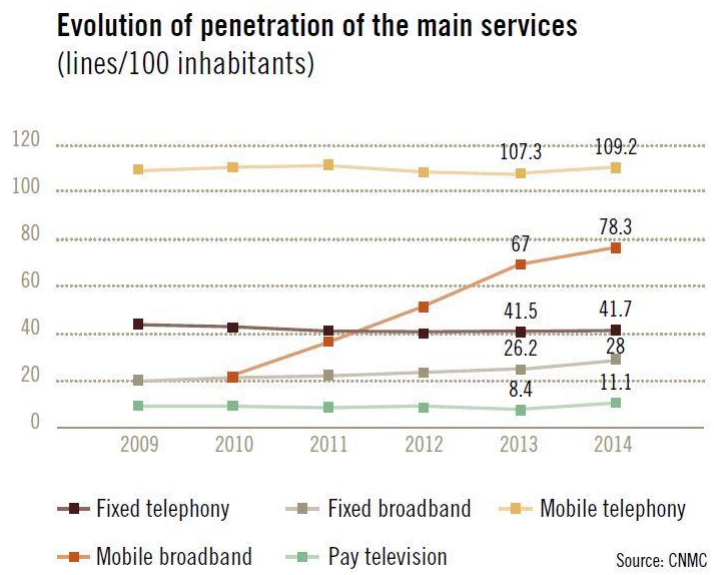


Figure 81: Evolution of penetration (Spain)

According to CNMC-Red.es Household Panel data, 83.7% of households had a fixed-line telephone service and 96% had a mobile telephone service. Furthermore, 29.4% of households had pay television and 72.2% had Internet access. However, there are significant differences as regards the penetration of the services in Spain, particularly in relation to Internet and pay television services. These differences are partly due to the relative urbanisation of the locations and, therefore, the size of the municipality in which a household is situated is taken into account; in those with less than 10,000 inhabitants, the penetration of the Internet is 12.7 points lower than the national figure and that of pay television, 7.4 points.

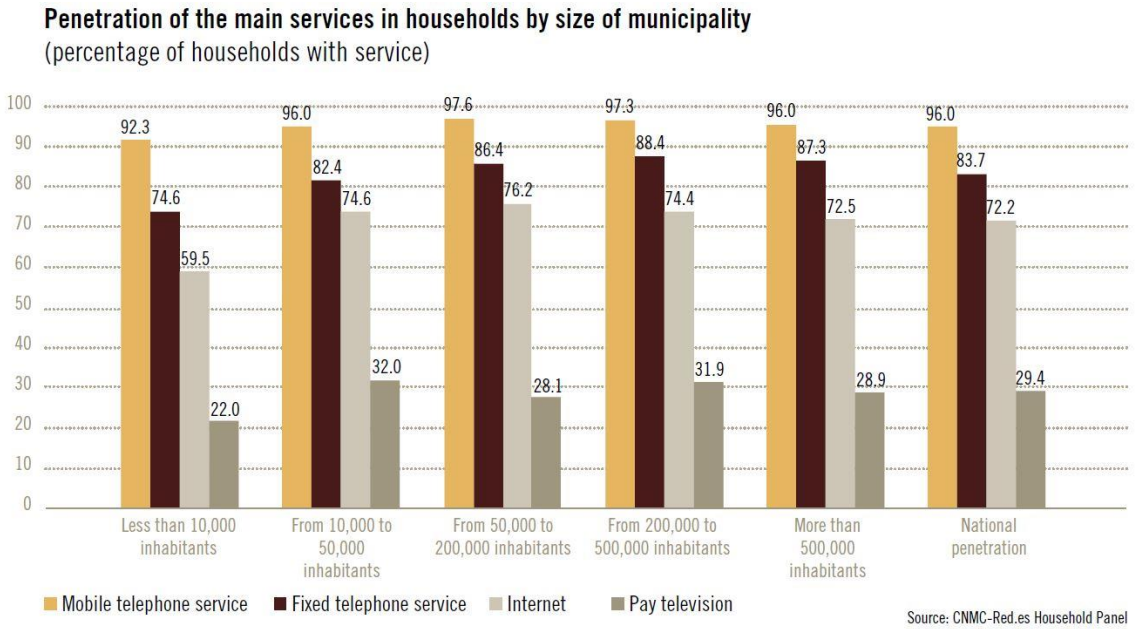


Figure 82: Penetration of the main services in households (Spain)

In the case of the Internet, there is also a significant difference between the percentage of households that subscribed to the service according to the age of the head of the family. For example, in households where the head of the family was aged 65 and over, the percentage with Internet was 41.1%, while this percentage reached 86.7% in households where the head of the family was aged under 35. There is a large generation gap in the use of and subscription to broadband services, both fixed and mobile.

