What are the Key success factors for viable and enticing FTTH deployment in Europe?

Dorian Ortolland

A dissertation submitted in partial fulfilment of the requirements for the degree of

Master of Science in Information and Communications Technology Business Management.

TELECOM Ecole de Management

Evry, France

Supervisor

Pierre Vialle

October 2010

Declaration of originality

This is to certify that the work is entirely my own and not of any other person, unless explicitly acknowledged (including citation of published and unpublished sources). The work has not previously been submitted in any form to TELECOM Ecole de Management or to any other institution for assessment or for any other purpose.

Signed _____DORIAN ORTOLLAND_____

Date _____13/10/2010_____

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude for the encouragement and support of numerous individuals and especially Nadine BEREZAK-LAZARUS whose contribution directly or indirectly made the completion of this thesis possible. And also to my colleagues Maxime Dubois, and Matthieu Decremoux

To my thesis supervisor, Prof. Pierre VIALLE who helped formulates my thesis question and was especially patient and conscientious in providing me with guidance and support. Thank you for the constant encouragement and support.

Abstract

Optical Networks and especially Fiber to the Home access will change the paradigms for the future of information systems, by increasing the viability and possibility of network-reliant application.

A Fiber to the Home network is a residential communication infrastructure where the fiber optical cable runs all the way to the subscriber premise. Concretely, FTTH has a clear advantage for the end-user because it provides higher bandwidth and better reliability than any other kind of broadband services, such as xDSL or Cable. The advantages are also clearly on the side of service providers, who are attracting and retaining customers with new services, (Triple Play, HDTV, SHD, 3DTV, Connected Home…), leading to new revenue opportunities. However the potential extends further and also includes lower operating costs, central office consolidation, and a network infrastructure that would guaranty an easier upgrade in the future.

I decided not to include ADSL2+, VDSL2 (FTTC/N) and DOCSIS 3.0 mainly because I do not consider them as "next-generation broadband", even if they promise increase speeds, I truly believe only FTTH demonstrates both long-term and short-term advantages. But regarding Coax Technologies, I do recognise FTTLA as part of the NGN roll-out and it will be taking into account in my thesis.

The objective of the thesis is to investigate FTTH deployment in Europe, through in-depth real case study analysis, within the scope of national policy, regulation challenges and Technology factors. The aim is to identify all the key success factors and best practices. Every aspect of FTTH market and roll-out will be taking into consideration, then analyzed and compared (Business Models, Policy, Opex/CAPEX, FTTH Architectures, Technologies, Open Access, Pricing, Cost, Services, utilities, Local Authorities, Incumbents, Alternative Operators, Location, Passed Households, Subscribers, Forecasts…)

Word Count

Number of Pages: 111

Number of Words: 25223

Table of Contents

CHAPTER 1

INTRODUCTION

1.1: Study Area

The study will only be focus on the European FTTH Market. Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, the Netherlands, the United Kingdom and Andorra, Croatia, Iceland, Norway, Switzerland and Turkey.

Some countries will particularly be highlighted and analyzed in details, to point out projects or national strategies from operators, regulator or governments, which are contributing to the success of a wide FTTH development and considered as a best practice example.

1.2: Dissertation Structure and Methodology

The structure will basically be done through 4 chapters with a logical articulation matching the need for a clear identification and understanding of all key factors leading to a successful FTTH deployment.

The first chapter will introduce FTTH in general terms and will detailed FTTH technologies and architectures available today for all operators. Information will be given concerning FTTH network layers, to better understand FTTH network's structures. This chapter will end with all the services now available for FTTH customers and the future bandwidth requirement related to future application.

The second part of the thesis will focus on the actual trends for FTTH in Europe. Starting with the overall situation of the European FTTH market and continuing with some countries performances. It is a way to highlight leading and lagging countries

in term of FTTH advancement, in order to correlate these information's with the strategy they employed. In the same chapter, key actors coming from the FTTH market will be identified to better understand their roles. And for the end of the chapter, a wide description will be done concerning the FTTH environment, in term of National and European regulation within the background of National ambition plans.

After having a broad view of the FTTH market, we will focus on the key parameters which are impacting FTTH deployment. These strategies will be highlighted, described, and analysed, in order to draw some key points of a successful FTTH roll-out. From the FTTH organisational strategy to the technological/architectural choices, but also all the key decisions related to Open Access or single/Multifiber choices, each of these elements will be threaded in a way to compare all the possibilities and choices possible for rolling-out FTTH in Europe. The objective is to better understand the appropriate strategies in each case scenario.

And the last part of the thesis will illustrate some of the best FTTH projects in Europe. We will analyse 2 projects where Public/Private partnerships are taking place, in a small rural areas (France) and in a very dense area (Netherlands). Also as a great example of wide successful deployment in Europe, Scandinavia FTTH market will be described and analysed in detail to better understand the reason of such a great FTTH penetration in those countries. Also 2 projects will be highlighted from Norway and Sweden.

In term of methodology and research organisation, all the materials I decided to use for the redaction of the thesis are coming from National Regulators reports, and white papers wrote by most of the major FTTH actors in Europe. For last updates and news, I used articles coming from websites specialized in ICT/Telecoms/Internet news. And I also used as important data, some of the statistics I personally made during my internship at bmp-TC. Those statistics mainly come from interviews I had with FTTH project managers or directors and also from Emails I sent them for particular question related to FTTH roll-out.

1.3: Aim and Objective

Study objective is to understand all the key factors impacting FTTH roll-out. Analysing those factors and describing those effects will help to clearly identify best practices and key success factors for a wide and enticing FTTH deployment. During this study, much information has been gathered related to the strategy employed by some FTTH actors. All those information's will allow us to draft the following key points with a major impact on the FTTH deployment in term of decision making.

- Technologies and architecture used
- Cost Efficiency: CAPEX/Opex strategy
- Role of Utilities (sharing Ducks)
- Incumbents, alternatives operators Local Authorities roles
- Regulatory: Open Access, Multiple fibers
- Government plan: Financial incentives…
- Organisational structure
- Financing the network
- Ect…

1.4: Fiber To The Home Introduction

A Fiber to the Home network is a residential communication infrastructure where fiber optic cables run all the way to the subscriber premises. After years of anticipation, various deployments of Fiber to the Home are finally becoming wide in Europe. Although Fiber to the Home is just a technology, it has interesting implications for the dynamics of competition in the local access market. The real advantage of Fiber to the Home networks is its ability to provide many times more bandwidth than currently available with existing broadband technologies.

1.4.1: Basic understanding of Optical Fiber Technology

But before going any further, a brief explanation is required to understand the principle of optical fiber − what is "fiber" and how does it work? Basically, optical fiber uses light as a means to transmit data from location to another. It consists of a

light source (laser or LED), an optical glass fiber as the transmission medium and a detector[1]. Commercially available lasers currently reach speeds of up to 10 - 40 Gigabit/second and with the latest technology 100 Gbit/s and recent research in commercial networks have shown that it is possible to achieve 1 Terabit/s[2]. Multiple fibers can be combined together to form one cable. Standard cables can carry up to 912 fibers in a cable.

ACE standard optical cable types for single or multi duct assemblies:			
Fibre Unit	EPFU	Enhanced Performance Fibre Unit	2, 4, 8 or 12 fibres
Micro-Cable	MuC	Micro Cable	2, 4, or 6 fibres
Mini-Cable	CTMC	Central Tube Mini Cable	4, 8, 12, 16 or 24 fibres
	LTMC	Loose Tube Mini Cable	24, 36, 48, 60, 72 or 96 fibres
Standard Cable	LTC	Loose Tube Cable	4 up till 912 fibres

Product catalogue: Fiber Opic Cables from *ACE*

These cables are put in the ground in cable ducts or strung over poles in the air. When telecommunications companies lay fiberducts on a route, they lay more empty ducts for later use. So companies might lay 12 or 30 ducts on a route and only fill 2 to 6 of those with fibre, leaving the rest for later.

Basics advantages of Fiber compared to Cooper cables[3]:

- Almost unlimited bandwidth, a very low attenuation and dispersion.
- No or few needs for repeaters.
- No influence from electromagnetic fields corrosion.
- Low weight (485 Kilo/km for 912 fibers, whereas 8000 Kilo/km for a thousand twisted pair telephony cable)

First generation broadband started as a copper based technology either through copper phone wires from the Phone Company or copper coax from the cable TV

[1] Fiber-optics.info, Optical Fiber Technology, 2010

[2] DTU Fotonik, Department of Photonics Engineering, Technical University of Denmark, Terabit/s serial optical communications, January 2010

[3] OECD, Working Party on Communication Infrastructures and Services Policy, 2008

company. In the last 20 years the focus was solely on using fiberin the backbone part of the network, up to the local Main Distribution Frames[4]. Today the focus is to bring the fiber ever closer to the subscriber, aiming to deliver the higher bandwidth possible. There are various technologies employed to deliver fiber to the last miles, Gigabit-Passive Optical Network (GPON), Ethernet Passive Optical Network (EPON), Active Ethernet (AE) and Point-to-Point Ethernet (P2P) are the major competing technologies.

1.4.2: FTTH Architecture

In order to specify the interworking of passive and active infrastructure, we have to make distinction between the topologies used for the deployment of the fiber (the passive infrastructure) and the technologies used to transport data over the fiber (the active equipment).

The two most used topologies are still today the point-to-multipoint, which often comes with a passive optical network (PON) architecture, and the point-to-point, typically using Ethernet transmission technologies.

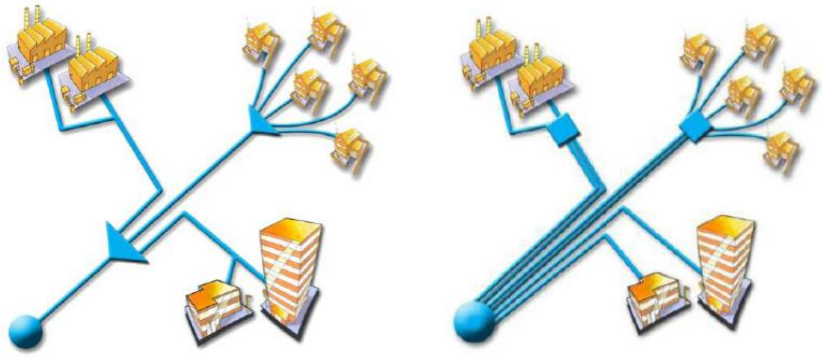


Figure 1: FTTH infrastructures P2M/P2P[5]

There are different termination points, FTTH which stands for "Fiber to the Home", indeed it means that each subscriber premise is connected by a dedicated fiber to a

[4] OECD, Working Party on Communication Infrastructures and Services Policy, 2008

[5]FTTH Council, FTTH Handbook Third Edition, March 2010

port on the equipment in the Point of Presence, or to the Passive Optical Splitter, using a shared feeder fiber to the POP[6]. The other well known termination point can be the building also called FTTB, for that network architecture each optical termination box is located in the basement of the building and is connected also by a dedicated fiber to a port of the equipment in the Point of Presence or the optical splitter if using shared feeder fiber to the POP.

1.4.3: The Passive Technology

The passive optical network (PON) is a point-to-multipoint, fiber to the premises network architecture in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises, typically between 32 and 128[7]. A passive optical network (PON) allows the elimination of all active components between the telecommunications service provider and the client. The use of these passive systems, whose main element is the optical splitter device, reduces the cost of installation and maintenance[8].

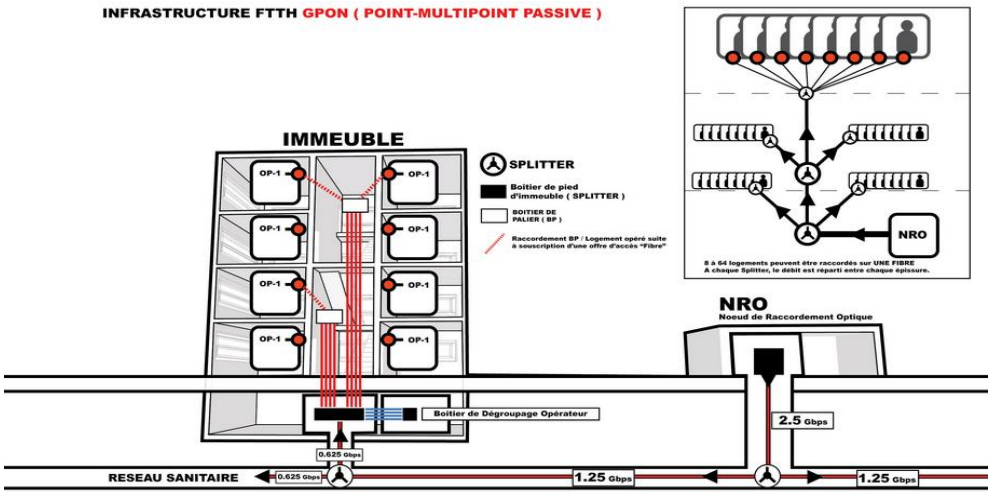


Figure 2: FTTH infrastructure GPON (Point to Multipoint)

---

[6] Point of Presence

[7] WDM Ethernet Passive Optical Networks. IEEE Optical Communications. February 2006

[8] FTTH Deployment Options for Telecom Operators by Jani Saheb Shaik, 2010

PON networks topologies:

The way PON networks are built influences the way they can be open to multiple service providers. There are three basic ways to build a PON-network.

- Firstly, if the fiberspliit is close to the home of the user **(Figure 3).** One fiber is used to pass a group of homes. At each home a separate splitter is installed to divert the signal to and from the home. This is the most fiber lean solution, but makes it hard for other operators to share the infrastructure through local loop unbundling. If the network is shared this needs to be done through wholesale broadband access[9].

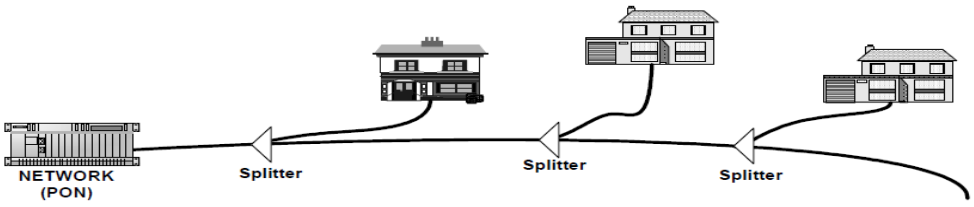
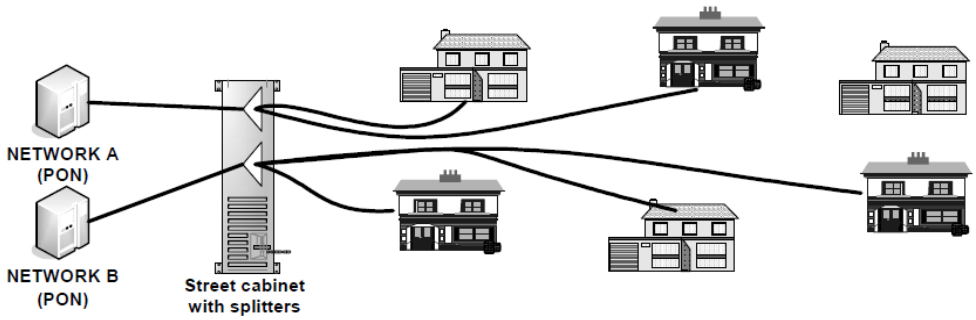


Figure 3: FTTH infrastructure PON topologie

- The second way is to split the fiber half way **(Figure 4).** A small bundle of fibers is brought to a street cabinet. In the street cabinet the optical signal is split and from the street cabinet the connection branches out using a point to point connection where every household has its own fibre. Switching providers is as easy as switching fibers from one provider's splitter to another, although this does require a truck roll to the splitter, introducing costs for switching[10].



[9] OECD, Working Party on Communication Infrastructures and Services Policy, 2008

[10] OECD, Working Party on Communication Infrastructures and Services Policy, 2008

Figure 4: FTTH infrastructure PON topologie n°2

- The third way is a Point-to-point architecture with PON **(Figure 5),** The network is built as a point to point network, but can be used as both a PON and P2P-network with the splitter at the local exchange[11].

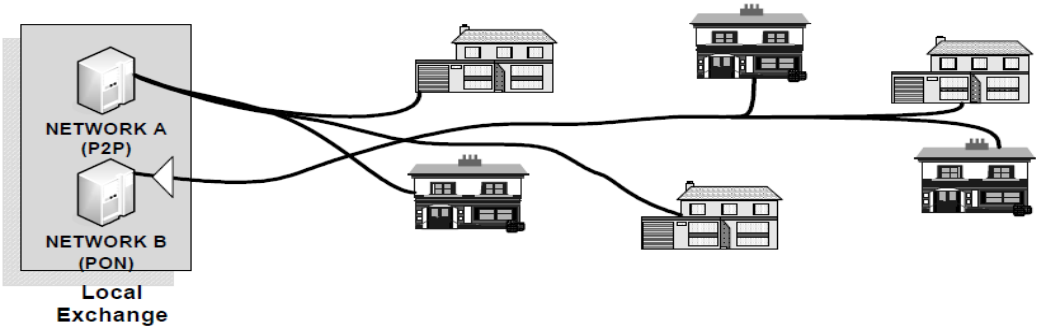


Figure 5: FTTH infrastructure PON topologie n°3

There are different PON standards used today:

- **APON/BPON (ITU-T G.983)** systems are based upon ATM as the bearer protocol. Downstream transmission is a continuous ATM stream at a bitrate of 155.52 Mb/s or 622.08 Mb/s with dedicated Physical Layer OAM (PLOAM) cells inserted into the data stream[12].
- **GPON (ITU G.984):** This is the official successor for APON/BPON and was finalised in 2005. It allows for 2.5 Gbit/s downstream and typically 1.25 Gbit/s upstream, though 2.5 Gbit/s upstream is also possible. It allows for a 64-128 way split. It can use either ATM or Ethernet over GEM as link layer protocols. It can reach up to 60 km[13].

[11] OECD, Working Party on Communication Infrastructures and Services Policy, 2008

[12] Networkdictionary.com

[13] Networkdictionary.com

- **EPON (IEEE 802.3ah)** Ethernet Passive Optical Network (EPON) is a point to multipoint (Pt-MPt) network topology implemented with passive optical splitters, along with optical fiber PMDs that support this topology[14].

1.4.4: The Active Technology

Active Ethernet also called Ethernet Switched Optical Network (ESON) or Point to Point (P2P) Network architecture provides a dedicated fiber to the side from the central office exchange shown in the **figure 6**.

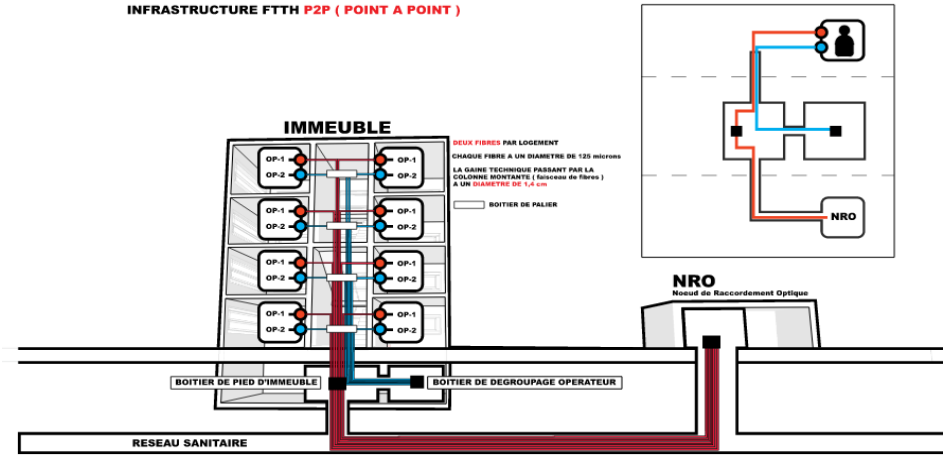


Figure 6: FTTH infrastructure P2P

Since the fiber is dedicated, operation, administration and maintenance of the content and troubleshooting become easy. Active FTTH solutions are implemented in many different ways, through both standard and proprietary methods. Transmission in P2P configuration is more secure, since all transmissions are physically separated by fiber. Only the end points will transmit and receive information, which is not mixed with that of any other customer.