7.5.2.2. Portability

Portability allows a user to change their service provider without having to change their telephone number. This possibility, which eliminates the drawbacks that users would otherwise encounter, makes it easier to change operator and Spain is traditionally one of the EU countries with the highest portability rates. In the last five years, average monthly figures for porting of mobile and fixed-lines numbers were 476,995 and 156,522 numbers, respectively. In 2014, the figure for porting of mobile numbers was 6.2 million, down 8% on the previous year, and the figure for fixed-line numbers was 1.9 million, a similar order of magnitude to 2013.

The graph below shows the operator switching percentages for services. Nearly all the percentages are similar to those for 2014, but the discrepancies between operator switching rates for the different services are somewhat smaller. The reason lies in the popularity of quadruple-play and quintuple-play bundles in 2013, i.e. the subscription to various fixed and mobile services in a single contract and with a single monthly charge. With these types of contracts, it is more likely that when a household changes the provider of one service, it also changes the provider of the other services, due to which the switching rates of the different services are similar.

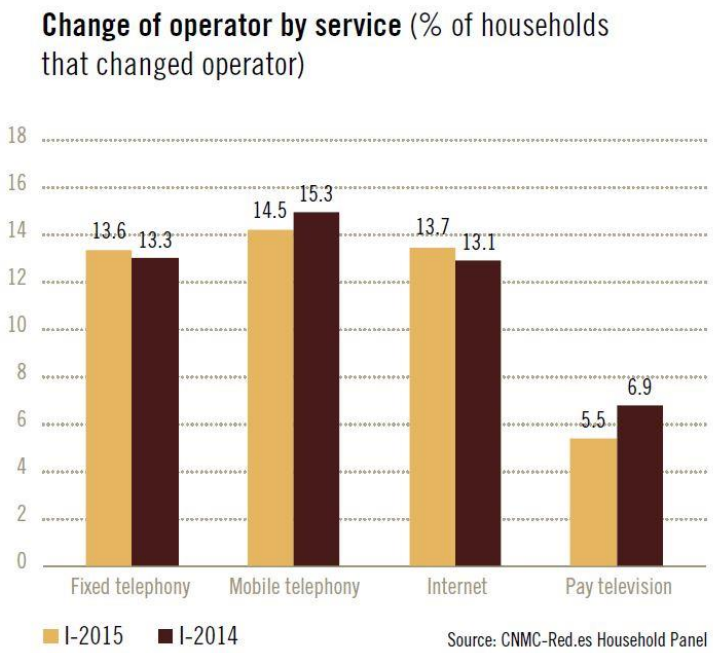


Figure 83: Change of operator by service (Spain)

A relatively common practice with operators is the use of minimum term clauses, which establish a financial penalty to be imposed on users if they decide to cancel the operator's service before a certain time period. These contractual conditions, agreed between operators and customers, indemnify operators for any losses arising from their customers ending the contract early, such as, for example, when the operator subsidises the purchase of a terminal or other pieces of equipment. In competitive markets, if users are aware of the minimum clauses and they are reasonable, they should not constitute a problem for competition, although they would restrict changing service providers.

However, in some cases, minimum term clauses give rise to anticompetitive behaviour, have restrictive effects on market competition and are detrimental to consumers. In October 2014, the CNMC imposed a e25 million fine on Movistar for failing to comply with Article 1 of Law 15/2007, on the Defence of Competition, by establishing an organised practice of maintaining a set of agreements with their corporate customers with minimum term commitments, the aim of which was to restrict competition by excessively limiting the ability of business segment customers to change provider.

7.5.2.3. Bundles

The total number of bundles that combine fixed and mobile services was 8 million at the end of 2014, compared to 5.9 the year before. If quadruple-play bundles showed the most growth in 2013, in 2014 it was quintuple-play bundles that took centre stage. This type of bundle -which jointly markets telephone and broadband services both on fixed and mobile networks plus pay television- gained an additional 1.5 million new subscriptions, ending the year with more than 2.2 million. Furthermore, quadruple-play bundles, while being the most popular in 2014 at 5.8 million, grew at a much slower rate than in 2013.