Figure 7 shows again the key FTTH technology options existing today and are already being deployed by some of the major operators in the Europe. Basically, GPON and EPON optimize the outside plant by using a passive splitter which

[14] Networkdictionary.com

provides bandwidth aggregation, requires less maintenance and doesn't have any power requirements like an active network element. In another hand, the Active Ethernet solution achieves optimization in the outside plant by using an Ethernet switch for aggregation, but requires hardened cabinets and remote power supply. The Point-to-point solution also uses Ethernet switching and aggregation, however all the Ethernet switches are deployed in the Central Office. These COs, also known as Points-of-Presence (PoPs) tend to be closer to the subscriber[15].

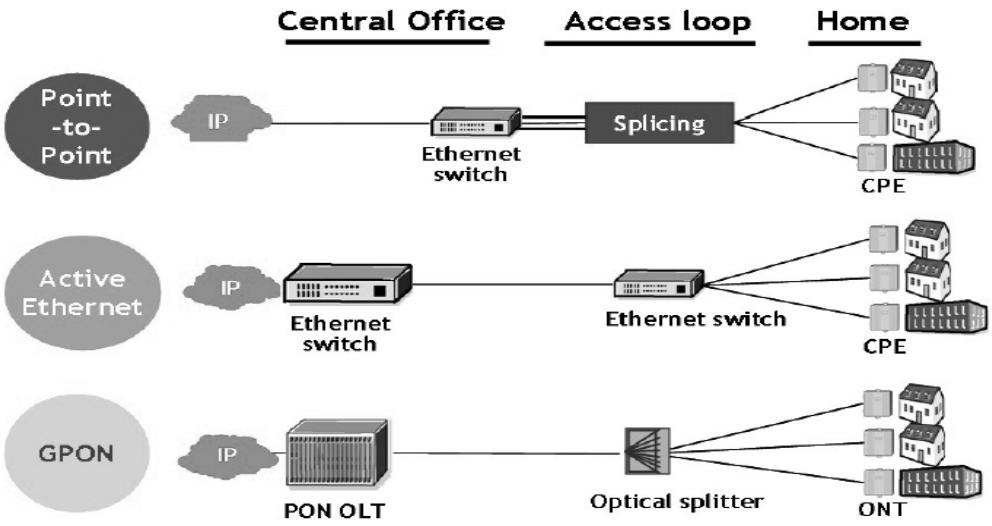


Figure 7: Key FTTH technology options[16]

1.4.5: FTTH Networks Layer.

FTTH networks have 4 layers: Firstly, the passive infrastructure including the fiber, duct, enclosures and other outside plant. Then there is the active network with all the electrical equipment. It continues with the retail services, which provides connectivity to the internet. And of course, finally the end-users arrive last. Some people also visualize an additional layer, the content layer, lying above the retail services layer, which may also be exploited commercially[17].

---

[15] FTTH network economics: Key parameters impacting technology decisions

[16] FTTH network economics: Key parameters impacting technology decisions SAMRAT KULKARNI, MOHAMED EL-SAYED, PAUL GAGEN, BETH POLONSKY

[17] genexis.eu, An introduction to the Genexis FTTH Network Architecture, June 2010

Passive infrastructure comprises all the physical elements needed to build the fiber network. This includes physical objects such as the optical fiber, the trenches, ducts and poles on which it is deployed, fiber enclosures, optical distribution frames, patch panels, splicing shelves and so on. Organization in charge of this layer is in general responsible for network route planning, right-of-way negotiations, and also for the civil works in order to install the fiber. This is the layer where the network topology is implemented, whether point-to-multipoint or point-to-point.

The active network layer refers to the electronic network equipment needed to bring the passive infrastructure alive, as well as the operational support systems required to commercialize the fiber connectivity. The party in charge of this layer will design, build and operate the active equipment part of the network.

Retail services layer, where the internet connectivity is packaged as a service for consumers and businesses. Besides enabling those services technically, the company responsible for this layer is also in charge of customer acquisition, go-to-market strategies, and customer service. The retail service provider may also decide to offer premium services from the content layer, such as IPTV.

1.4.6: FTTH Services for end-customer

FTTH will multiply the demand and possibilities of existing Internet services and applications (P2P, Online Games, and so forth), and will allow for new services as HD Television on demand, and public applications to e-Education and e-Health.

But the main value of FTTH is bandwidth. Indeed FTTH offers the highest available bandwidth of any technology, in both downstream and upstream directions. Here on **Figure 8** you can observe a selection of existing and future services and their bandwidth requirement.

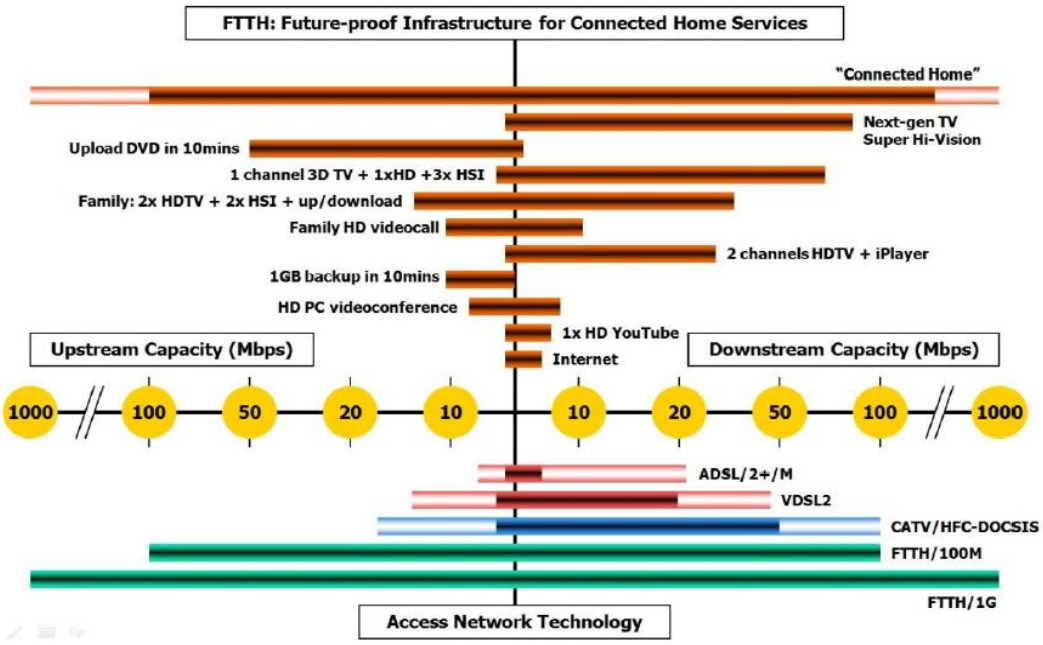


Figure 8: FTTH versus other fixed-line technologies [18]

Broadband marketing has typically focused on downstream bandwidth, but upstream bandwidth will become increasingly important as applications that require two-way video sharing become commonplace, and cloud-based services proliferate. Not only does FTTH offer the highest upstream data rates, it also opens the way to symmetrical bandwidth.

[18] Awt.be, FTTH versus other fixed-line technologies, March 2010

CHAPTER 2

FTTH deployments trends in Europe

2.1: Introduction

The previous chapter aimed to better understand what FTTH was all about. And now in the following chapter we will describe the European FTTH market's trend. The chapter will be starting with the overall FTTH situation in term of deployment and country performances. Based on the last statistics I gathered during my internship.
Then we will be continuing with a complete identification and description of each key actor and their role into the FTTH market. Indeed, knowing the growing role of some particular FTTH actors is a key to better understand the market. And at the end of the chapter it would be interesting to apprehend all the externals factors impacting the FTTH roll-out, especially the national and European Telecommunication Regulation paradigm. This has a major impact on the FTTH deployment, we will see how each country and how Europe is trying to increase FTTH adoption through, openness and concurrence oriented regulation. And then conclude with the range of political measure and financial incentives, countries are taking to speed up FTTH roll-out.

2.1.1: Overall situation of the European FTTH deployment

There are some 3,2 million FTTH connections in service in Europe in September 2010. But the FTTH situation significantly differs from country to country. The majority of subscribers are still concentrated in 7 countries. We can see nearly 74% of FTTH/B subscribers and more than 54 % of households passed in Sweden, Italy, France, Norway, the Netherlands, Denmark and Lithuania[19]. Many European countries are still lagging behind in terms of FTTH development whereas they benefit from high broadband penetration rates, such as Germany or the UK. On the other hand, some Eastern countries that are lagging behind in terms of broadband penetration are implementing FTTH, for instance in Romania, Hungary.

[19] bmp TC, Statistics September 2010

The European market is still atomised with over 400 FTTx projects[20] and the most dynamic countries concerning FTTH/B deployments are the Nordics and some Eastern European countries, Slovenia or Latvia for instance, are becoming active. FTTH is growing steadily. Some countries have undergone significant growth lately. For instance, Latvia has started its migration to FTTH technology with a 477 % growth achieved throughout 2008 to 2010 in terms of households passed[21].

2.1.2: FTTH Countries performances

Scandinavian countries such as Sweden, Denmark or Norway are often taken as a reference for the FTTH initiative by public authorities or operators. Indeed these countries have early seen the upsurge of FTTH projects and are leading the way of Europe for FTTH. In the European FTTH market, Scandinavian countries have a preponderant role. Norway, Denmark, and Sweden feature in the top for FTTH penetration **(Figure 8),** highlight the Scandinavian region's advancement in telecommunications.

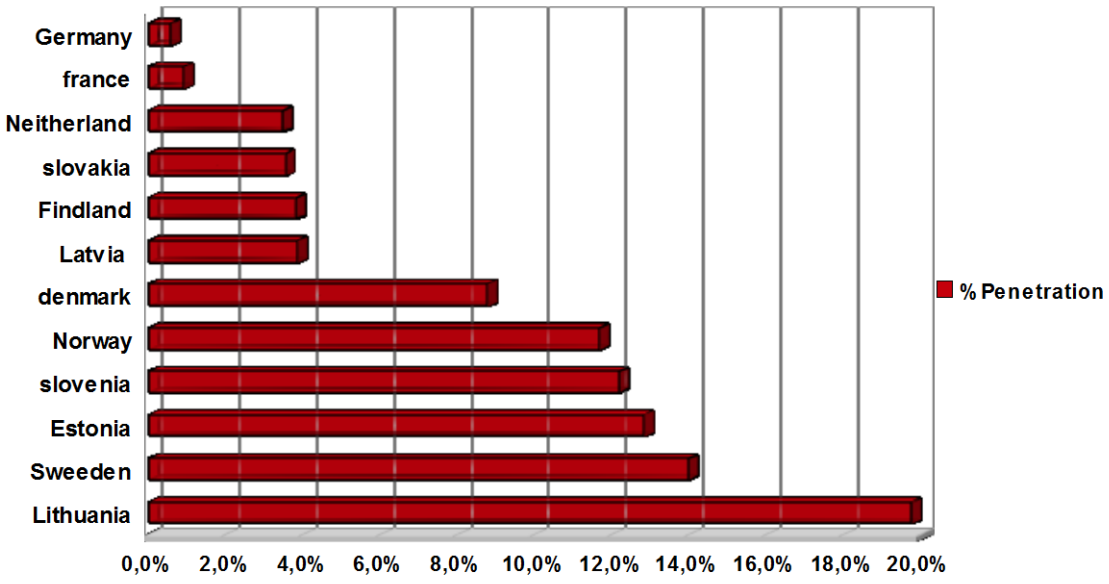


Figure 9: Top 12 Penetration of passed FTTH or FTTB Households (bmp TC 2010)

[20] bmp TC, Statistics September 2010

[21] bmp TC, Statistics September 2010

The development of FTTH in each European country depends on several conditions, such as the importance operators give to VDSL and other broadband technologies, the competition level on the market and the role of public authorities.

Cities and regions have been the most ambitious public authorities in terms of FTTH deployments. Indeed, more than 238 of the projects (58%) have been initiated by municipalities or power utilities in 2010[22] Indeed, private operators are willing to invest more to face a still harsher competition but they have for long hesitated to significantly invest into FTTH due to the heavy investments and to the threat of having to open their FTTH networks to other operators. However significant dynamics are being identified, incumbents have worked dedicated strategies for FTTH and planned investments to be conducted within the coming years. Furthermore quite a number of incumbents promote the concept of open access in an increasing way, like with KPN, Swisscom, TDC, Deutsche Telekom or France Telecom. For some of them they have announced to build fiber networks to be shared with the other operators in a neutral and non-discriminatory way. It is interesting to see that this is happening either through regulative measures or for some in the absence of specific regulation…

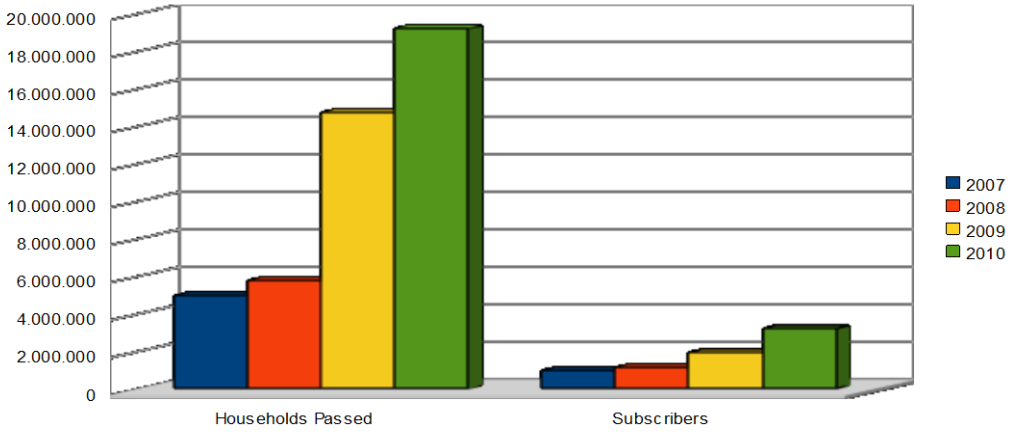


Figure 10: Comparison of European FTTH market from 2007 to 2010 (bmp TC)

[22] bmp TC Statistics, 2010

We can also observe the number of households passed which has considerably increased between since 2008 (from 5,8 million to more than 20 million)[23] so has, in a smaller proportion, the number of clients. This was to be expected as commercialisation has been starting recently. These results are including FTTH/B and also FTTLA (Fiber to the Last Amplifier) projects.

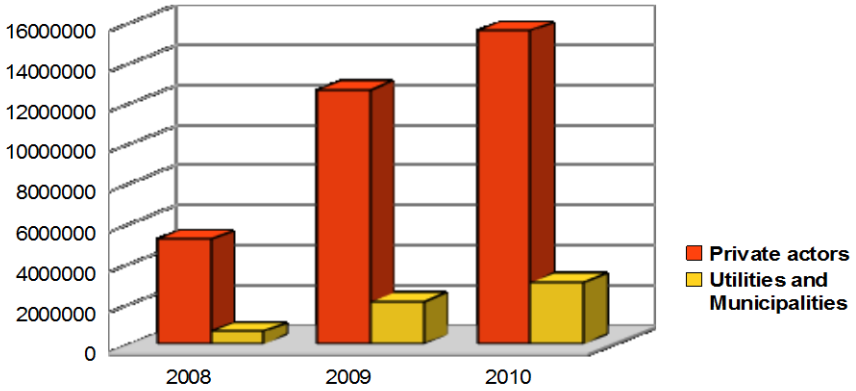


Figure 11: Evolution of households passed per type of actor (bmp TC)

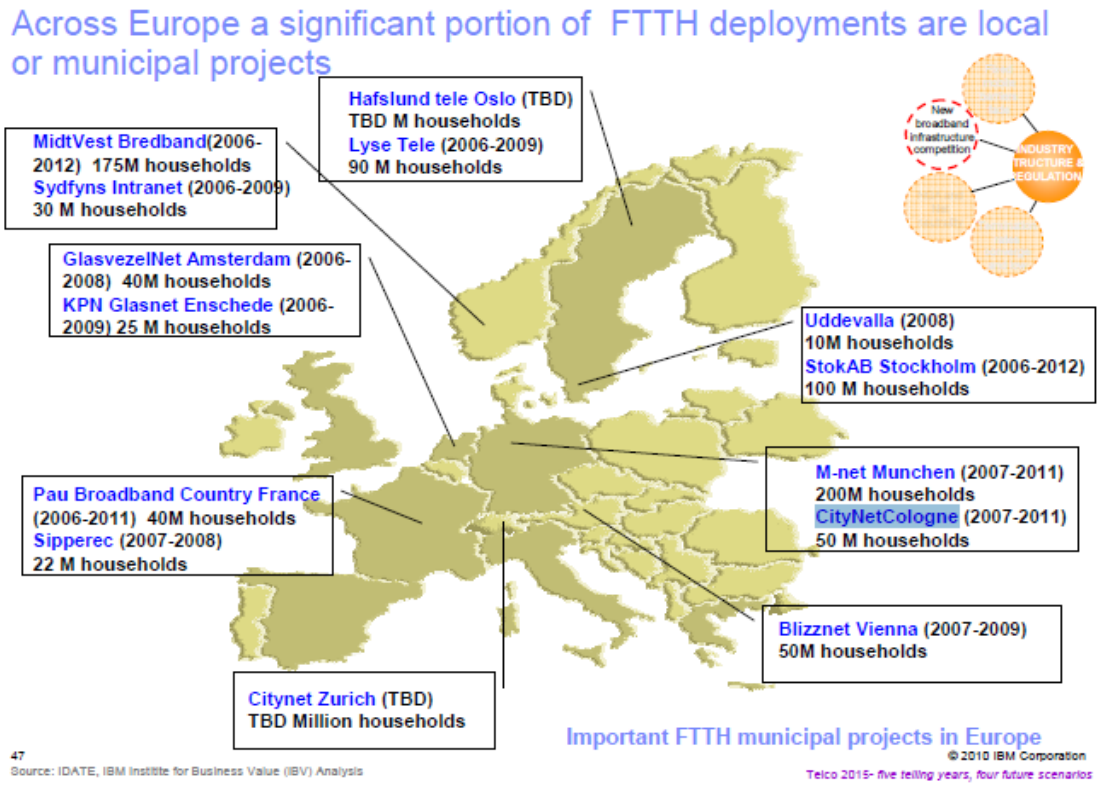
Most of deployments in term of home passed are run by private operators in Europe and this trend seems to be confirmed in 2010. Operators are passing now more than 73% of all the households with 178 projects in 2010[24], the number of projects run by municipalities and power utilities represent 232 projects for approximately 3 million Households passed[25]. With nearly half of these projects are run by utilities and the rest are conducted directly by the local authorities. We also note that in average, municipal projects are relatively smaller in size compared to project operated by private actors. This is confirmed in 2010 by the growth of the number of households passed by utilities or public authorities' projects which has increased by more than 800% since 2007 while the number of households passed by operators' projects increased by 180% at the same time frame[26].

[23] bmp TC, Statistics September 2010

[24] bmp TC, Statistics September 2010

[25] bmp TC, Statistics September 2010

[26] bmp TC, Statistics September 2010



2.2: Key actors on the FTTH market

2.2.1: Public Authorities a key players for FTTH

In many countries, regional public authorities have become a key element of the FTTH market. The role of public actors takes place at different levels. Regional authorities or municipalities (and very often their public utilities) are more and more directly involved in FTTH projects. In April 2010 public actors alone initiated more than half of all identified FTTH European projects[27]. Understanding the role of Public authorities is essential for the FTTH market comprehension.

Indeed, telecommunications networks and FTTH are being seen by public players as a means for guaranteeing economic prosperity, rendering their territories attractive and enabling innovative e-services for inhabitants and businesses. FTTH is seen as the best choice as it allows reaching the largest bandwidth and speeds and enables a better scalability for future requirements. Finally, high-speed network connectivity is

[27] bmp TC, Statistics September 2010

having a significant impact on sectors such as health, education, transportation and electricity, all sectors crucial for the development of the Society and the economy on a local or national level, it is thus also a way to let municipalities, regions or states emerge as highly attractive and competitive locations for businesses and citizen. Governments and public actors have indeed seized the opportunity of FTTH and their long term involvement is strategic.

Regional authorities have as well been quick to set up dedicated programs to bring FTTH to their population. One of the most ambitious project is led by the Conseil Général des Hauts de Seine in France which plans to give access to FTTH to all its inhabitants by 2013, that is to say 1,5 million persons and 100.000 companies. The regional authority has chosen a consortium led by French cableco Numericable (80%) and including Eiffage (15%) and LD Collectivités, a subsidiary of Neuf-SFR (5%). It is understood the Hauts-de-Seine project will require an investment of € 422 million, of which € 59 million will come from the public purse (in order to cover unprofitable areas which account for 47% of the region area). In October 2009, the deployment concretely started: 827.000 optical connections should be built within 6 years, more than 51% of them forecasted for the first 3 years[28].

Sweden is, one of the pioneers regarding public initiative projects such as the city of Stockholm which in 1994 began to promote economic growth and stimulate IT development in the region through one of the most representative FTTH project in Europe[29]. In 2009 there were more than 155 public initiative networks with 1,3 million homes passed and covering 2/3 of all municipalities.

It appears clearly that local authorities are key actors for FTTH deployment and will become more and more involved in such plans or projects in the coming years to reach new socio-economic and customers' needs. Speeds and scope of FTTH deployments could then be closely linked with regional authorities' involvement.

---

[28] Opticalreflection.com, France: landmark decision for fiber projects (THD92) October 2009

[29] www.itu.int, A Look at Digital Cities: Stockholm, Sweden, May 2010

2.2.2: Increasing impact of Utilities within the FTTH deployment

As previously seen, the role of public authorities remains a major element within the development of FTTH activities in Europe. More particularly, energy utilities have taken a pioneer and dominant role and have been growingly committed to FTTH.

The reasons are various. With demand for energy rising globally, energy providers are beginning to see the value in gaining real-time information to make real-time decisions in order to mitigate the effects of shrinking generation reserves, outdated communications infrastructures, and lack of true visibility. This in mind, Fiber-to-the-Home (FTTH) has quickly became the communications medium of choice for many utilities, with FTTH deployments even happening at various levels within the utility industry. Furthermore quite a number have started the deployment of FTTH telecoms services using their infrastructure and expertise resources. Today more than 50% of the utilities involved in European FTTH projects originate in Scandinavian countries[30]. Nearly 33% of all European FTTH projects are being led by utilities in Denmark, Finland, Norway and Sweden. Following this leadership, a growing number of other European countries are seeing this trend appear.

In view of the telecoms activities to be led, utilities often appear as an appropriate instrument for public local authorities. Many municipalities or regions seem indeed to delegate the strategy and operational aspects of a massive FTTH roll out to their related public utilities. Just to name a few of the most representative, the French "Département de l'Ain" or the municipalities near Chartres (SEIPC)[31], or Zürich in Switzerland are following this trend. In Germany local authorities and their utilities are especially involved with the municipality of Schwerte[32], or Helinet an association of municipal utilities operator of the City2020 project[33]. In Essen, Essen.net will partner with city utilities provider Stadtwerke Essen[34].

---

[30] bmp TC, Statistics September 2010

[31] Localtis.info, La fibre optique arrive jusqu'au domicile en pays chartrain, June 2010

[32] Lessons Learned in Municipal Owned Fiber, Slide N°5/18, April 2010

[33] Hammtv.de, Das City2020 Projekt -Die Ersten sind online, July 2009

[34] Portel.de, Stadtwerke Essen und Conlinet gründen 'Essen.net', April 2009

Utilities projects following a municipal initiative are numerous and their role remains strategic. The enhancement of telecommunication networks could support the economic development and allow the retention of existing businesses and the attraction of new ones. Further, it could improve the quality of life, the educational and the medical resources for citizens[35]. Besides, in areas where a deployment will not be economically viable for operators, such initiatives enable to fight the digital divide n°2 (related to Ultra-Broadband).

As their public shareholder increasingly seizes the challenges and opportunities related to FTTH, utilities are expected to be of growing importance within the European FTTH market, though their relative market share might stabilise compared to private actors.

2.2.3: Alternative operators, a new business model

Alternative operators have made relevant investments during the last years to offer services based on ADSL2+ technology using the local loop unbundling facilities[36]. In Europe the strategies followed by alternative operators will be depending on the deployments made by incumbent operators, whose access networks are used by alternatives to provide their services. As we will see further, these strategies will be strongly marked by regulatory decisions regarding the access to the infrastructure network.

Alternative operators, which used the unbundling access to local loop, will have to review their business model. This would lead to two different strategies. The first strategy would be an evolution toward the final step of the ladder by building up their own access infrastructure to streets cabinet level or to customer's houses. Or the descent of one step, renouncing to provides service over its own infrastructure and becoming a reseller using wholesale access over the incumbent's new network. Also, we observe in some cases, alternative operators rolling out their own fiber

---

[35] Utc.org, Utilities Telecom Council, Slide 4/13, 2008

[36] Princeton.edu, Local Loop Unbundling and Broadband Penetration, November 2008.

infrastructures, although this strategy demands a greater investing effort. This proactive strategy allows an increase of the competitiveness of their networks and services, and could encourage infrastructure competition. The approach taken by alternative operators is basically due to a scale question. Many of them come from a long investing process and need enough efficiency and market share to initiate a new intensive investment process. The market share that an alternative operator must reach in order to start an FTTH deployment vary, from 15% claimed by liad in France[37] to 40% (In environments with less access to passive infrastructure). According to specialists, the market share needed by an alternative operator to make profitable an own FTTH deployment can be valued at 25%[38].

2.1.4: Incumbents, still lagging behind

Incumbent operators have generally an extensive access network of copper pairs deployed. The evolution towards FTTH will be influenced by the competition degree from the remaining agents of the market and especially their capacity to establish business models. The following elements are the main determining factors of incumbent's strategies and its evolution towards VDSL or FTTH architectures. Incumbent are in the process of making fundamental choices about technology and planning deployments.

Indeed the topology of existing network, including local loop length, existence of street cabinets are key elements driving incumbents moves. Furthermore EU regulators did not actively encourage them to invest in fiber. Incumbent telecom operators have to react now to the double-squeeze from cable operators and from the FTTH deployments by utilities and alternative operators. If they do not act, they risk an erosion of their core business. As long as European governments and regulators do not improve the FTTH framework by protecting investments or by providing direct funding, incumbent operators will not invest into any significant FTTH deployment.

---

[37] Freenews.fr, Conférence ILIAD : des précisions sur le FTTH en IDF, 2006

[38] This is the finding of WIK (2008), XVII

2.3: Environment of the FTTH market

2.3.1: In the scope of the National and European FTTH regulation

In order to foster the deployment of NGAs, some legislative measures have been taken in many European countries like Portugal, Austria, France or Slovenia, aiming to facilitate the access to physical infrastructure and facility sharing. For the same reasons access to passive infrastructure has been imposed by numerous NRAs (Portugal, Germany, France, Spain, Denmark, Greece, Estonia, Slovenia,), aiming to facilitate network deployment by alternative operators[39].

In France, Portugal and Spain measures have been taken regarding in-house wiring by means of symmetric obligations. Further consistency, transparency and legal certainty are needed in regulatory measures such as those concerning the migration from copper to fibre. For that matter, the Commission will adopt a recommendation on regulated access to NGAs in the course of 2010[40]

The EU Commission shares the view that broadband access represents a strategic issue for economic and social development; it has thus emphasised this importance through the vigorous support to the 2010 Lisbon goals[41]. Until today, France Telecom, Deutsche Telekom, and Telefónica have been among the most vocal incumbents in calling for clear regulations before any major investment in FTTx. Operators have actually fearing that their investments in a FTTH network could potentially benefit to other operators which would not have shared the initial risks.

In this context and in order to foster the development of FTTH in Europe, the European Commission launched a public consultation on the regulatory principles to be applied by EU Member States in Next Generation Access networks in October

---

[39] Annex to the BEREC Report Next Generation Access – Implementation Issues and Wholesale Products March 2010

[40] 15th Progress Report on the Single European Electronic Communications Market, May 2010

[41] FTTH Conference Lisbon 2010,

2008[42]. The objective of such a common regulatory frame was to enable a consistent treatment of operators and thereby ensures the necessary predictability to invest. The Commission suggested definitions for harmonizing categories of regulating services, network access conditions, rates of return and appropriate risk premiums.

In June 2009, the EU announced the results of this consultation which confirmed the need to provide guidance on how the current regulatory framework should apply to NGA investment, in order to avoid Single Market distortions and to create legal certainty for investors[43]. It also confirmed general support for the proposed balance between investment incentives (especially in this time of crisis) and the protection of broadband competition. However, there were also calls to consider alternative mechanisms to diversify the specific risk of NGA investment as a way to foster investment in fiber. Then the Commission has decided to have a second consultation focusing on more specific points in June 2009, asking for comments by end of July 2009. This will be allowing it to set up a draft Commission Recommendation.

Gathering the 27 national regulators of the European Union, the new European regulator BEREC was created at the end of January 2010 and has already defined a new "Telecom Pack". Twelve measures were adopted and have to be transposed into national legislation by June 2011[44]. For instance national regulators will have the possibility to force (if necessary) operators to separate their network from services they provide. This separation should allow more competition. One other measure announces to promote competition and investment in new generation networks (NGA).

As part of the new "Telecom Pack" stands the relationship between different network layers. This is important to underline that the pack specify that all interested service

---

[42] European Commission "Europe's Information Society" Next Generation Access Networks, November 2008

[43] Commission Recommendation on Regulated Access to Next Generation Access Networks (NGA) June 2009

[44] BEREC Report, Next Generation Access – Implementation Issues and Wholesale Products, March 2010

providers are granted access to infrastructures. The goal of the regulation is therefore to discipline market power on the infrastructure layer. This goal is attained if third parties are not discriminated while property rights are least infringed. There are several options[45]:

- Non-discriminating access to network infrastructures can be attained by regulating access to an integrated operator's network, potentially in combination with various degrees of separation.
- Access regulation concerns non-discriminatory prices and conditions of access to the infrastructure of an integrated telecommunications operator. Such regulation may either be ex post or ex ante and based on several possible calculation methods.
- Separation of infrastructures from services in an otherwise vertically integrated operator facilitates the non-discriminatory access to infrastructures and therefore competition on the services-layer
- Accounting Separation is the least intrusive form of separation. It is a requirement that forces greater transparency in accounts to disclose the real costs involved in the production of regulated bottleneck resources in order to avoid cross-subsidization, margin squeeze or to enable cost-oriented pricing.
- Functional Separation requires the creation of separate divisions within vertically integrated operators. It does not change ownership of bottleneck resources, however. Nevertheless, it requires operations and management separation and decisions to be made independently by the separated business unit and the rest of the company. While the exact location of separation may be variable, it typically includes a separation of functions, employees, and information (systems).
- Structural Separation implies that the vertically integrated operator is forced by regulation to dissolve the bottleneck away from the rest of the company. The independent unit may still be owned by the incumbent company, be sold to a third party or even be nationalized.

---

[45] Commission Recommendation on Regulated Access to Next Generation Access Networks (NGA) June 2009

- Ownership regulation of the infrastructure. Forced sale to an independent owner or to government are probably the most intrusive regulatory measures to assure non-discriminatory access conditions.
- Sector-specific regulation contains a much broader spectrum of remedies to bottlenecks than competition law. This difference is due to the latter's generality which does not allow for sector-specificity and is the very reason for the co-existence of competition law and sector-specific regulation.

The European Union naturally acts by taking into account the necessary competition between operators that must be ensured. The EU is among others controlling if FTTH projects implemented by public authorities might represent a distortion of competition in the market. For instance, in the Netherlands, UPC had accused the Citynet Amsterdam project of infringing competition[46]. The company would have wanted municipal participation in the project to be banned but after analysis the European Union has stated against it. The fact is that the favourable regulatory conditions in Europe in favour of the incumbents have not seemed to spur on FTTH investment. In the few countries where FTTH is being deployed, the causes are a combination of competitive pressure and government/public funding.

The European Union indeed plays a role within the European broadband market through the structural funds it allocated. Thanks to these funds, many local authority broadband projects in Europe can be implemented more easily, enabling open neutral FTTH networks. One of the last ones is in the frame of the stimulus efforts for the economy the budget of € 5 billion for bringing very high speed internet (among these fibers) to rural communities in Europe. In term of national policies, only a few regulators are currently starting to settle a clear legal frame. Consultations are currently processing or in preparation in various markets (Croatia, Hungary, Poland….). The French market is one of the most advanced concerning the regulation paradigms. The French regulator ARCEP has been working for years now on the technical details of the FTTH deployment, such as methods for

[46] telecomengine.com, FTTH 2007 Europe: CityNet Amsterdam Under Fire, February 2007

performing work on client's premises, the location of a shared access point and technical options for sharing the last part of the fiber connection[47]

In October 2008 the French Parliament and the French regulatory authority ARCEP took major steps in defining a regulatory framework (LME[48]) proactively to the European framework. It aims at achieving widespread deployment of Fiberto the Home. Among others, this includes obligations on all operators to meet reasonable requests for access to in-building fiber (at an access point called mutualisation point to be defined). Furthermore it implies an infrastructure access obligation on France Telecom (as open access to spare capacity within ducts is expected to lower the costs for other operators and should entice them to roll out their fiber network) and a decision not to mandate wholesale broadband access over fibre[49]

In June 2009, solely concerning dense populated areas, ARCEP defined rules to "improve investments" according to which operators are obliged to enable the presence of several operators or technologies per building[50]. The approved regulatory framework for fiber deployment in densely populated areas mandates multi-fiber deployment and guarantees technology neutrality for all service providers. This means that any service provider deploying in-building fiber will be obliged to install additional fiber if another service provider makes that request and agrees to share the installation costs. This agreement must be reached at the beginning of a project. ARCEP estimated an extra cost of 5% more of investment and on this point France Telecom disagreed, pointing out 40% additional cost[51].

---

[47] ARCEP : Fiber rollouts and sharing of the last part, 2008

[48] Loi de Modernisation de l'Economie

[49] T-Reg.com France: FttH law adopted and new ARCEP decisions, new access obligations

[50] MuniWireless.com ARCEP regulates fiber local loop to stimulate FTTH investment in France

[51] TelecomsEurope, Regulator encourages multi-fiber model, October 2009

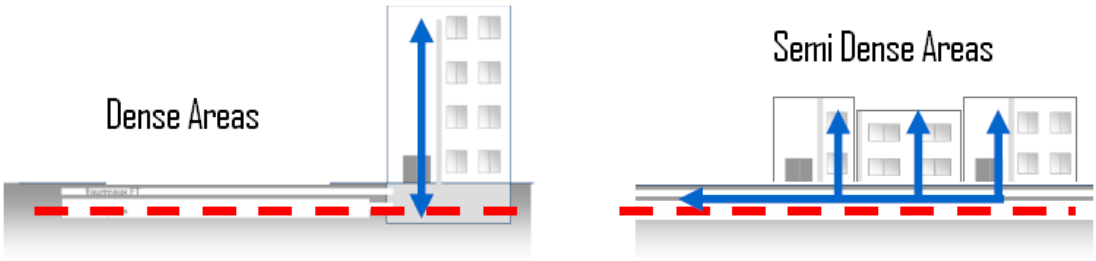


Figure 1: Principles of the mutualisation points according to areas' typology

France Telecom demonstrated its opposition to this decision and stopped to invest in FTTH deployments in large cities right after this announcement. Later, in October 2009, FT reported some improvements and clarifications concerning the regulatory framework. However, FT did not take any decision in terms of investment awaiting the European validation of this regulatory framework[52].

In July 2009, ARCEP made a second announcement agreeing to the SFR and Iliad initiative which would consists in a conjoint development of open access optical networks (open for all operators) in area with medium density population rate. The set-up of these networks might get the support of the public financing institution CDC[53].

In November 2009, the Commission endorsed French access rules on fiber in-building wiring. The Commission thus expects ARCEP to monitor the effects of the proposed regulation and to undertake, if necessary, the appropriate steps to ensure fair high-speed infrastructure and services competition to the benefit of French consumers. Since the endorsement of the French Regulation policy by the European Institution France Telecom and alternatives operators have resumed their investments[54]. Indeed, in February 2010, all most important internet access providers and especially France Telecom officially agreed to publish their

[52] Zdnet.fr, FTTH : France Télécom refuse toujours de reprendre ses investissements, October 2009

[53] Fiberevolution.com, ARCEP clarifies vertical sharing mechanism, June 2009

[54] Generation-nt.com, Fiber optique : Orange reprend les investissements, February 2010

deployment “roll-out” in order to facilitate the access sharing to their fiber networks[55].

In June 2010, the roll out of fiber in France is developing at a slower pace as expected (+2,5% for the last 3 months), even if mutualisation is in place since a couple of months. An association of consumers believes that delays are caused by defining various zones for regulation principles (Dense, Semi dense and less dense areas) that underpins the fiber deployment in France. As well the lack of competition in this market segment and the entailed high tariffs of ducts' rental seem to have hindered the take up of FTTH connections in France[56].

After finalizing the framework for high-density areas in January 2010, the French regulator, ARCEP, has announced in August 2010 a number of measures in relation to rolling out high-speed broadband in less dense areas. Indeed ARCEP has submitted a decision on FTTH network sharing, which mandated symmetrical sharing of the terminal segment of the network. The other relevant measures are: The development of solutions related to sub-loop access, which ARCEP has specified as a subsidiary solution to FTTH. ARCEP’s review of its analysis of Market 4 (the physical network infrastructure that comprises the fixed local loop), which will involve specifying France Telecom's obligations related to its local sub-loop. And France Telecom, SFR, and Iliad’s agreed for a network-sharing trials in three towns situated in less dense zones[57].