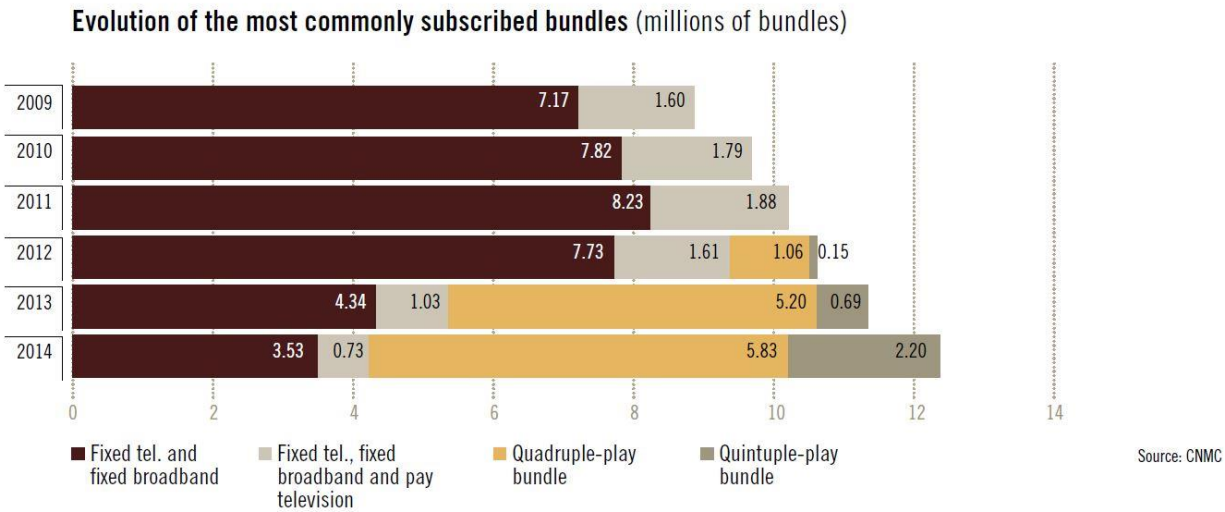


Figure 84: Evolution of the most commonly subscribed bundles (Spain)

7.5.3. Revenue per service

Total sector revenue fell in 2014, although at a slower rate than in the previous two years. Revenue totalled €30,888.5 million, down 6% on 2013, as a result of the negative variation rates of approximately 7% recorded in the two previous years.

Regarding the main retail services, three grew in terms of revenue (fixed broadband, mobile broadband and audiovisual communication services), in contrast to data for the period 2011-2013, when growth was only recorded in revenue from mobile broadband. Growth in this service slowed in 2014 and the positive rate of 9.2% contrasts with the double-digit growth recorded in the preceding years.

Revenue from end services 2013-2014 (millions of euros and percentage)

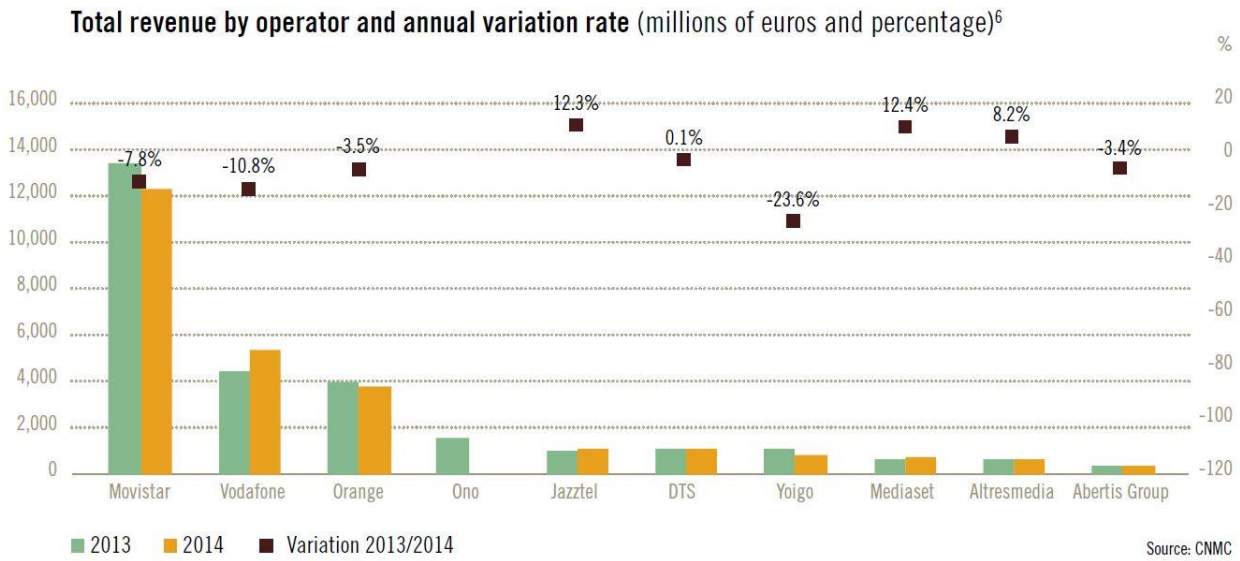
	2013	2014	VARIATION 2013/2014
Fixed communications	**9,235.47**	**8,573.82**	**-7.2%**
Fixed telephony	4,190.79	3,471.77	-17.2%
Fixed broadband	3,558.82	3,641.08	2.3%
Business communications	1,445.28	1,429.60	-1.1%
Telephone info.	40.58	31.38	-22.7%
Mobile communications	**10,888.97**	**9,777.54**	**-10.2%**
Mobile telephony	7,576.89	6,161.81	-18.7%
Mobile broadband	3,312.08	3,615.73	9.2%
Audiovisual communication services	**3,613.30**	**3,786.41**	**4.8%**
Other	**3,516.56**	**3,415.57**	**-2.9%**
Total	**27,254.30**	**25,553.33**	**-6.2%**

Source: CNMC

Figure 85: Revenue from end services 2013-2014 (Spain)

7.5.4. Revenue by Operator

Total revenue of the ten operators with the highest billings in 2014 fell compared to the previous year, except for that of Jazztel, Vodafone and the two leading free-to-air television operators, Mediaset and Atresmedia. The recovery in advertising revenue spurred the growth of these two companies, as it represents over 95% of their total revenue. Furthermore, Jazztel recorded significant growth in the mobile communications business, due mainly to the success of its combined fixed and mobile service offerings. Movistar's revenue fell by 7.8% overall, with a sharper drop in the mobile business than in the fixed business. Lastly, Vodafone, after acquiring Ono, recorded a negative variation of 10.8% compared to the combined revenue of the two operators in 2013.



[5] In this report, Vodafone data for 2014 include Ono data for the whole year, despite the fact that the acquisition was formalised in July 2014. Movistar includes fixed and mobile business data for all years.

[6] Vodafone's annual variation rate is calculated adding Ono's revenue for both 2013 and 2014.

Figure 86: Total revenue by operator and annual variation rate (Spain)

7.5.5. Installed NGA connections by operator

In 2014, operators continued their investment in the rollout of fibre to the home (FTTH) networks. In addition to Movistar, which has an extensive FTTH access network, alternative operators had significant presence in this technology. It should be noted that there is significant rollout of FTTH networks in larger towns; this has enabled operators to offer their services over optical fibre connections rather than traditional xDSL connections.

Specifically, Movistar was able to end the year with a total of 10.34 million FTTH connections installed. This was followed by Jazztel, with just over three million connections. For their part, Vodafone and Orange achieved more than 839,000 and 826,000 FTTH connections, respectively. Overall, more than 15.13 million FTTH connections were installed.

HFC connections (connections with fibre to a node and coaxial cable to the subscriber) grew moderately. In the last year, the number of HFC connections installed grew 3.1% to 10.42 million. Of this figure, 98.4% related to connections installed in nodes with DOCSIS 3.0 technology, allowing speeds of over 100 Mbps. It should be noted that this is the first year in which the volume of FTTH connections installed exceeded the number of HFC NGA connections.

On the other hand, copper pair connections continued to predominate as a proportion of total connections (with 15.44 million lines) being the most commonly used, both by the historical operator and by alternative operators that do not use HFC access, through the local loop unbundling service, to offer voice and data services.

These traditional copper connections (from a subscriber to an exchange) do not constitute the only manner of reaching users by means of xDSL technology. In addition to conventional exchanges, there are other network elements, called remote nodes, connected to the exchange by optical fibre and providing service to a few hundred loops, and there may be multiple remote nodes within the area of the exchange. Given that the quality of the xDSL service is very sensitive to the distance from the loop, the objective of these remote nodes is to reduce that distance through the installation of a network element halfway. These elements are deployed either to improve broadband services in certain areas of an exchange or to provide services to new urban areas. Broadband access services based on the use of remote nodes therefore substantially improve speed compared to that, which would be obtained providing the service from the exchange. At the end of 2014 there were a total of 6,101 remote nodes in the network, with 1.18 million copper loops dependent on them.