In Netherlands, the national regulator OPTA, developed an innovative regulatory approach, introducing that selective price undercutting and loyalty discounts are forbidden. Tariff differentiation on the basis of the demand profile is permitted under certain conditions or safeguards. Tariff differentiation on geographical criteria

---

[55] lesnumeriques.com, FTTH : les opérateurs vont bientôt jouer carte sur table, April 2010

[56] lemondeinformatique.fr, Les offres FTTH peu plébiscitées, June 2010

[57] telecomseurope.net, Fiber beyond the city: France's approach takes shape, August 2010

is permitted under certain non-discrimination conditions[58]. This approach aims to provide a long-term regulatory certainty for fiber investors and access seekers. It allows operators to go forward with FTTH projects. OPTA has been basing its analysis that one of the main elements of investor's regulatory uncertainty has to do with (future) pricing (principles) of NGN Access. Therefore OPTA has published these Policy Rules for NGN Access Tariff Principles. The starting point for these policy rules is an effective access of unbundled FTTH. As a good example, KPN-Reggefiber will offer wholesale fiber for between € 12 and € 17,50 a month (depending on factors such as geography). The monthly fee per customer is dependent of the area type and CAPEX[59] Example of proposed tariffs: Access to Area PoPs (EUR 500 per month), Backhaul from the Area PoPs to the City PoPs (EUR 600 per month), Onetime costs (EUR 100 per line and EUR 3,000 per Area PoP)[60]. We do understand clearly that the widespread deployment of P2P has been supported by OPTA, which has been proactive in promoting open access on a large scale in order to better facilitate competitor access to fiber access networks. This includes as we said, a cost-orientated price control obligation for unbundled access to the fiber access network.

Italy does not seem to have a clear national strategy for the development of next generation networks. AGCOM is favouring the share of existing infrastructure and co-investments among operators in order to rationalize costs and limit duplication. But on the other hand, it does not impose any obligation to unbundle new fiber cables. In July 2009 the regulator announced that they opt for a fiber optic grid operator to offer wholesale services to the different network operators to deploy new access infrastructures. Italy's goal is to handle the move to a neutral fiber optic network which would be supported with private and public funds, in addition to create an integrated fibre-optic and copper national network for broadband coverage of 50% of the households. Indeed at the same time, Fastweb, Wind and Vodafone

---

[58] T-Regs.com, Netherlands: OPTA consultation on fees for unbundled fiber access, November 2008

[59] Internetthought.blogspot.com, KPN/Reggefiber offer fiber for €12 euro/month, November 2008

[60] Telecompaper.com, TDC follows KPN but what will the regulator do?, November 2009

launched a new investment plan to deploy fiber networks in 15 metropolitan cities with an investment of 2.5 billion Euros. These networks will be open to access by third parties at non-discriminatory conditions[61].

The UK regulator Ofcom has published its proposals for the introduction of super-fast broadband to UK homes and businesses. Ofcom's plan of action should encourage further investment while promoting and sustaining competition. One of the main elements of Ofcom's proposals is to create a clearly defined regulatory environment for next generation services, including developing standards for wholesale products, allowing pricing freedom and enabling transition to new fiber networks. Results of the consultation were published early in 2009 and highlight the central role of Ofcom to enable both investment and competition in super-fast broadband. For instance, Ofcom will ensure wholesale pricing flexibility to enable returns appropriate to the considerable risks of building new networks, but constrained by the market in the interests of customers[62]. In March 2010, Market regulator Ofcom opened a new consultation on measures to help and encourage the rollout of "super-fast" next generation broadband services across the UK. The move includes a proposal requiring BT to offer ISPs access to its underground cable ducts and overhead telegraph poles. It also proposes a Local Loop Unbundling (LLU) style process for BT's own fiber optic infrastructure[63]. The European Commission (EC) has approved in June 2010 The Ofcom UK proposal that oblige BT to provide 'virtual' unbundled (LLU) access to its superfast next generation fiber optic broadband platform. This move would allow a rival ISP, such as TalkTalk or Sky Broadband UK, a greater access and control over BT's latest range of 'up to' 40Mbps FTTC and 100Mbps FTTH / P broadband products, resulting in a greater freedom to differentiate their packages (cheaper packages etc.)[64].

---

[61] Findarticles.com, National FTTH plans in France, Italy and Portugal, April 2010

[62] Thecma.com Ofcom should provide framework for investment in NGA, July 2009

[63] Ispreview.co.uk, Ofcom Proposes Regulation to Boost Rollout of UK Fiber Optic Broadband, March 2010

[64] Ispreview.co.uk, Europe Approves Ofcom UK Plan to Open BT Fiber Optic Broadband Network, June 2010

Ofcom expects to take forward a number of key actions, such as supporting on-going industry development of active products, including the characteristics, technical requirements and standards for these products. Ofcom further work to understand the prospects and use of duct access in delivering super-fast broadband investment and competition. This will include understanding levels of industry demand as well as building on the outcomes of a duct survey; and monitoring prospects for and implications of any future transition from copper to fiber access networks. Finaly Ofcom is playing a leading role in working with stakeholders to define the need and possible scope of actions to further extend the availability of super-fast broadband services beyond where the private sector alone will deliver. Concretly, Ofcom's current NGA policy strikes a balance between promoting competition and securing investment in new infrastructure.

The Swiss regulator (ComCom) has developed an FTTH policy which sets out a coordinated rollout of FTTH, with multiple fibers to each user. Infrastructure competition will be between Swisscom, Cable TV operators and utility companies (mainly city-nets). The Swiss regulator has been looking closely to NGA since Swisscom announced in December 2008 that it would invest € 6.6 billion (FR 8 billion[65]) in deploying FTTH over the following six years, based on the multi-fiber model "fiber Suisse". As such, the regulator has encouraged all parties involved to reach an agreement on unified technical standards. The agreement involves the main industrial players, including telecoms service providers, cable network operators and electricity utility companies[66]. The regulator will continue to monitor the situation to see whether further regulatory intervention will be necessary in order to remove potential future problems such as access discrimination for those service providers that will rely on the incumbent's infrastructure.

---

[65] 24heures.ch, Le haut débit va gagner Lausanne, December 2008

[66] fibre-suisse.ch, Swisscom: tout savoir sur « fibre suisse » avec Giovanni Conti, July 2009

In May 2009, the Spanish regulator (Comision del Mercado de las Telecomunicaciones), announced that over a period of 15 years (2008, when it started investments for fiber, and 2023) between 43% and 46% of Spanish homes will "should" have FTTH[67]. The regulator presented some elements of its strategy regarding NGN deployments in Spain in 2009. CMT's strategy to maintain incentives to invest in NGN infrastructures ask for no physical access obligation to FTTH networks (GPON). But require letting the Access to wayleaves, for all technologies, not only for fiber (Cable) and also for access networks (including MNO's). Again in term of regulatory obligations on the wholesale physical network infrastructure access, the CMT want no discrimination and a total transparency. To achieve it, they underline the need for a reference offer with prices orientated to costs (in case of no capacity in ducts dark fibre)[68] In term of preventing market closure in the access to the buildings (70% of the total Household in Spain are in-buildings), the CMT impose some symmetrical obligations to all operators. Such as the obligation on the the first operator deploying fiber in the building, to give at reasonable prices, with transparency an access point after the last fiber splitting (for any other operator interested)[69].

In Ireland, Forfás is concerned about the slow progress in developing the next generation of broadband networks necessary to support bandwidth-intense applications and services which are becoming increasingly available to consumers and businesses in other countries. Driving next generation connectivity is a key enterprise policy priority. The report released in 2009 "Next Generation Broadband: Gateway to a Knowledge Ireland" makes a number of key policy recommendations to address those issues. Arising from changes in EU policy, the Irish Department of Communications and ComReg review options to increase revenues and reduce costs and risks for private sector operators while continuing to support competition in the market. This includes ensuring an appropriate return on investment for private

---

[67] Cn-c114.net, Spain Set for FTTH Surge, May 2009

[68] FTTH Council Europe, FTTH Conference 2009 Regulator Spain CMT, February 2009

[69] SPAIN, European commission Report (15th), May 2010

telecoms operators to incentivise investment in next generation networks; examining the potential for infrastructure sharing between telecommunication operators; reducing the costs of building access networks, and enabling wireless spectrum to play a strong role in the delivery of higher-speed broadband; And actions to utilise existing state investment and regulation to support development.

In any case, as seen through some of the national regulation happening in Europe, NGA will need a change in regulatory paradigms, as shown in a growing number of countries. The issue of access regulation in a NGA context is no longer; how to provide access to existing network elements or to existing infrastructures but; how to structure new network elements such that efficient access opportunities for alternative operators do emerge in Europe (regulation of market segments 4 and 5)[70]. Forfás proposes the creation of a single high-speed network which would be available to all telecom providers on an open-access basis. But today the main development in term of regulation to support a wide FTTH roll-out in Ireland is to facilitate access to public ducting and other infrastructure that could be used for fiber deployment. The Department of Communications has committed to a "one-stop shop" for State broadband infrastructure to provide broadband operators with integrated access to State owned infrastructures[71].

If we resume, we can see key success factors when:

- There is a co-financed FTTH roll out in the form of public and private partnerships. Municipal governments can, for example, join a consortium with incumbents and utilities to jointly rolling-out FTTH infrastructure.
- Establishing a fund to provide financing to selected FTTH roll out efforts
- Financing each household passed, in some areas, to further stimulate deployment. Governments can provide subsidies for the roll out of in less economic areas.
- Providing tax benefits, low cost loan

[70] forfas.ie, Ireland's Broadband Performance and Policy Actions, January 2010

[71] finfacts.ie, In Ireland 0.6% of broadband connections are fibre optic, January 2010

- Ensuring that the national regulator supports fiber roll-out by facilitating tasks such as moderating the interests of potential partners, or by setting-up a catalogue of duct infrastructures of telecommunication operators, utilities, gas pipeline operators, etc.

For every country analysed the state of the actual regulation, only have been chosen those with the most relevant points of the regulation in course (cf. above paragraph). Those particularly points of the regulation are those with a direct impact on the fiber roll out, because they greatly influence new operators, or existing one to foster FTTH deployment. Even if a clear regulation framework is of course a necessary condition for a successful implementation of FTTH in Europe. We also will see that each regulation policy impacts the FTTH deployment with more or less efficiency.

2.3.2: National ambition and plan for FTTH

In all the European countries the 2009 financial crack, has slowed down ambitions from Operators to Governments to accelerate the roll out a new fiber network. But as you will see, there are still some exceptions where government are deploying themselves the new access networks, or are investing hard to achieve competition and funds. Indeed many plans target Ultra-Broadband for a part of their population such as, Germany, France, Sweden, Portugal and Greece. And some others have already settled FTTH access as a universal service: like in Finland or Estonia, where governments expect to offer 100Mbps to 100% of the population by 2015-2020 but with different approaches regarding investment.

Finnish government plans to funds up to a third of the required investments (approximately € 67 million). The remaining costs are expected to be covered by telecom operators (one third), municipalities and financial support from the European Union (max one third in total)[72].

[72] FINLAND, European commission Report (15th), May 2010

The Estonian government announced that the EU structural funds will cover for 25% of the total project's budget which is a € 384 million plan. The rest will be financed from the telecom companies gathered within the ITL association[73].

In Greece an ambitious public investment plans to provide 100Mbps connections to 40% of the population. The Greek government announced to award one third (€ 700 million) of this project which is a public-private partnership forecasting the deployment of a dark fiber infrastructure over the next 7 years. (But at the time of the writing the plan has been postponed...)[74]

In Sweden, the government plans to make available 100Mbps connections to 90% of the population by 2020[75].

The French "Grand Emprunt" will allocate € 2 billion for optical networks deployments, the government forecasting to offer connections up to 100Mbps to 70% of the population by 2020. Public support is envisioned in two forms: Through public loans for projects in "viable" zones, and through direct state aid for "less viable" zones[76].

In Germany the federal government of Germany, with its Breitbandstrategie (Broadband strategy) plans a € 180 million investment in order to support the coverage of 75% of the population with 50Mbps connections by 2014. This can be considered as very low compared to other countries[77]. But this is mainly due because most of the deployment will be made of VDSL2 technology, which is of course cheaper to deploy but this is not a bet on the future.

---

[73] Broadbandprime.com, Estonia Jumps on the FTTH Bandwagon, April 2009

[74] Samknows.com, Greek FTTH plan is down but not out, November 2009

[75] SWEDEN, European commission Report (15th), May 2010

[76] Telecomseurope.net, Fiber beyond the city: France's approach takes shape, August 2010

[77] bmwi.de, Breitbandstrategie der Bundesregierung, February 2009

In Portugal the government aims for 100% fiber penetration. To facilitate the rollout of high-speed access lines, the government says it is "committed to opening ducts for NGNs, to regulating networks, to maintaining a centralised information system and to providing a line of credit with a minimum of € 800 million for NGN construction». The operators' commitments include investments of about 1 billion Euros. This protocol has been signed in January 2009, the Portuguese government signed it with several operators (Portugal Telecom, Zon, Sonaecom); two other operators (DST and Oni) joined a few months later, but the protocol is open to further participants. Only Vodafone Portugal has declined, so far, to put its name to the "Protocol on NGNs" that the other operators have signed[78].

As we previously wrote, Italy does not seem to have a clear national strategy for the deployment of NGNs, as the Italian government facing problem with the deficit, has suspended its commitment to provide subsidies to spur investment in broadband connections. As a result many Italian telecom operators turned to signing agreements with local governments and municipalities to extend broadband coverage in areas where the return on investment is considered low or non-existent[79].

[78] findarticles.com, National FTTH plans in France, Italy and Portugal, April 2010

[79] Broadband Infrastructures as a Common and the Role of Local Governments P6/23 June 2010

CHAPTER 3

Key parameters for a successful FTTH roll-out

3.1: Introduction

We will consider each network economic modelling framework including capital investments (CAPEX) and operations expenses (OPEX) optimization for the technology options and across scenarios applicable to typical service provider networks (Organisational choices, Open access/Vertical Integration, Active/Passive Sharing, Infrastructure/Services Competitions, Single/Multi Fiber...). Each times we will evaluate and assess various modelling framework. As we previously introduced, there are different technology option available to operators today for their FTTH network deployment strategy decisions. Technology that are the most used actualy; GPON, EPON,Active Ethernet, P2P . There are a number of technical, economic and business drivers that impact the right choice for each specific network situation. Those options will be analysed and described during the following chapter, based on some real case study, for a better understanding. Indeed, we will discuss best practices cases through in-depth studies of state of the art FTTH deployment. (Regie des Pays Chartrains, ATB-Nett, Karlstads city network, Amsterdam Citynet)

3.2: Key strategy analysis

3.2.1: FTTH organisational choices.

This is a fundamental question related to the organisational structures of operators. This has a major impact on the FTTH roll-out. As we wrote in the introduction, there are networks layers, and each of them is corresponding to a function. Many options are available regarding each layer. Indeed the network owner is in charge of the first layer but he might decide to outsource its construction to a third party. While, the wholesale provider owns the active equipment, and the retail services are provided

by another ISP. These 3 functions can be integrated within the company or can be under the control of different organisations.

This lead to the question; witch solution is the most adequate or adapted regarding a particular situation? First of all, in case of vertically integrated model, a single player owns all 3 layers of the network. We often see the case of incumbents like France Telecom, Eircom, or BT in this scenario. This is a clear form of infrastructural competition, you can control the total value chain and cash flow profiles but the cons are related to the complex operation to set-up and of course execution risks are higher[80]. But Incumbents are usually willing to take that risk, mainly because they are the most prepared (financially and technically) to face such challenges.

At the opposite, you will find the model of Full Separation layers. The model makes partitions of the ownership with different layers. Each layer is owned by a different player, with the infrastructure owner generating income by providing passive infrastructure access to the network operator, who in turn wholesales broadband access to retail service providers. This model has been chosen by some major operators like the Dutch KPN/Reggefiber[81] controlling the passive infrastructure through a Joint Venture, with BBNed running and operating the active network and providing wholesales access, and finally for the last layer, various retail service providers with their Internet services selling directly to the end-customer. This model stimulates competition at the services level and goes hand in hand with regulatory requirements for passive and active wholesaling.

Passive Sharing model can be seen as a form of infrastructural competition, it leverages a single passive infrastructure, which is built and maintained by one. The active and services layers are owned by a different organization. A second service

---

[80]Centre for European Policy Studies, Approaches to FTTH-Regulation: An International Comparison, November 2009

[81] Telecompaper.com, KPN, Reggefiber set up FttH joint venture, May 2008

provider may share the same passive infrastructure with the first service provider, but will still have to invest in active network equipment and operations as well as the services and go-to-market activities. Typically, this model goes hand in hand with regulatory requirements for passive wholesaling82. Concerning the Active sharing model, it is often a single organization that owns the passive infrastructure and at the same times operates the active network. This vertical infrastructure owner wholesales broadband access to the various retail service providers who will then compete against each other for customers. The regulatory framework associated with this operator model regulates active wholesale specifically, and clearly seeks to encourage service competition.

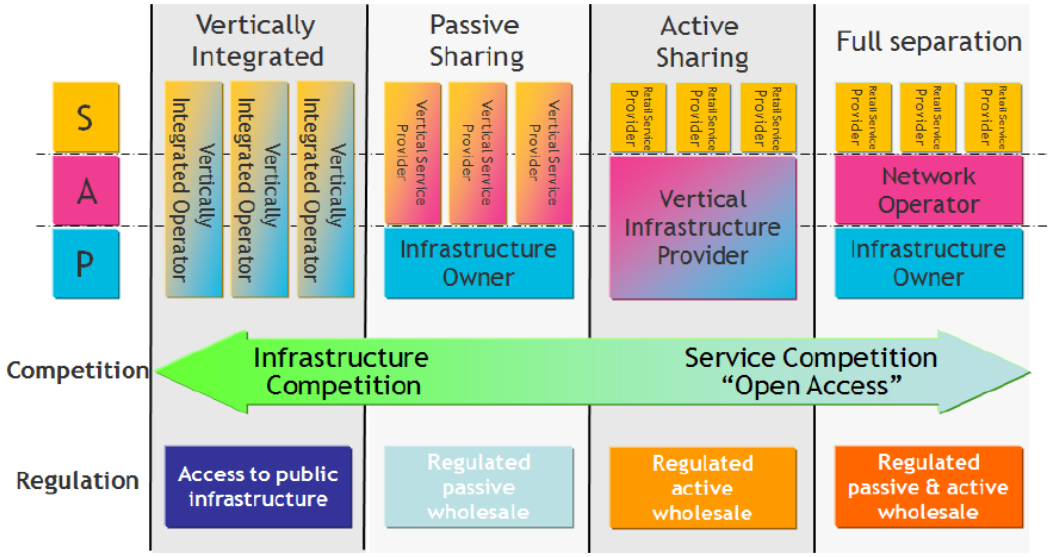


Figure 12: FTTH operator models and regulation[83]

[82] Buidling FTTH Revenues – New Business Models, 2009

[83] FTTH Business Guide, Helping you to develop the business case for FTTH, March 2010

Example from HanseNet (Germany)

Why choosing a Vertical Integrated Model?

In the Eimsbüttel area of Hamburg, in October 2007 Hansenet planned to cover 15.000 buildings and 100.000 households with fibre, with about € 50 million to be invested. Based on the GPON standard, the network will connect every customer with 100Mbps[84]. The first phase was announced as successfully completed by Huawei by passing 50 buildings in November 2008. The second phase kicked off recently and will add fiber optics to another 500 buildings. The number of households that are going to be passed will depend on the first results and the amount of money that the city will accept to deliver[85].

In term of FTTH type of organization, HanseNet has decided to use the "vertically integrated" model. Indeed, since the beginning of the project layers have been planned, built and commissioned by HanseNet with its own resources or implemented under its project leadership. As one of the biggest ISPs on the German telecommunications market, HanseNet has the professionals and expertise to plan and implement the whole network. HanseNet choose not to give one or more network layers to another company to build and operate. But HanseNet established partnerships with other FTTx-providers, (whether they are just building up a passive or active network or whether they are a vertically integrated operator). Until now HanseNet has been using service platforms from other carriers in Germany to distribute the Alice portfolio all over Germany[86].