Evolution of installed connections

	2010	2011	2012	2013	2014
Copper pair	15,996,403	16,065,690	15,740,106	15,539,052	15,435,440
HFC	9,439,863	9,497,692	9,773,825	10,107,515	10,422,742
FTTH	524,370	1,607,108	3,250,556	6,244,313	15,134,930
FTTN	668,724	691,435	700,495	709,946	716,744
Radio	226,186	236,807	219,532	262,030	234,445
Other	20,027	14,207	19,322	19,167	40,467

Source: CNMC

Figure 87: Evolution of installed Connections (Spain)

Installed NGA connections by operator
(DOCSIS 3.0, FTTH and FTTN)

	2011	2012	2013	2014
Movistar	2,274,614	3,907,699	5,935,292	11,062,959
Vodafone			1,868	8,242,122
Jazztel			868,500	3,008,881
R	757,155	838,255	900,250	945,702
Euskaltel	890,368	904,263	909,260	913,473
Orange			67,377	826,689
TeleCable	400,875	417,515	422,899	426,855
Procono	250,762	282,747	322,226	363,079
Ono	6,708,603	7,063,153	7,171,267	
Other	66,130	142,860	261,935	321,223
Total	**11,348,507**	**13,556,492**	**16,860,874**	**26,110,983**

Source: CNMC

Figure 88: Installed NGA Connections by Operator (Spain)

7.5.6. Mobile Network

7.5.6.1. Evolution of the number of base stations by technology

In 2014, for the second year in a row, mobile communications operators rolled out their networks based on Long Term Evolution (LTE), i.e. the fourth generation of the mobile communications standard, also called 4G technology. It should be noted that network access using LTE technology makes it possible to reach data transmission speeds, which can be in excess of 100 Mbps.

In 2014 mobile network operators installed a total of 14,654 LTE base stations. This first phase of the rollout focused on the largest Spanish cities, mainly provincial capitals. Operators also continued to invest in other mobile technologies. An example of this was the number of UMTS/HSDPA base stations reported in 2014 (47,260 active stations) representing year-on-year growth of 4.4% compared to those reported the previous year.

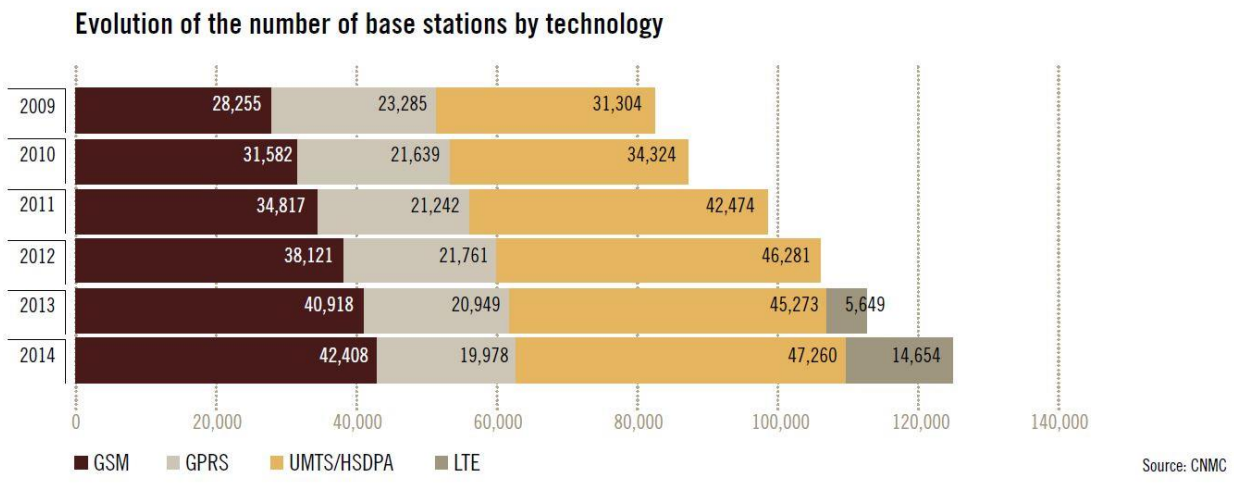


Figure 89: Evolution of the number of base stations by technology (Spain)

7.5.7. Base stations by technology and frequency band

It should be noted that the amendment of 87/372/EEC (known as the GSM Directive) and Decision 2009/766/EC at European level introduced the principle of technology and service neutrality. One of the consequences of the application of this principle was the possibility of using 900 MHz and 1800 MHz bands, not only for GSM technology-based systems, but also for other systems that enable higher data transmission speeds, such as UMTS/HSDPA, LTE or other compatible technologies. This measure will help to drive the rollout of mobile broadband ac- cess systems, particularly in rural areas. The following graph shows, for 2014, the distribution of base stations according to their technology and frequency band used.