The main reason for choosing a vertically integrated model was because HanseNet wanted to have a technical and financial proof of concept. Using the experiences gained from the Hamburg trial, HanseNet will be able to determine the value of

---

[84] Computerbild.de, Angriff auf die Telekom: Hansenet plant Glasfasernetz in Hamburg, 2007

[85] Germany: Hansenet has deployed an FTTB network using VDSL from Huawei, May 2009

[86] Teltarif.de, HanseNet baut eigenes Glasfasernetz in Hamburg aus, May 2009

potential partners. This is important because it is unlikely that a single provider will be able to build up FTTx networks all over Germany; instead there will be a lot of partnerships for a German-wide rollout of FTTx networks. We do understand that this is the most suitable model for Telecom Operators like HanseNet, where complete control and can scale up of the network is a major concern.

3.2.2: Open Access enabling competition

Today the aims of any government or regulator are to enable a full competition on the deregulated telecommunication market for NGN. It should be noted that competition can be enabled in a number of ways and Open Access is one way. There are numerous methods used to enable Open Access for the Next Generation Networks. As you will see, methods vary from country to country, regulator to regulator mainly because local market conditions have to be taken into account.

New trends inherent to FTTH networks deployments are explained by the current favourable evolutions from a vertical integrated network to an open network. For instance open access seems to offer numerous of advantages. More and more public actors are investing in the deployment of this kind of networks, often through the involvement of their utilities. In this context, we could think that every players of the FTTH market benefit of these circumstances such as alternative operators which can offer some new services without having to invest the cost of an FTTH network deployment, or end-users which benefit of more competitive prices and services. However, this point of view is usually not always shared by incumbents.

From the end customer's perspective having a central infrastructure provider strongly decrease the disturbance caused to the residents as the streets are only dug up one time. Indeed, it avoids every operator from duplicating deployment with separate network infrastructure.[87] This obliges a coordination of infrastructure work or sharing of a single infrastructure. Of course the total costs are also minimized, as the

[87] Ecitele.com, Open Access and Local Loop Unbundling on GPON Networks, February 2009

work is done only once and the same infrastructure costs are shared by all fiber broadband users

At first approach, open access, this obligation to let access to the network infrastructure to other operators in the same conditions, is synonym of more competition on the market. Thus, incumbents could consider this kind of network management as more competitors, less customers and less revenue. Although, in an increasing manner we have seen incumbents taking initiatives and action in order to take direct benefits from Open Access. Indeed, in the Netherlands, the incumbent KPN first preferred to roll out fiber nationally together with the cable companies. But then KPN changed its mind as it began to see the great advantages of open networks like the high revenue from the leasing of its fiber[88]. He came to an agreement with the regulator OPTA[89] who had been pushing the incumbent to voluntarily implement the concept of open networks. With widespread industry and regulatory agreement on the fiber regulations in place this is paving the way for KPN to become the key infrastructure provider in that network.

Open Access deployments initiatives in big cities have been promoted from political actors, city councils and main public corporations that consider the ultra broadband infrastructure, especially the fiber based one as "a public service on commercial terms"[90] . Indeed, most municipalities tend to favor Open Access models, either because they are obliged to do so by regulation or because they want to foster competition on their footprint. These initiatives pretend the deployment of open access FTTH networks which encourage the service driven competition and, as a result, promote the cities due to the competitive advantage caused by the availability of ultra broadband infrastructures. This could be achieved by involving a dark fiber

[88] Fiber to the home in The Netherlands WIK Conference FTTB/H in Europe, March 2009

[89] Opta.nl, Agreement between OPTA and KPN: Removal of barriers will allow greater pricing discretion.

[90] Stokab's mandate from the City of Stockholm, which can be summed up as "public service on commercial terms", is based on the Swedish parliament's decision to create "an information society for all".

installer and a neutral host provider which provides a non discriminatory and open access to the different service providers. The architecture chosen for this strategy is usually a point to point which is better for open access provision. The main examples of this strategy take place in the cities of Vienna, Amsterdam and Stockholm where municipal infrastructure operators (Wienstrom[91], GNA and Stokab respectively) aims to roll out the fiber P2P networks covering 100% of the city. Often, the choice of the municipality is either to offer its own services alongside other service providers (hybrid open access) or be the sole service provider until the network is paid off and then goes open access (**Figure 13**).

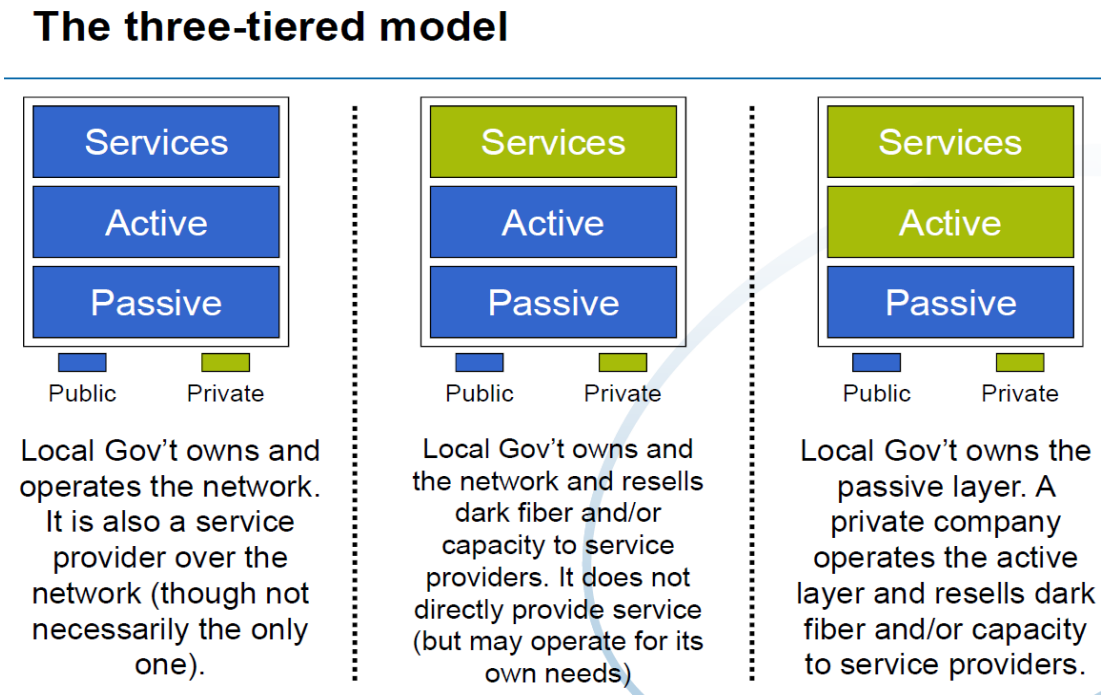


Figure 13: The Three-tiered model[92]

With access networks migrating to fiber infrastructures, the debate continues between PON and P2P approaches. Two of the aspects that are being brought into this debate are those of Local Loop Unbundling (LLU) and Open Access. When sharing the access fiber network infrastructure, there is the full unbundling model.

---

[91]PacketFront.com, PacketFront, enables open access FTTH broadband for the City of Vienna, 2007

[92] Oecd.com, FTTH and Local Governments An Overview, April 2008

This leads to the assumption that the optimal way of implementing unbundling in the fiber access network is physically allocating a dedicated fiber from the customer location to the alternative operator in P2P architecture. This perception leads to the adoption of P2P over GPON fiber access architecture. But in some ways GPON architectures provides also a (cheaper) solution for unbundling and open access. Indeed with the Data Path Bit Stream method, the fiber infrastructure still belongs to the incumbent, and allows for a modular and cost-effective sharing of the connectivity between many alternative operators[93]. To make it simple data path bit Stream method is broadly similar to Service Access, a wholesale service offered by the infrastructure provider whereby the competitive provider has no equipment co-located with the infrastructures provider but the subscriber will have a full access to their content and services through the fiber access network. Instead P2P offer access to the Fiber for the competitive provider, it means a wholesale service whereby the competitive provider will co-locate network elements at some point in the fiber access network. It might be at the Central Office, or further towards the customer premises and even in the building in case of FTTB inside multi dwelling units.

Service access is for sure, the most preferred method of Open Access by the infrastructure provider, because they have no direct access to the customer premises or the access network. Like we previously wrote, this way simply allows the competitive provider to access the subscriber via a data path, like what is done today with unbundled competitive DSL services. The 2nd option would allow the competitive provider more control over their service while lowering the cost compare to a full fiber plan rollout. Indeed they would be able to locate their own network equipment in the fiber access network from the infrastructure provider. In this way the competitive provider is leasing the connection from their network equipment to the customer, and it gives a greater control over the network topology and a total control over the traffic and service mix on each fiber.

---

[93] Ecitele.com, Open Access and Local Loop Unbundlingon GPON Networks, February 2009

But open Access face some issues, when it comes to subscriber churn. Indeed open access enables multiple providers to offer services. But for the network provider it is not as easy as with mobile networks when it comes to connect subscribers to another provider. Today fiber connections are managed via an Optical Distribution Frame, or a Fiber Distribution Hub using manual patches channel[94]. It means each times a connection is changed a technician is required to visit the site of the ODF, to locate the fiber requiring change and manually move the fiber from one port to another. It necessarily leads to an issue related to the cost of churn for the provider. Those costs include the requirement to maintain a large support staff and vehicle feet as well as issues of human error, subscriber management and inventory management…
Assuming that the provider has 1 million subscribers, with each year a 5% rate of churn, the average cost of a truck roll with a skilled technician is approximately € 75[95], it makes the one year cost for subscriber churn management close to € 4 millions. This figure clearly illustrates the significant additional cost that would face providers when enabling open access.

To conclude on Open Access, we see as the main driver for the development of these local open access networks, the fundamental belief in the importance of ubiquitous and affordable FTTH access for all. Indeed, the Open Access deployment is closely linked to involvement of local governments and municipalities, driven by the view that today incumbent service providers are not doing enough. This concept of user/municipality owned networks is nothing new in the context of a local area network. What is new is the emerging idea of open access networks with strong user control if not ownership, as a means of redressing the failure of the conventional telecoms business model to deliver fair value and benefit to end-users. In the near future, it is expected that all telecommunications provider networks will by choice, or by government mandate, become open access in nature.

---

[94] Calient.com, Implementing Open Access on NGA Networks using Optical Switching Networks, 2009

[95] Calient.com, Implementing Open Access on NGA Networks using Optical Switching Networks,

3.2.3: CAPEX optimisation

The initial investments costs remain the main obstacle for massive FTTH deployment. Indeed, analysis shows that the cost of the civil engineering (civil work, ducts, cables…) related to the set up of the FTTH network set up can range anywhere from 60% to 80% of the total estimated network CAPEX[96].

As for OPEX, economics of scale are vital for CAPEX considerations. As a rule of thumb, the passive network alone stands for (70%-80%) of the CAPEX in a FTTH project[97]. For the remaining (20-30%), CAPEX related to active equipment and support systems, many players seek to alternative solutions for lowering the CAPEX component[98]. Again, consolidation is an emerging trend for CAPEX reduction. Smaller players see the benefits of doing joint investments in centralized CAPEX intensive components of the network solution, and together with improved OPEX conditions this proves as an attractive solution to pursue.

There are ways to reduce or alter CAPEX, however this is dependent of structure and ownership of a FTTH deployment. Examples how to reduce or alter CAPEX, in particular for local FTTH deployments[99];

- Guarantees and Backstops
- Rights of Way
- Existing fiber, poles, and/or other telecom assets
- Space in existing facilities to place equipment
- People (Time and Expertise) and/or Construction Equipment
- Bylaws and Regulatory Assistance

All together, these elements are in one way or another substitute of hard cash, and may have significantly positive impacts of a business case. As FTTH deployment is a large project involving a lot of trenching work it needs a large amount of upfront planning, which is usually related to the overall size of the project (could be

---

[96] lightwaveonline.com, Modeling and simulation improve FTTH planning, July 2009

[97] FTTH Business Guide, Helping you to develop the business case for FTTH, March 2010

[98] Fibersystem.org, Optical access: is cost still the sticking point?, 2006

[99] Broadband Municipal Optical Networks: A Suitable Business Model, 2008

estimated to 10% or less of the project).[100] Therefore networks operators are trying to reduce this CAPEX focussing on the major costs drivers.

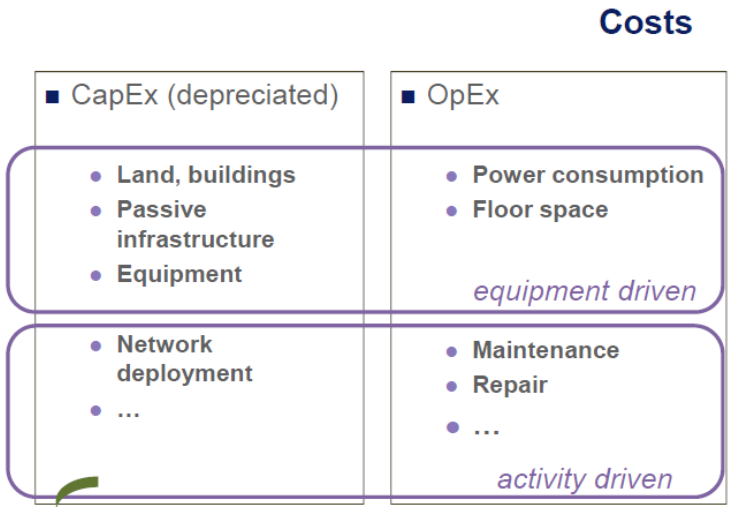


Figure 2: Cost of the Network, Activity driven/Equipment driven for the CAPEX/OPEX[101]

Geographical features are then an essential topic when deploying a network. Geographical and demographical factors will have a significantly large impact on the costs. As shown on the graph **Figure 14**, costs are naturally a higher obstacle in the suburban and rural zones, due to lower density of population and specific topology for instance. Moreover, in rural settings, ducts and cables of the backbone segment imply a higher CAPEX than the whole deployment cost of FTTH in urban dense settings102. The return on investment in high capacity network infrastructure is also often too low to sustain commercial operations outside dense areas.

---

[100] The Journal of ITP Volume 2 Part 3, 2008

[101] University of GENT, Practical steps in techno-economic evaluation of network deployment planning, 2010

[102] ICT regulation toolkit, February 2010

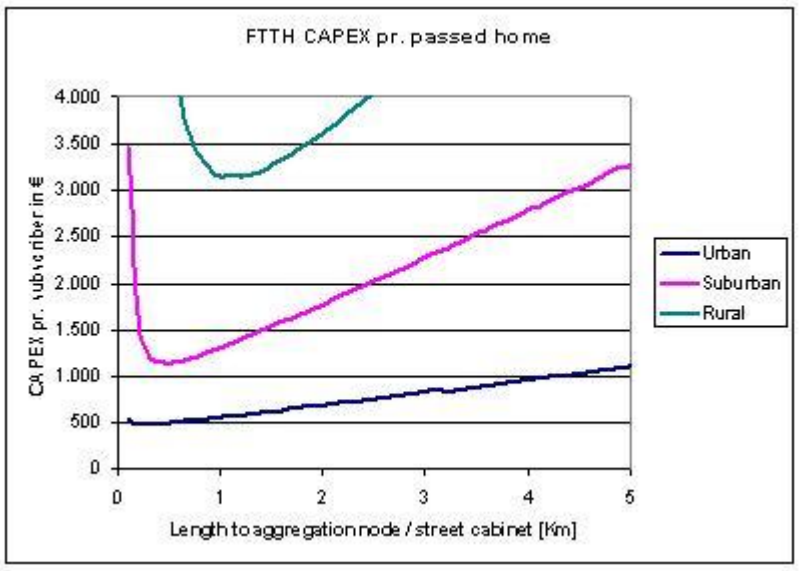


Figure 3: CAPEX per subscribers according to the Length of fiber from the first aggregation node / Street Cabinet depending of the topology (Urban,Suburbain,Rural) September 2010[103]

The French telecommunications regulator ARCEP has highlighted that the total cost of deployment per subscribing household is expected to amount to € 1.000 in Paris[104]. However, these costs are inversely proportionate to urban density. Outside the major cities, costs are prohibitive, and often limit FTTH network deployments. Indeed, a new study demonstrated that the total cost forecasted for a 100 % FTTH coverage in France is expected to be up to € 30 billion[105] (of which 50% were assumed as coming from public funds)..

Site preparation and acquisition costs account for an average of 20% of the CAPEX dedicated for fiber roll-out, and setting up towers in rural areas is more costly (30-40 %) than in urban areas, given that these towers generally have to be ground-based and consume more materials. Estimates from ITU suggest that the cost per kilometre of laying fiber is approximately €11.000-15.000 if the cable is directly buried at 1.2 m depth. The price increases considerably when the cable is being laid in hard rock, and it decreases slightly when doing so in loose sand. If, however, the fiber is strung

---

[103] ictregulationtoolkit.org, PRACTICE NOTE: Cost Analysis for FTTH, September 2010

[104] Point d'Appui National Aménagement Numérique des Territoires, Étude de piquetage du FTTH à l'échelle intercommunale 5/7, March 2010

[105] fiberevolution.com, Cost to Fiber 100% of France: 30 bn EUR, February 2010

in urban areas on poles, the amount per kilometre is closer to €1.500 but the maintenance cost will be much higher. One study estimated that after 10 years, both methods amount to approximately the same cost[106].

In order to reduce CAPEX, infrastructure sharing is one major element to enable considerable improvement. The deployment costs of an FTTH network could be divided by two when ducts already exist.[107] The strategy considering the share of infrastructures is getting more and more relevant and entails concrete impacts. These initiatives mostly arise from national regulator. As a good example, the French Regulator (ARCEP), in November 2009 announced the complete mutualisation of inbuilding fibers. Furthermore ARCEP also ensures each operator to co-invest before making any response to call for tenders. ARCEP also obliges any in-building operator to meet reasonable requests from alternative operators to roll-out extra, fiber lines on condition that the requesting operator is willing to co-invest. Additionally, ARCEP defines where the in-building fiber connection point must be located[108]. Government funds so-called "the Grand Emprunt" will be in priority allocated to cooperation between (Operators or Utilties).

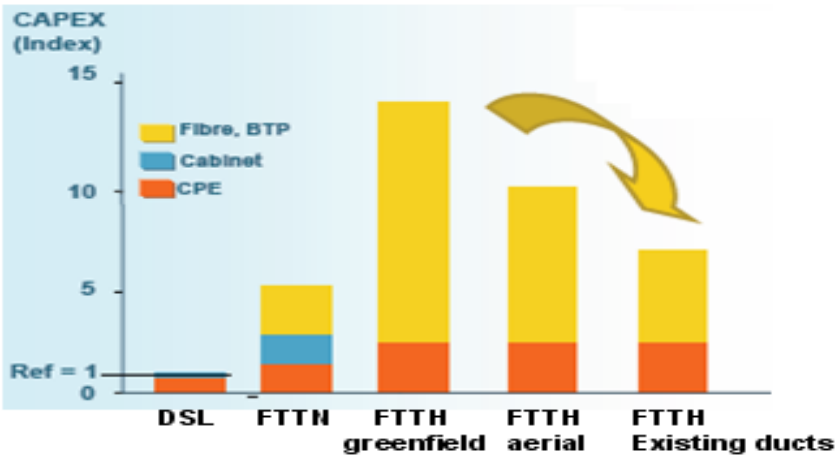


Figure 4: CAPEX Comparison (ARCEP, November 2008)

---

[106] ICT Regulation Toolkit, The Cost of Broadband Fiber Network Rollout, 2010

[107] FTTH Council, FTTH Infrastructure Components and Deployment Methods, 2007

[108] Arcep.fr, Scorecard for wholesale fixed broadband and ultra-fast broadband offers - 4th Quarter 2009 - 15th March 2010

Considering sharing, all possibilities should be studied. Telecommunication ducts could be shared but also aerial electrical networks or manhole access, sewage infrastructure…. The deployment could also be done in parallel with underground energy networks (energy, water or gas). The in-road surface roll-out (micro-tranche) can also be considered, as allowing networks to be buried at a lower cost and quicker (Micro-tranche are made in surface, 15 cm deep and 5 cm wide maximum, Mini-tranche are 30 cm deep and 15 cm wide maximum)[109]. Through narrower cuttings than traditional methods made to deploy FFTH in urban environments. Those solutions can lead to major saving in term of CAPEX expenditures, (40-60% savingsfor the CAPEX related to the fiber roll-out[110]).