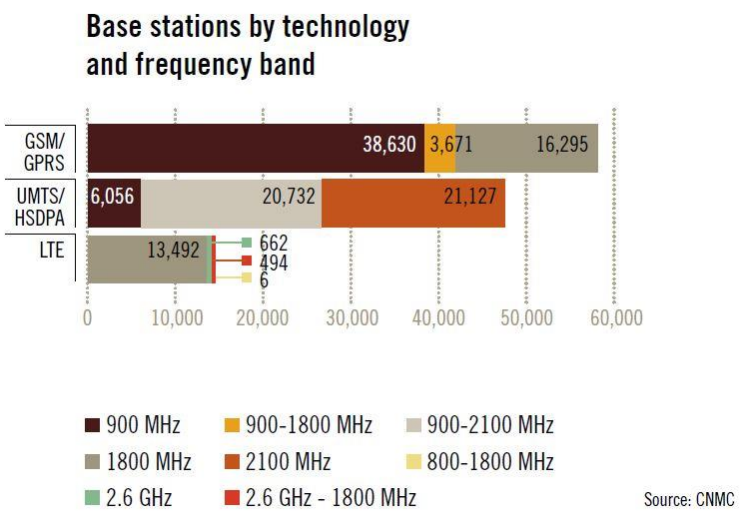


Figure 90: Base Stations by technology and frequency band (Spain)

The development of radioelectric equipment has enabled a single telecommunications site associated with a mobile technology to transmit the signal at numerous frequencies. Thus, in the previous graph it can be observed that part of the equipment deployed by mobile operators incorporated this possibility, thereby enabling better coverage and a clear saving on the cost of rolling out new mobile technologies. By way of example, in 2014, 20,732 base stations with UMTS/HSDPA technology transmitted simultaneously in 900 MHz and 2100 MHz frequency bands. In fact, this form of transmission became the most widely used when rolling out UMTS/HSDPA technology in Spain.

7.5.8. Distribution of base stations by operator

The following graph details the total number of LTE base stations according to the network operators that installed them. We can therefore observe that Yoigo, the network operator with the smallest market share, has installed a greater number of LTE stations than operators with a substantially larger market share. This can partly be explained by the fact that, in May 2013, Yoigo became the first Spanish operator to announce its intention to offer its customers commercial products with 4G speeds. Subsequently, the other network operators started announce their fourth-generation technology rollout plans until, in September of that year, the four 4G technology networks that currently offer high-speed mobile connectivity began to operate.

It should be noted that the category 'Other' refers to the operator Consorcio de Telecomunicaciones Avanzadas (COTA) which, despite being a local initiative focused on the province of Murcia, became, at year end 2012, the first operator that officially offered LTE connectivity in Spain.

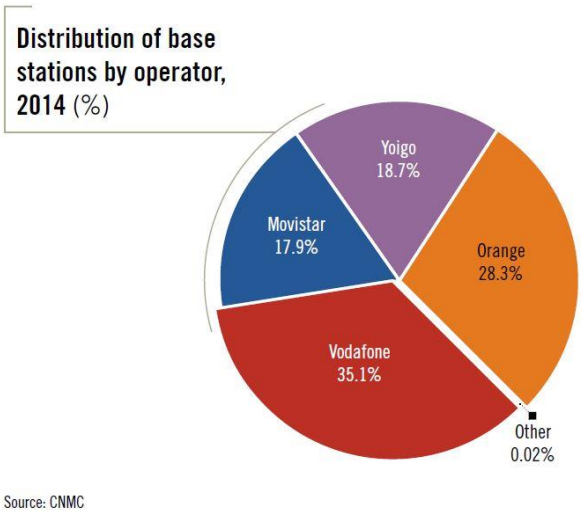


Figure 91: Distribution of base stations by operator (Spain)

7.5.9. Populations with access to Next-generation networks (UMTS/HSDPA)

The main consequence of the growth in 3G base stations was the increase in population covered by this type of technology. The following graph represents, at provincial level, the mobile network with the highest degree of 3G service coverage, in accordance with minimum required quality standards. In general, provinces with higher concentrations of urban population had broader 3G network coverage.