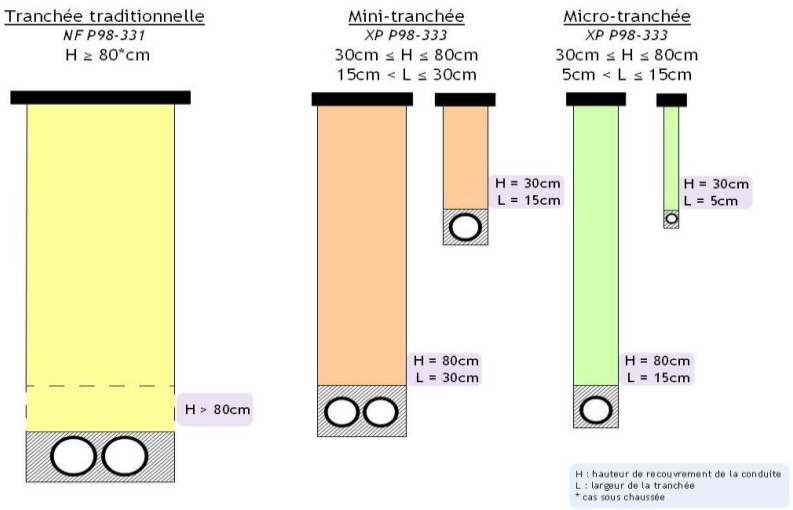


Figure 5: Different size of tranche, example of transversal cuttings.

The control of bottleneck facilities by a single infrastructure operator tends to slow down the development of competition and the market growth in general[111]. In developed economies, sharing plays an important role in rolling out FTTx access and expanding Ultra-Broadband into areas such as rural communities.

---

[109] CETE de l'Ouest, Autoriser les tranchées de faibles dimensions pour faciliter le développement des réseaux optiques, January 2010

[110] Alcatel-lucent.com, Building the Fibre Nation Progress and Policies, June 2008

[111] ITU.int, sharing infrastructure: The importance of national fiber backbones, August 2010

One largest group in the cost breakdown of a FTTH network is formed by the costs of connecting the customers to the network (and subscribing them to a specific service seen more as an OPEX). The inbuilding strategy is differing according to the strategy worked out, some operators preferring to proceed to the connection of the users later as soon as the first client wished to get a subscription. Connecting a customer at a later point in time will clearly cost more than installing him right away. Return on experience from various projects (such as Citynet in Amsterdam, EWZ in Zürich) shows that delaying the connection within the building is not economically viable. Citynet Amsterdam has proceeded to connect all homes within a building in the current and future phases of the FTTH network's deployment[112]. (Amsterdam is characterised by a majority of MDUs[113]).

The Capital Cost per Home Served depends quite heavily on the penetration achieved. The following figure shows the Capital Cost per Home Served for the three FTTH architectures for different penetration levels: Home Run Fiber, Active Star Architecture and PON.

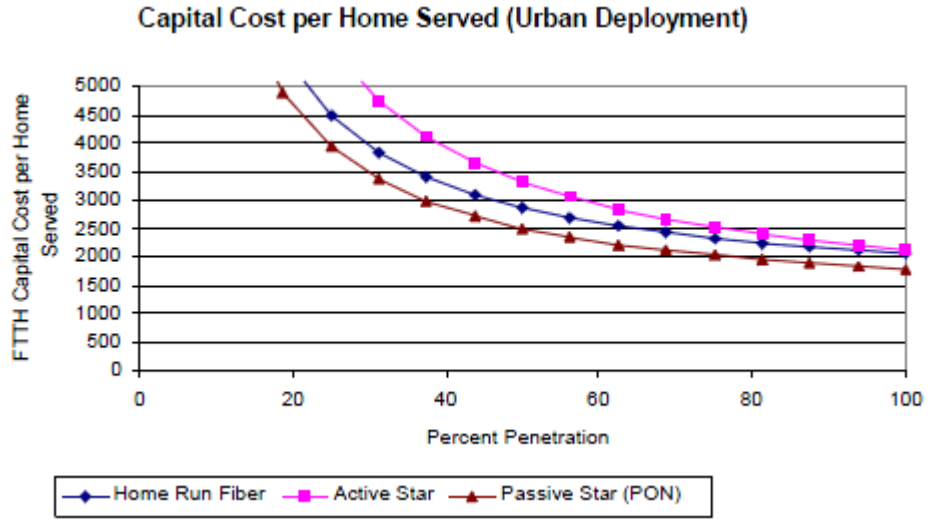


Figure 15: Capital Cost per Home Served (Urban Deployment)

[112] Broadbandprime.com, Amsterdam city FTTH network still one step Ahead, February 2009

[113] Multi-Dwelling Units

CAPEX reduction can be reached by the help of the local or municipal utilities. Indeed in the Aquitaine region of France, where the municipal authorities are motivated to ensure that any new civil work on existing utilities can accommodate future fiber deployment[114]. The experience there suggests that the cost of the FTTH passive infrastructure can be reduced by as much as 65%. This example illustrate clearly that costs are optimized when three practices converge: pre-planning, co-ordination and collaboration. To achieve this convergence, local or municipal authorities have to assume a central role. They must create an inventory of duct assets; create a master plan maximizing the elasticity of passive infrastructure costs, look to create the necessary synergies across all stakeholders

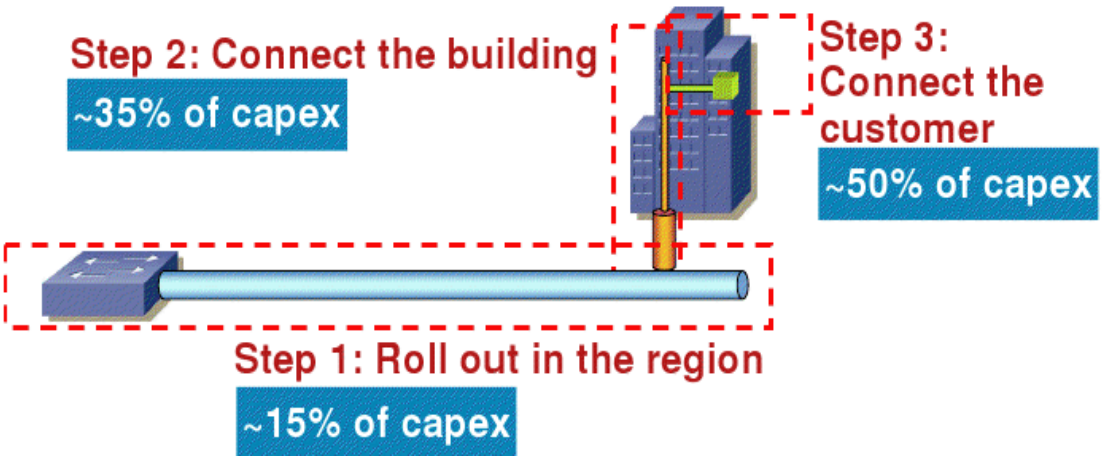


Figure 16: 3 Steps and 3 significant investments. [115]

Costs for GPON and E-P2P are quite close. Civil engineering represents 70% of the costs **(Figure 17)**

[114] Tic.acquitaine.fr, Etude FTTH Région Aquitaine, September 2009

[115] Cisco IBSG

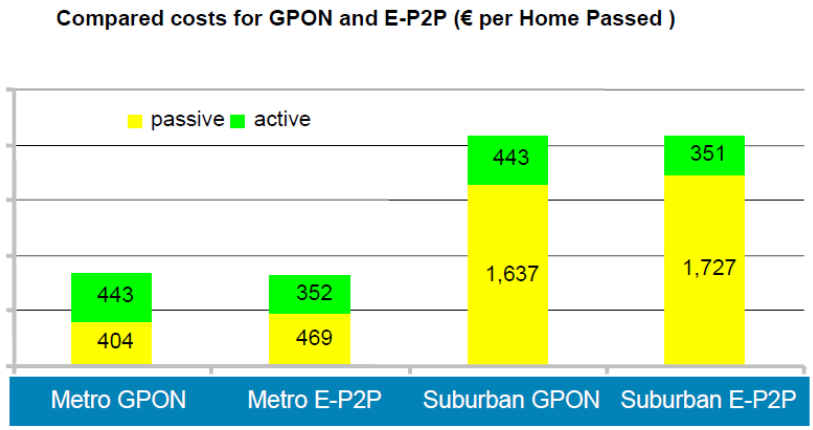


Figure 17: FTTH CAPEX Comparisons[116]

Finally, all these issues regarding CAPEX have to be known by players involved in FTTH networks deployments as high investments costs, often lowering their activities. Further an appropriate investment is closely linked with future network performances and then operational costs. The main objective is to create an infrastructure that maintains capital expenditure as close as possible to revenue generation while, at the same time, offering reduced operating expenses, so that investment in new services is possible. We will in the next paragraph further discuss the CAPEX consideration depending on the chosen FTTH technology. Indeed, some projects also show a lower CAPEX when using PON in comparison to P2P. But we will also see that only the first step of the investment (Roll out in region) representing approximately 15% of the total CAPEX can make a difference between access network architectures.

[116] IDATE 2008

3.2.4: Appropriate technological choice

Fiber to the Home networks can be easily categorized into two main architectures. The "home run architecture" or also called "Star architecture", in which a dedicated fiber is connecting each home to the point of presence (POP), the "tree architectures", where many homes share only one feeder fiber, and the last one, is the ring architectures of Gigabit Ethernet switches.[117]

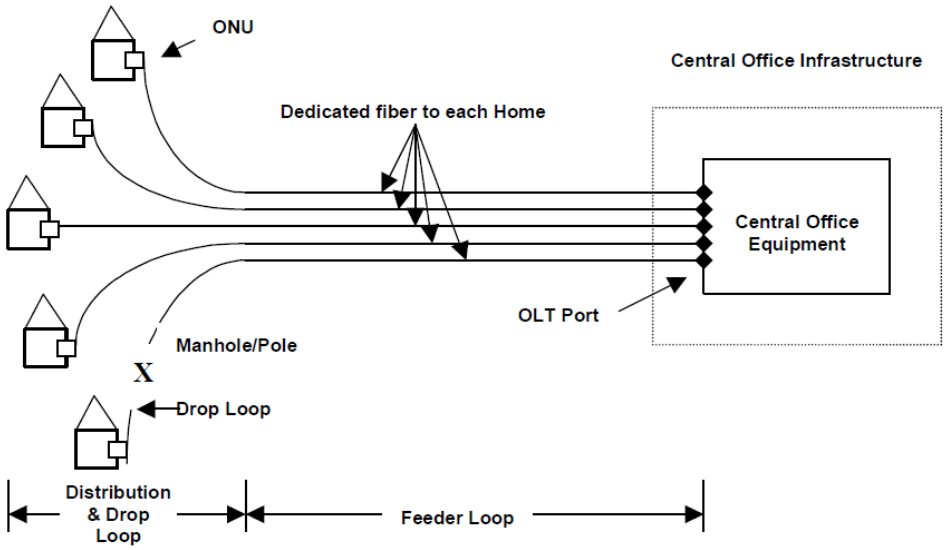


Figure 18: Home Run Fiber Architecture[118]

Because the Home Run Fiber architecture has a dedicated fiber deployed all the way from the Central Office to premise it requires much more fiber and OLT ports (One port per homes) compared to shared infrastructures. (But fiber cost is only 6% of a network cost). The Point-to-point solution uses usually Ethernet switching and aggregation, however all the Ethernet switches are deployed in the Central Office (CO). These COs, also known as Points-of-Presence (PoPs) tend to be closer to the subscriber.

---

[117] Opterex.com, Towards Technologically and Competitively Neutral Fiber to the Home (FTTH) Infrastructure

[118] Andrew.cmu.edu, Towards Technologically and Competitively Neutral Fiber to the Home (FTTH) Infrastructure

There are many advantages with the home run architecture firstly because as we said, you have the direct fiber access to individual subscribers. Then you get direct access to the switches in CO (or cabinet) or in case of FTTB a direct access to switches in basement of MTU. This is a very flexible and future proof solution as it allows virtually unlimited bandwidth per customer. Furthermore that fiber topology is technology neutral with the LLU intrinsically embedded in the architecture. It means an easier migration to new technologies with higher speeds that can be done on a customer by customer basis. This is enabling competition among different technologies. P2P designs allow also FTTB/FTTH to be mixed on the same physical network, but with PON technologies this cannot be done[119]. Multiple wholesale services providers are able to operate on the same infrastructure. For example this is happening in Stockholm already. Indeed Stokab owns the fibers and there are several operators of wholesale services selling to various ISP's.[120]

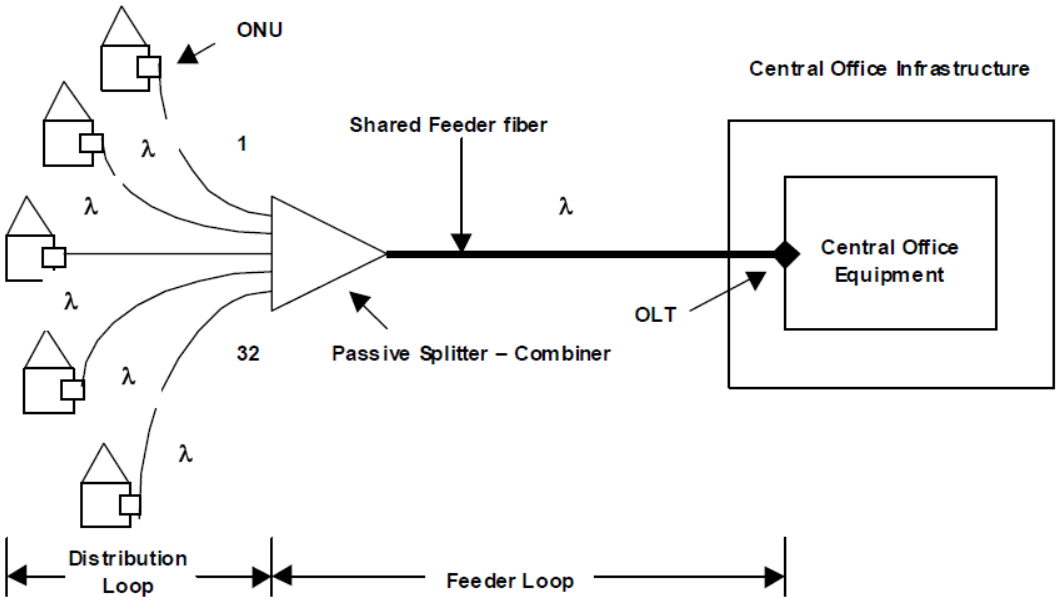


Figure 19: Passive Optical Network Architecture

[119] Internetthought.blogspot.com, PON networks vs P2P networks, 2008

[120] Citynet.nl, Citynet Dynamics in Europe. The State of Municipal Fiber to the Home.

In the Passive Star network, the outside plant does not have any active electronics (and hence does not need any powering arrangements). At the remote node, a passive splitter replicates the downstream optical signal from the feeder fiber onto the (4-64) individual distribution fibers while a coupler combines optical signals from the individual homes onto the feeder fiber using.

There are major motivations for choosing PON deployment. Indeed on the short term you are saving money and fiber (between splitter and CO/POP)[121]. Also in the CO/POP, where you need to terminate thousands of fibers, you only use 1 or 2 PON switch ports, compared to P2P (One OLT port per Fiber!). At the same time the CO consumes 1/3 of what consumes P2p's CO. There is no need for a deployment of active equipment in the outside plant, typically PON increased optics efficiency and allows cable runs up to 30 km PON can be a relevant strategy in a case where existing cables or ducts need to be reused towards the splitter or where fiber deployment is restricted (aerial cabling). But GPON would bit less relevant for Greenfield scenarios, because the cost of fiber is marginal compared to digging or splicing…

GPON face also some disadvantages compared to the P2P topology, firstly because the bandwidth is shared among all users on the tree, creating a need for "Encryption key management". Then bandwidth efficiency is not optimal and asymmetric with PON architecture, indeed restriction caused by MAC protocol and encryption overhead decrease the bandwidth efficiency. Also every endpoint (OLT, ONT,) has to operate at the aggregate bitrate, a GPON ONT delivering 100 Mbit/s to an end customer has to operate at 2.5 Gbit/s[122]. Theoretical maximum number of customers per tree is rarely reached due to take-up rates. The LLU is also virtually impossible unless if the network operator decide to use expensive ODFs in the field in order to allow flexible connection of drop fibers to SP-specific splitters (but major OPEX issues!). In term of failures, a corrupt CPE can impact entire PON tree and the

---

[121] Citeseerx.ist.psu.edu, On The Evolution of PON-Based FTTH Solutions, 2010

[122] Cisco.com, Cisco: FTTx Access Topologies/ Technologies, 2009

jamming is very easy. Indeed like we wrote in the previous chapter, passive optical fiber just transmits continuous light ... extremely difficult to track down. And the last issue and maybe the most significant occurs when the technology will become obsolescent, all terminations on a tree will need to be replaced.

OPEX is also impacting architecture aspects, and the following paragraph will compare each point of issues for both technologies. Before making any technological choices, it is relevant to understand how architectures impact the operating expenses.

Firstly, "the resource planning in access" is quite simplified with P2P architecture because of the dedicated fiber. At the opposite it makes PON architecture more complex because of the shared medium and mutual dependency of subscribers. PON is then less relevant when it comes to "Engineering rules", indeed the work have to be done as much as the number of customer per PON tree[123].
"Fiber troubleshooting" is simple with P2P and failures are only located trough reflection measurements, but it becomes much more complex for PON, especially when the location of the failure is behind the splitter, it is quite difficult to identify. We also observe the main advantages for P2P network architecture, when network operators are willing to upgrade the technology and increase the bandwidth, indeed you need to replace all active equipment at once but you don't need to do such things with P2P because it can be done on a per customer basis[124].
In term of Customer Churn, P2P allow switching over the other service provider via ODF (Local Loop unbundling) but with PON you can switch through config changes (wholesale) and this is cheaper, because there are less labour involved. Concerning the connection of new subscriber, you just need to configure the OLT if you operate on PON architecture, but you have to patch at ODF and configure the switch if you operate on P2P network architecture.

---

[123] FTTH Technologie PON vs. Point to Point Ethernet by Cisco

[124] FTTH Technologie PON vs. Point to Point Ethernet by Cisco

To conclude on the Technological/Architectural choice; if cost is a primary consideration for a new FTTH network project, PONs should be carefully considered. Indeed, this is quite clear that PONs tend to be the least expensive option overall and can optimize deployment cost in the very short term, no matter what the location, especially for larger carriers/Incumbents serving primarily residential markets that have reasonable take rates. In another hand, Star architectures with AON are seen as the most future-proof solution. We have seen that AON can provide increased service flexibility, including better support for media-rich applications requiring high-volume symmetrical bandwidth. AONs are very suitable for smaller independent operators that are deploying an all-IP suite of services for voice, data and video, and targeting a mix of customers (commercial buildings, residential multi-dwelling units (MDUs) and households in high-density areas). Operations and maintenance lifecycle need also to be considered along with the expected costs for upgrading to newer technologies. This is now clear that the majority of the costs in an FTTH deployment are associated with the outside plant (material costs for conduit and fiber and installation costs). With a life-expectancy of more than 40 years, it is mandatory to protect this investment with making FTTH deployment future-proof[125].

3.2.5: Financing Network Deployment strategy

Incentives to service providers do not directly affect the deployment of FTTH-infrastructures. However, they increase demand for FTTH infrastructures and therefore strengthen such infrastructures indirectly. Tax exemptions for FTTH-service providers, are one such possibility, even if today the European trend is not

[125] Techtarget.com, Choosing the right technology for fiber to the home (FTTH) deployments, March 2010

going this direction[126]. In South Korea, such demand-oriented policy has proved very effective[127].

Without regulatory intervention, the growth of FTTH-networks follows the rules of the market. Any potential operator is willing to invest only if it can expect appropriate profits. With governmental control of private investments, especially if investments are supposed to exceed their optimum levels, there is a need for network financing. This should be designed with the least possible distortion on the market outcome. Ideally, it is just the net cost of the according obligation that is being compensated. This results from the difference in an operator's profit level with and without that obligation[128].

The first option is a network-internal financing by charging users; the least distortion on the market as a whole could results from a financing through usage fees of the network itself. When the network is built, it can be amortized through access charges. (But in the case of an integrated network operator, this poses the general challenge of non-discriminatory pricing). Even with separated operators, there may be a financing problem. In none of the countries they considered, FTTH with full area coverage is economically self-sustained. A profitable FTTH-deployment is possible for only about 25% of all households. High access charges result in reduced network usage as fiber-based networks compete intermodally with traditional copper-bound infrastructures. One possibility to broaden the financial basis of FTTH-infrastructures is to grant exclusive rights. Another is to share the cost among operators by means of some form of compensation fund.

The most relevant example of FTTH deployment partially financed by users occurred in Finland (cf more details in the next Chapter); the project has been decided and implemented by the Regional Council of Ostrobothnia. Ulf Grindgärds has been

---

[126] Ernestyoung.com, Remise en cause par la Commission européenne du régime de TVA applicable aux offres « triple play », August 2010

[127] jcrni.org, CENTRE FOR EUROPEAN POLICY STUDIES, Approaches to FTTH-Regulation: An International Comparison, 2009

[128] jcrni.org, CENTRE FOR EUROPEAN POLICY STUDIES, Approaches to FTTH-Regulation: An International Comparison, 2009

working with IT-infrastructure matters in Ostrobothnia for the last nine years[129]. Seven years of these engaged by The Regional Council of Ostrobothnia where he today is Special Planner with the responsibility to implement the Osttrobothnian Regional Broadband Strategy. Ulf Grindgärs says, the specificity of the project, is "each household pay once to get fiber-connected", and the mainstream is that the household takes part in the investment. In some case a partial subsidies come from some European Projects dedicated to the backbone part of the network. The construction cost is also covered by the connection fees which are 1700-3000 euros/connected house. The connection fee was paid in three instalments. The household had the possibility to take a loan in local banks. To cover operational cost and costs for maintenance a monthly fee about 15 euros is collected. The pre-connection phase needed a 40% penetration to keep the connection fee human, says Ulf Grindgars[130].

Sector-Internal Financing by a Compensation Fund; This can been an alternative to the user access charges financing. A compensation fund can be implemented to which all market participants contribute. Also operators in related markets (even copper-based infrastructure) may be asked to participate in the financing. To ovoid a small base of contributors (only telecommunications operators) the participation has to be enlarged to all other related businesses. Indeed if the contribution base is small, rates will become too high.

In the UK, They choose to finance FTTH network from a wide range of sources: commercial gains from tendering contract and design, contributions in kind from private partners, contributions from other public sector organizations in the regions which benefit from increased connectivity, and consumers. To finance the next-generation final third project, the government plans to establish an independent Next-Generation Fund, based on a supplement of 50 pence per month on all fixed copper lines[131].

---

[129] Source: Bmp TC, 2010

[130] Source: Bmp TC, 2010

[131] Berr.gove.uk, Digital Britain: Consultation on Proposals for a next Generation fund, January 2010

Public Funds; is one possibility to reduce the distortions resulting from a small contribution bases. This is the case scenario with financing from public funds. However, in this case distortions are not limited to the telecommunications sector but spread over the entire economy. An important example for this approach is France which plans to heavily support fiber-based infrastructures with public funds. (2 Billion euros Plan dedicated for PPP[132])

3.2.6: Single/Multi fiber strategy

There is a trend in Europe on deploying fiber not as a single fiber connection between the customer and a network node but by installing a number of fibers to one single end-customer. This approach has higher additional deployment cost but aimed to come close to full-fledged infrastructure competition.

As we previously wrote, there are 2 kinds of relevant FTTH architectures (P2P and PON). With P2P the fiber is an individual fiber connection, while PON concentrates an amount of fibers from the homes (up to 128) to a single fiber using an optical splitter in a concentration point. Multi-fiber architecture deploys more than one single fiber per home, in the drop cable segment or optionally in the feeder cable segment. For example, in the case of Swisscom in Switzerland there are 4 fibers per homes, in order to enable several operators in parallel to get access to the same customers and thus offering the end customer a larger choice of ISP's. The advantages are clearly identified; the multi-fiber model generates more competition at deeper level than service wholesales. The multi fiber allows new competitive scenario where user can choose different services from different operators (TV from Fiber operator X, Internet from Fiber Operator Y…)

For a multiple terminating fiber configuration in a passive GPON unbundling, it involves laying one fibre for each operator from the splitter to the home. Each

[132] THD : Les collectivités invitées à dévoiler leurs projets, September 2010

operator is always connected to every home and, when a customer churns, the customer simply connects to a different fibre at his home. These passive options require greater investment, but offer altnets the advantage of owning the active electronics. [133] Multi fiber on GPON Unbundling creates a further trade-off, as the single-fiber option incurs OPEX when fibres are swapped over at the flexipoint, while the multifiber option involves higher CAPEX for deployment of more fibre.

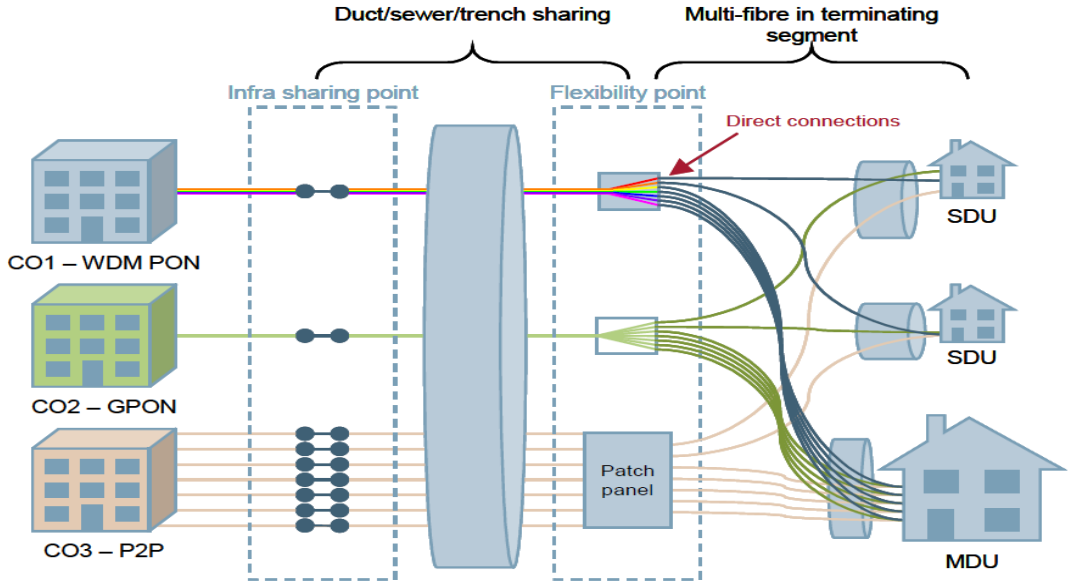


Figure 20: Multi-fiber Model for PON and P2P architecture[134]

Figure shows the total investment for a multi-fiber network is between 10 % and 20% higher than for the comparable single fiber networks. The differences are mainly driven by the higher number of fibers per customer which generally leads to additional works in inhouse cabling and splicing, digging of larger trenches and deployment of higher sized cables as well as the installation of collocation equipment. Indeed the main issue with this solution resides in the amount of fibers to install in the buildings/households. In large, multi-dwelling buildings, this number

[133] Ofcom.org.uk, Competitive Models in GPON: Initial Phase, October 2009

[134] Ofcom.org.uk, Competitive Models in GPON: Initial Phase, October 2009

may be very significant and may cause a problem in some buildings due to space constraints[135].

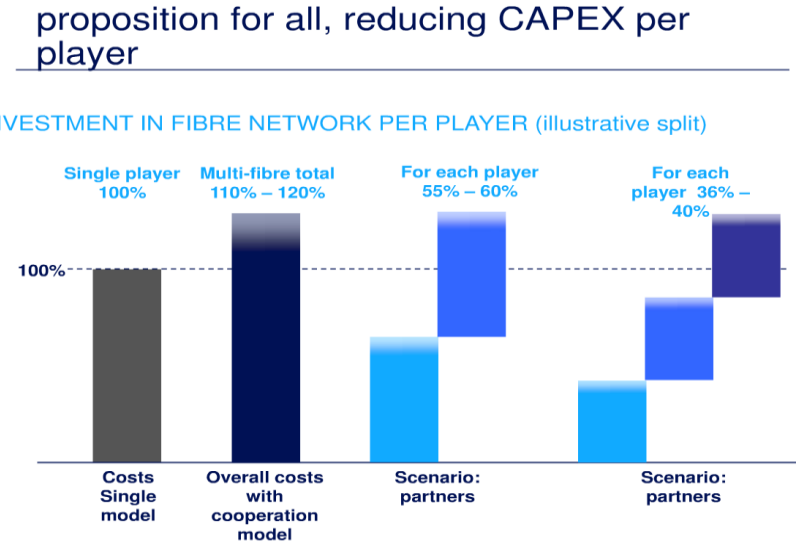


Figure 21: Multi-fiber Model for PON and P2P architecture[136]

The highest increase in investment results especially for P2P. This architecture considers four fibers per customer on the complete length between the customer's premise and the MPoP, thus in the drop and feeder cable segment. In these two segments the high number of fibers requires larger trenches and bigger cables which are able to capture the higher fiber capacity. The four fibers per customers also need customer sided OSDF and ODF ports which increases the investment The total investment in the multi-fiber network increases if the number of co-investing operators increases either.

---

[135] Presentation at the Eleventh ACCC Regulatory Conference "Market Structure Revisited" Structural models for NBN deployment, July 2010

[136] Swisscom.ch, FTTH Conference 2009 Swisscom Multiple Fibers, 2009

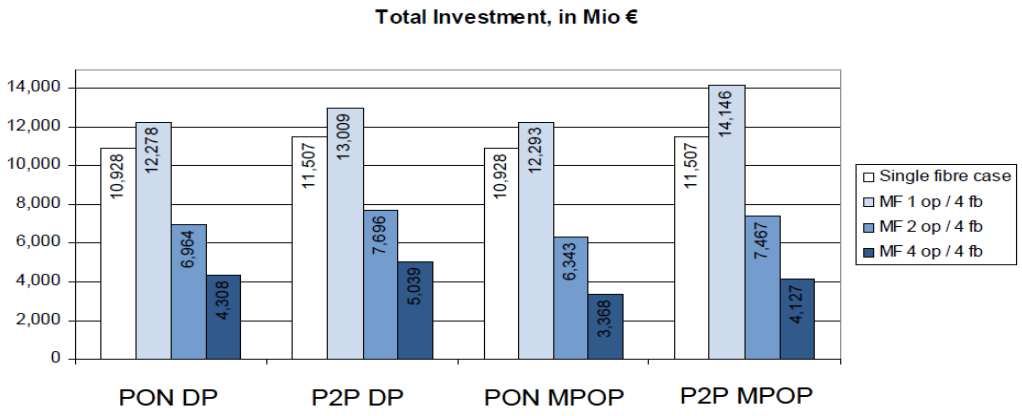


Figure 22: Multi-fiber investment comparison for PON and P2P architecture

But in term of relative value, a multi-fiber approach with two operators reduces investment per operator by about 40 % to 50 % compared to the same infrastructure operated by only one. With 4 operators, the investment per operator is even lower accordingly (60 % to 70 %)[137]. Concerning the total investment per cluster, it is obvious that in less dense clusters the relative investment difference between the single fiber case and the multi-fiber case with one operator decreases. For example, the P2P case with fiber hand-over at the DP indicates for the dense urban cluster a relative increase of about 20% while in the dense suburban cluster the relative difference is 12%. For the multi-fiber case it can be stated that the less dense the considered cluster is, the less is the investment share of the inhouse cabling segment and the distribution point equipment relative to the total investment. These positions are the main cost drivers of the multi-fiber case. The effect is higher for P2P, because the more fibers are deployed, the lower is the incremental investment per fiber, and so common deployment implies higher investment savings for P2P than for PON.

To conclude it becomes clear for operators that the investment per homes passed increases in case of multi-fiber compared to single fiber networks which is due to the additional equipment required in the multi-fibercase. If the number of operators

[137] Presentation at the Eleventh ACCC Regulatory Conference "Market Structure Revisited" Structural models for NBN deployment, July 2010

joining the co-investment model increases, the investment per operator and homes passed decreases due to the segment sharing.

CHAPTER 4

CASE STUDIES

4.1: Introduction

This part will highlight and identify some of the best practices coming from countries involved in ambitious FTTH projects. This is a way to go beyond theoretical thinking through describing some of the most enticing FTTH network in Europe. Indeed, the purpose is to illustrate what have been previously written. Here you will find some of the best FTTH deployments with an in-depth description of the choices that have been made, in term of technical, architectural and organisational matters, always with the background of the National regulation and plans from governments. Starting with a FTTH project in the "Pays Chartrain", who can be seen as a great example of small rural PPP. Then the next one take place in Netherlands, the network is called "Amsterdam Citynet". This project is a good example coming from one of the most ambitious PPP FTTH project in Europe.

We will be continuing with a detailed Scandinavian FTTH market analysis and adding two in-depth project descriptions coming from Norway and Sweden (ATB Nett AS and Karlstads City Network). Those two networks are clearly showing the Scandinavian way, and it proved to have worked fine during the last decade, especially if we consider the FTTH penetration rate in all Scandinavian countries, one of the highest in the world behind some Asiatic countries...

4.2: Public authorities involved in FTTH as a Best Practice

4.2.1: France: R.É.G.I.E.S (Pays Chartrain)

Organization	Le Syndicat Electrique Intercommunal du Pays Chartrain (SEIPC)
Project/Operation	Réseau d'Initiative Publique (RIP) Célièno « Green HD ».[138]
Location	71 municipalities in rural/semi-rural areas
Network/service status	Partly established, and commercialised, extensions under construction
Network technologies	P2P
first phase	First phase completed- January 2010
Budget forecasted	Total investment : € 4 million while SEIPC intends to invest 51% of the total Budget for the projet "Green HD", the rest poised for subsidies by the government for Ultra Broadband in rural areas
Public Subsidi	€ 2 million
Cost per House	€ 300 to 3000 HT, € 1200 average[139]
ISP	Numéo / Alsatis / e-tera / Wibox[140]
Network coverage	71 municipalities which are not covered by triple play and competitive offers
Subscribers	Less than 1.000
Home passed	5.000 households (2010) with extension 32.000 households being connected by the fibre network, 2.100 inhabitants are now directly co by fibre[141]
Business model	Open Access [142]
Price	wholesale offer being priced at less than 10 Euros a month

[138] avicca.org, 123 fiches projets des RIP en exploitation ou en construction au niveau national, 2009

[139] Lechorepublicain.fr, Le très haut débit à la vitesse de la lumière, September 2010

[140] Ariase.com, Une offre FTTH est déjà disponible à Chartres, June 2010

[141] Localtis.info, La fibre optique arrive jusqu'au domicile en pays chartrain, June 2010

[142] Célièno.com, La REG.I.E.S. (Régie Intercommunale d'Énergies et de Services),

The first phases of the project resulted in the creation of a neutral carriers' called Céliéno, which sells the services to any operator in a neutral and non-discriminatory way.

Today the network is constituted of a backbone which enables to connect to Paris directly for the IP transit connectivity, of a wireless local loop network enabling the offering of 3 Mbps and 6 Mbps to white zones entailing the disappearance of these (generating 600 subscribers per today and 2 000 by year end), and of an extended Fibre to the Building network for the businesses located on industrial zones. With its activities foremost the REGIES and its network Céliéno have demonstrated that ultra-broadband can be turned to reality for typical rural zones. As well the project Céliéno shows that smaller network operator can be successful and deploying state of the art infrastructures and offering innovative and competitive services to semi-rural and rural zones. It also shows that CAPEX can be controlled in using the existing infrastructures, enabling a business case for less dense municipalities.

As Alain Guillotin, operational director at the REGIES, states the network set up was conceived in full control of the costs entailed and in view of maximising existing assets[143]. Thus the infrastructure was built up by renovating existing ducts, while complementing some parts of the network with additional civil works[144]. The success and cost control of setting up the Céliéno network consist in the right mix of methods: overhead fibre lines were laid, ducts were used as much as possible and the REGIES monitors the fibre works completely (connexions, activation, provisioning). Including the service offer design and management for the client operators (dark fiber/bitstream)

Furthermore a crucial factor for enabling the open access networks to be commercialised and thus to attract service providers willing to involve themselves

[143] Sources : bmp TC, 2010

[144] Présentation REGIES A Guillotin - Fibres Optiques En Pays Chartrain, 2007

for relatively limited potential clients was the offering of competitive IP transit and of TV contents. So says Alain Guillotin already in 2005 the 71 municipalities established a connection directly to the Parisian Telehouse 2 (TH2) in order to bring the most competitive IP transit possibilities to the far reached region. Indeed before the set-up of the project, even the biggest nearby city Chartres was not benefiting from unbundling offers due to the lack of fiber networks connecting its central offices[145].

Thus a fiber connection was set up in order to enable to get the European interconnectivity also in the more rural zones. One other important factor for success was to interconnect with the existing public networks being established at the frontier of the territories, thus Céliéno is interconnecting with the public funded network in the state of Yvelines (CG 78) and others. This enables to get to a coherent network beyond the regional level. Since then other fiber loops have been set up, enabling the step by step connection additional rural municipalities.

Today the network Celieno will be further expanded into the more rural zones, trying to connect these neglected zones with Ultra Broadband. To be noted also, ashighlights Alain Guillotin, the efforts undertaken in the field of content creation. Foremost the REGIES has put at disposal some TV channels that the ISP can include in its offer. E-téra has developped the kiwi offer available now on the Céliéno network, which other ISPs might as well take in their commercial offers. The Celieno FTTH clients will also benefit from several local TV channels[146].