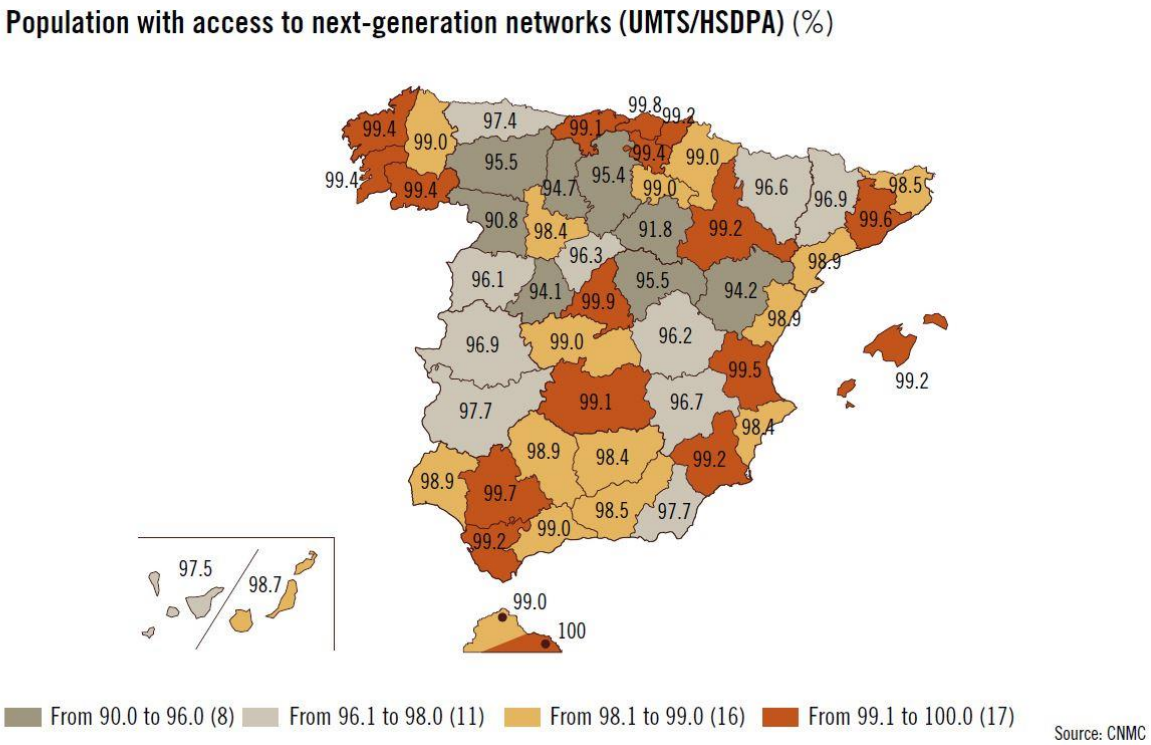


Figure 92: Populations with access to next-generation networks (UMTS/HSDPA) (Spain)

7.5.10. Populations with access to fourth-generation networks (LTE)

In the case of 4G coverage, this trend is even more marked. Thus, Madrid and, to a lesser extent, Barcelona, had a greater coverage that the rest of Spain. These differences are expected to level out progressively as operators broaden their base station network.

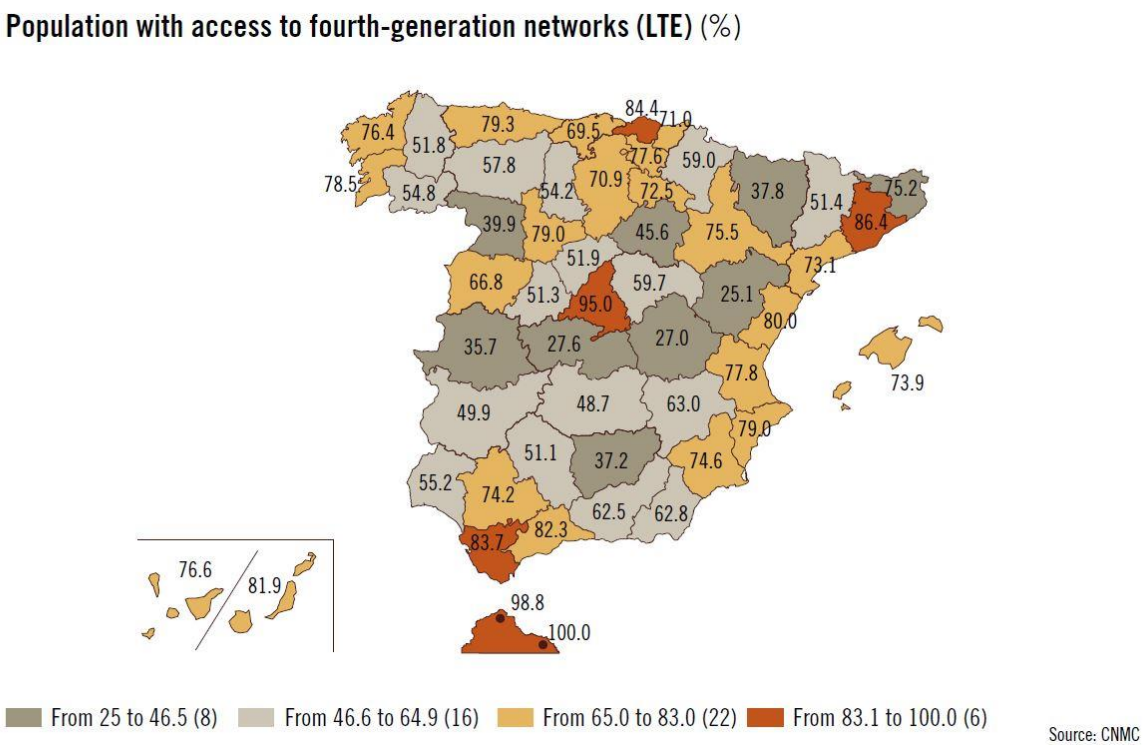


Figure 93: Populations with access for fourth-generation networks (LTE) (Spain)

7.5.11. Evolution of broadband line data traffic

In 2014 the improvement in broadband access networks and the marketing of products with higher connection speeds continued. Additionally, the widespread and intensive use of Internet-based services together with the increase in the number of active broadband connections was reflected in the recorded growth in data traffic. Thus, by year-end, a total traffic of 6.5 million terabytes was recorded, up 33% on 2013.

The following graph shows the evolution, in the last four years, of the average volume of data for each broadband line in gigabytes per month. In the last year, average monthly traffic grew 8.4 gigabytes as compared to 2013.

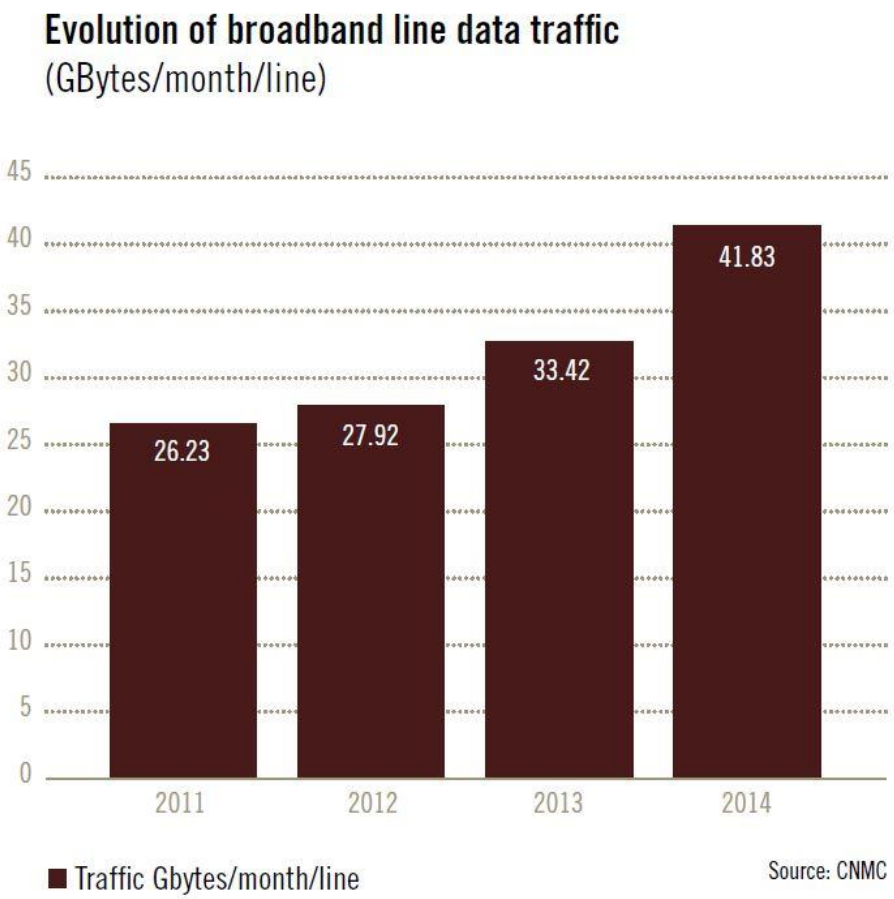


Figure 94: Evolution of broadband line data traffic (Spain)

The Spanish Market analysis is an extract from the reference document [28]

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