[145] Source: bmp TC, 2010

[146] Source : bmp TC, 2010

4.2.2: Amsterdam Citynet FTTH Network

Infrastructure ownwer	Glasvezelnet Amsterdam (GNA) The municipality, the housing associations and private sector investors ING Real Estate and Reggefiber set up GNA, with each one investing €6 m in 2008 KPN bought 41% minority interest in Reggefiber[147]
Network operator	BBned (open access layer)
Country	Netherlands
Location	Amsterdam
Network/service status	Commercialisation – extension for the next 85.000 buildings
Business model	Horizontally separated, open access network
ISP	8 ISPs using the network
Network technologies	A point-to-point fibre topology (also called "home run") was selected because it offers total flexibility in selection of equipment – any technology can be supported including Ethernet and PON. The technology is Ethernet with analogue cable TV on a second fibre[148].
Time to deploy	Phase one to connect 40,000 homes took 2.5 years, finishing in February 2009. Plans for connecting the rest of the city are underway with an expected completion date of 2015.
Budget forcasted	30 Million € to connect the first 40,000 addresses
Public Subsidi	6 Million € from the municipality, 6 Million € from the housing association
Cost per House	700,00 € [149]
Network coverage	Amsterdam area
Subscribers	4000[150]
Home passed	43000[151]
Main suppliers	Include Cisco Systems
Deployment	direct buried cables and 96-fibre ducted cables[152]

[147] broadbandprime.com, Incumbents acquire muni/city FTTH networks, June 2010

[148] ftthcouncil.eu, FTTH SUCCESS STORY: Amsterdam Citynet, August 2010

[149] Fibresystems.org, Amsterdam's Citynet scores a home run for fibre, February 2009

[150] Source: bmp TC, 2010

[151] Source: bmp TC, 2010

[152] arstechnica.com, How Amsterdam was wired for open access fiber, February 2010

Method	
Package	Voice, plus 50 channels of digital TV, including four High Definition TV channels
Price	€40 [153]
Local background	CityNet is an FTTH network sponsored by the Amsterdam local government. BBned is a wholly-owned Netherlands subsidiary of Telecom Italia.

In 2006 started the building of a city-wide fiber network in the whole Amsterdam area. The aim of Glasvezelnet was to create an open and future communication infrastructure through an innovative private and public collaboration. The exact objective was to reach around 40.000 homes in 2010, and it has been achieved the last couple of month[154]. The new target is to connect another 100.000 homes by the end of 2012. The project has been a pioneer, while integrating municipal and local utilities into a consortium of private investors, to deploy an Open Access fiber. Any ISP is allowed to use the infrastructure and deliver ultra-fast internet access.

Difficulties started when wiring up home and office buildings with multiple occupants. In dense city like Amsterdam approximately 90% of all buildings are MDU with up to 500 individual apartments per building[155]. The technical challenge was to get the fibers distributed from the basement or street level up to each individual dwelling. The experience in Amsterdam resulted over the years in using products like miniature direct burial cables, special high-rise cables with break-out windows to allow very fast builds inside MDUs, fibers that can bend sharply, easy-install Fiber Termination Units (FTUs) inside apartments, and so on.

Because you do not want to repeat burring cable, you need future proof technology and it need to be done right, so Glasvezelnet decided to deploy their fiber with a Point to Point fiber topology. To motive the choice of P2P, they argue the need of

---

[153] www.kpn.com/prive/internet.htm

[154] Source: bmp TC, 2010

[155] arstechnica.com, How Amsterdam was wired for open access fiber, February 2010

flexibility and future proof technology[156]. Indeed P2P helps easy unbundling of individual lines and this is a feature very much appreciated by regulators and customer in Europe.

They build an open-access, passive fiber plant that supports multiple ISPs in competition. It means unbundling dark fiber access lines which can be rented individually by an ISP who wants to serve that particular customer. And ISPs can get access to APOPs to install their line cards and related equipment, patch in their customer access line, and connect to their own backhaul network[157].

In practice, to prevent a clutter of patch cords in the APOP, the patching is limited per group of connections (1,500 to 3,000). When an ISP wants to service a customer within the group, it has to place equipment within the group patch area. A group of 1,500 to 3,000 patches to a limited number of ISPs can be de-cluttered within a reasonable amount of time if the need should arise[158].

Service providers on the network include Alice, Concepts ICT, InterNLnet, Tweak and KPN. Internet, double and triple-play packages are also available. The cost for InterNLnet who offers 100 Mbps symmetric broadband is €119.95 per month. It raises the question about end-users satisfaction. Indeed the lack of digital and HDTV offerings in the TV package supplied by BBned has been a source of complaints but an upgrade to a more competitive TV offering is expected at the end of 2010. In fact the price for 100Mbps offers exceed 100 Euros and this can be seen as a serious break, especially those who are already enjoying HD programs through DSL technology, looking for the added value of a 100Mbps…

The key to success on this project was the detailed design, good organization, and social engineering when dealing with people who live in the MDUs. In fact, this is

---

[156] ftthcouncil.eu, FTTH SUCCESS STORY: Amsterdam Citynet, August 2010

[157] Fibresystems.org, Amsterdam's Citynet scores a home run for fibre, February 2009

[158] arstechnica.com, How Amsterdam was wired for open access fiber, February 2010

much more important than trenching and putting in fiber. Only 120,000 meters of trenching was needed for the first 40,000 connections, an average of three meters per connection. Roughly 80 percent of the costs were labor costs, while 10 percent were fiber[159].

[159] arstechnica.com, How Amsterdam was wired for open access fiber, February 2010

4.3: Scandinavian Best Practices

Scandinavian countries are leading the way of FTTH in Europe and can be taken as a best practice as a whole. Indeed Sweden, Denmark and Norway remains the markets with the highest penetration and also the biggest number of projects within European FTTH market[160].

Even if Norway has not always been known as a FTTH market leader until the last couple of years, but it is today one of the leading markets for FTTH penetration and activities[161]. Concerning Sweden it has been a pioneer on the European FTTH. Indeed, 10 years ago, the Swedish government started to assist the deployment of municipal broadband in financial terms with providing the municipalities a developed long term strategy for their ICT Infrastructures. The strategy described goals and means for achieving a successful deployment. As a result, in April 2010, about 68% of all Swedish urban networks developed broadband strategies on a local and regional level. The combination of governmental financially assistance and developed broadband strategies, has been recognize as the most successful FTTH strategy in Europe[162]. The Swedish regulator, PTS, offers additional explanations, such as the fact Swedish operators and service providers steadily have been offering robust and secure communication networks and services to the market[163]. Also the cost for broadband access and services is Sweden is low compared to most other comparable markets[164].

Scandinavian markets can be characterised according to several factors. In term of regulations, governmental incentives and frame the Scandinavian countries shows

---

[160]Source: bmp TC, 2010

[161]satellite.tmcnet.com, Inventory of FTTH in Europe & Middle East, February 2010

[162] sweden.gov.se, Broadband Strategy for Sweden, 2009

[163] pts.se, Proposal for Swedish broadband strategy, 2007

[164] pts.se, Sverige i framkant - En internationell jämförelse på slutkundsmarknaden för elektronisk kommunikation, March 2009

some interesting elements. Firstly the regulators have chosen to postpone any kind of regulation of fiber deployments until further notice, this to stimulate all players including the incumbents to roll out fiber based networks. On the contrary of other markets the political authorities show few, if any, signals to encourage FTTH roll-outs, there are just few incentives from governmental bodies earmarked for FTTH deployments[165]. For example the Bynett association in Norway claims that the FTTH penetration in Norway could have been higher today, but lack of common sense in a socio-economic perspective allows for cases where competing players builds parallel fiber networks to the same households. According to Bynett[166] the competition should be carried out at the service level, by offering the service providers non-discriminative access to the network.

The Swedish government has set the target for its population to have access to world class broadband by year 2020; whereas 90% of businesses and households should have access to a minimum of 100 Mbps bandwidth. In order to reach these goals, the government has instigated a forum called "Bredbandsforum"[167]. This is an arena where governmental bodies, authorities, organizations and corporations should find constructive solutions to increase broadband deployment, facing the fact that the market forces alone cannot fulfil the target. This group will identify obstacles and hurdles, and propose incentives that will further stimulate fiber deployment.

Even if most FTTH players are pleased with the regulators standpoint of not intercepting the market development through regulation, these same players are expressing frustration over unpredictable frame conditions, a common point of frustration across Scandinavia.

In Norway there are no general and predictable conditions for establishing new infrastructure. In most cases building infrastructure is residing under the laws of different governmental bodies, and the 431 local Norwegian communities in addition to road, railroad and port authorities have different views and interpretations of the

---

[165] OECD, workshop on fibre investment and policy challenges, 2008

[166] Source : bmp TC, 2010

[167] ARCEP, La montée vers le très haut débit : Rapport public au Parlement, P90/161 Septembre 2010

governing laws and regulations[168]. An interesting example is coming from Drammen kommune (Drammen municipality), where the FTTH deployment is nearly brought to a halt due to increased digging costs. In terms of costs, the budget for digging a normal trench would reside around € 2600, whereas the actual cost in this case was € 14.000. This represents a devastating and unpredictable rise of costs, which in return cannot be met by additional ARPUs[169]

Concerning the Business models of the Scandinavian model, the vast majority of Swedish urban networks are "open access" networks[170]. Today, the discussion is to what extent the competition should work on the infrastructure level as well as for the service level. In practicality, there is no competition on the infrastructure level, and as a consequence all urban networks are mandated to offer dark fiber. The introduction in 2009 of a common market place tool called CESAR, has facilitated the sales and deployment of dark fiber from the various networks.
Norway strikes between "open access" and "closed models"[171]. FTTH networks are more economically viable one than the other. Until today none of the networks have proven more economically viable than the other but so far vertically integrated networks like Lyse Tele has been dominant in Norway[172]. Looking deeper into the different type of networks, one will find that most "open access" networks in reality are "hybrid" networks. In practicality this means that the network owner often provide the service with the best margin, in most cases the pure ISP-service. Other lower-margin services, such as IPTV and VoIP, are left to 3rd party service providers.

The Norwegian regulator NPT stated February 10th 2010 in a report commissioned by the Norwegian Department of Communication that "NPT finds no valid reason to

---

[168] home.hisf.no, Local government and administrative structure in Norway,2007

[169] Source : bmp TC, 2010

[170] shatwan.com , Varying models of Broadband Deployment in Sweden, 2007

[171] telecomde.com, Open-Access Fiber Networks, 2009

[172] .oecd.org, The role of facilities-based competition with fibre in Norway, April 2008

point out one business model over another in terms of stimulation of increased roll-out of high capacity networks. Any competition issues that calls for regulation of providers are continuously being evaluated in the analysis being conducted by NPT on a regular basis as a part of the general regulation of the market"[173]. The price for access to copper local loops is regulated in Norway and the regulated price is aimed to give incentives to use the existing copper access network. In December 2007, Telenor voluntarily lowered the price for LLU-access (below the regulated price cap).

In Denmark, there is still evolving in term of FTTH business models. Indeed, 15 utility companies[174] (Sydfyns El, EnergiMidt, Tre-For, NyFors, SydEnergi, Seas NVE, Østjysk Energi, Verdo, NRGi, Energi Fyn, Bredbånd Nord, HEF Bredbånd A/S, Galten Elværk, Elforsyningen Nordvendsyssel, Elforsyningen Sydvendsysse), recently formed the joint "COMMX". How "COMMX" will shape their business model, remains yet to be seen. However, the press release indicates that the service offering will be based on a common set of services offered through the 15 FTTH operators[175] COMMX works with localities to make use of some existing duct infrastructure and added new ducts for access to homes and buildings thus rolling out a new FTTH[176].

In term of market dynamics related to business case elements, the most obvious solution in this respect is to increase customer base and market potential by consolidating FTTH networks. This is starting to emerge as a trend among Scandinavian FTTH networks, most clearly visible in Denmark where 15 FTTH-players have joined together under the working title "COMMX". In Norway, ATB-Nett is a confederation of 6 network players with more network players knocking on the door to a certain extent, Lyse/Alt-i-Boks with is franchising model is representing

---

[173] Npt.no, The Norwegian market for electronic communications services 2009, May 2010
[174] Bloobble.com, Overview of Current European Experience in FTTH P 31/76, 2008

[175] FTTH Conference 2009 Regulator Denmark, 2009

[176] Smilecontent.dk, Pressemeddelelse: Waoo køber Dansk Bredbånd, 2010

a level of consolidation, offering a centralized model for operations, services and sales/marketing.

In Sweden, OpenNet can be seen as a runner-up offering operational services that significally reduces OPEX for FTTH network owners[177]. OpenNet offers centralized network operations and services (excluding passive networks), eliminating the need for staff and equipment expenses[178]. It is likely to believe that companies offering centralized solutions for operations, service and sales/marketing of FTTH networks will gain stronger foothold in the market, and even expand their operations outside Scandinavia.

Maximising revenues for FTTH deployments is a real challenge, and also for competitors in the same market. In general, ARPU is considered to be declining over time regardless of service type, and the evident remedy to increase the revenue streams in this respect is to increase the number of services per customer, and supply the market with new and attractive services. Is spite of pressure from regulators and authorities to unbundle services and service-packages, it seems that pre-packaged like triple play services still are popular among end-users, and turns out to be easier to sell than stand-alone separate services. The reasons for this are many, but easy set-up, ease-of-use and single invoice seems to be of importance. Among Scandinavian FTTH networks, new revenue streams are emerging as FTTH networks cooperate and offer high capacity IP transit services in competition with national operators. The fibre networks of local players holds a high technical standard and high-capacity transport services are now being offered to the market. An example of this is the newcomer OneStream, consisting of Pronea (Tromsø, Norway), AC-Net, Norrsken, IT Norrbotten and Bahnhof (Sweden) and JNT (Finland)[179]. Aggregated the cooperation has control over 20.000 km of fiber optics cable, with revenues topping

---

[177] SwedenOpen.Net, An open access network with a freedom of choice

[178] ARCEP, La montée vers le très haut débit : Rapport public au Parlement, P90/161 Septembre 2010

[179] computersweden.idg.se, Nätoperatörer i nytt nordiskt säljsamarbete, February 2010

NOK 1,2 billon (€150 millions). The cooperation offers high capacity transit services within the Nordics, with sidings to continental Europe.

In southern part of Norway several corresponding regional initiatives are emerging, posing competition to the national operators on elements as price, capacity and quality. Regional FTTH players can play a role on a national level and expand their revenue streams based on the foundation of their initial FTTH deployment.

Access to viable services is of key importance to assure customer uptake in accordance to the business plan. In particular where competition from incumbents or cable operators is imminent, the success of a FTTH deployment is dependent of an attractive service offering to the market. In case of smaller FTTH deployments, the larger service providers (in particular IPTV-providers), have shown little interest in offering their services to the local FTTH projects.

In Scandinavia development has been driven in two ways:
1) Consolidation of smaller FTTH deployments into larger bodies more attractive for the larger service providers[180]
2) Development of new and adapted services from the service providers. In Sweden the DTT service provider Boxer is performing trials on FTTH deployments in order to commercialise a FTTH based service for FTTH networks, and in Norway the second largest cable operator "GET" had a relatively success when offering an adapted version of the Get Digital TV service on open access FTTH networks. The Norwegian subsidiary of TeliaSonera, NextGenTel, is also offering its Triple Play service offering on a general base to FTTH deployments,

The success factor in these cases is very much residing on how the cost of service transport can be reduced, the transport of a 1,5 Gbps IP multicast stream is costly and must be justified by a minimum customer base to get the business case in balance.

[180] wireless-center.net, FTTH: The Swedish Perspective, 2007

By means of consolidation and/or cooperation, more and more local FTTH deployments are reaching critical mass and reduced transport costs.

4.3.1: ATB-Nett AS

Infrastructure owner	ATB-Nett is a constellation of 6 networks, where the fiber infrastructure is owned by utilities (Numedal Fiber, Drangedal Everk, Telefiber, Tinn Bynett), local community (Bykle Breiband), and part private and utility (20/80%) (Samnett)[181].
Network operator	Each network owner operates its own network for now.
Country	Norway
Location	Bykle, Numedal, Tinn, Bø, Kvitseid, Drangedal[182].
Network/service status	Fully operational. Currently expanding network to reach the growing recreation and holiday property market.
Business model	Open/hybrid network access at fiber, capacity and service level
ISP	6 ISP (Mix of local and national brands)
Network technologies	P2P Point-to-point FTTH and Ethernet, a small portion of GPON. Other technologies (xDSL, cable) are also at hand.
Rollout of the first phase	From 2001 and onward by each local network. ATB-Nett was formed February 2010.
Cost per House	Connection cost € 1255 – € 3100 depending on location. Monthly Network cost apply, dependent of network supplier[183]
Strategic Partner	NetNordic Bredband (access) HomeBase (content)[184]
Network coverage	ATB-Nett spans over 3 counties, Aust-Agder, Telemark and Buskerud, within

[181] bynett.no, atb i ferd med å se dagens lys, November 2009

[182] bynett.no, atb i ferd med å se dagens lys, November 2009

[183] Source bmp TC, 2010

[184] bynett.no, atb i ferd med å se dagens lys, November 2009

	the locations of Bykle, Vest-Telemark, Midt-Telemark, and Numedal. This covers approximately 22.500 private households and 30.500 holiday properties[185]
Subscribers	3500[186]
Home passed	15000[187]
Main suppliers	Packet front and Cisco Systems[188]
Internet Speed	Up to 100Mbit/s, dependent on service and provider
Package	Various packages from HomeBase and AltiBox (triple play), ISP from the respective network owner and other combinations of offerings of double and triple play[189].
Price	Varying on package and network supplier, from € 37-€ 100[190].

Small utility and network companies often do not have the resources necessary to offer competitive broadband solutions in their communities, and therefore it is often the major players that dominate. This is the backdrop for why 6 utility companies in Southern Norway calls to action. Located in the counties of Agder, Telemark and Buskerud, the 6 companies have formed the new company ATB. Through ATB it will be feasible for smaller players in the region to offer high-speed fiber-based broadband to their customers.

By aligning the individual company's assets and operations, ATB aims for lower operating costs, less risk, and being able to share the purchase costs for content.

- "The fiber networks are for a great part already interconnected for all 6 companies. What really has lacked is a legal party for service providers and customers to", says general manager of the ATB network, Harald Kinch[191]

---

[185] Source bmp TC, 2010

[186] Source bmp TC, 2010

[187] Source bmp TC, 2010

[188] packetfront.com, Chooses PacketFront for fiber to the home (FTTH), 2007

[189] www.altibox.no

[190] numedalfiber.no, Tjenester, 2010

[191] Source bmp TC, 2010

The idea is that the small fiber-owners who participate in the cooperation will be much stronger when they negotiate deals with content and service providers. It will provide for more competitive pricing on content, while it will also be easier for suppliers to have one company to deal with. At this point, all members of ATB confess to an "open access" business model, which in turn means that content and services is being provided by 3rd party providers[192].
The fiercest competitors at the regional level are according to Kinch companies that offers services on a national base, namely the incumbent Telenor and Ventelo (formerly BaneTele).

The growing cooperation started a couple years ago, when the utility owned companies Samnett, Bykle Broadband, Numedal fiber, Drangedal everk, TeleFIber and Tinn energi began to explore the possibility of aligning each other's fiber networks and operation. At the end of 2009 the cooperation was formalized, and Samnett, Tinn energy and Numedal Fiber founded the company ATB Nett AS[193].

- We are now working to get more partners in order to cover a larger area. It is also possible that the county of Vestfold may be interesting to address, as it geographically in a way belongs to our region", says Kinch. He primarily wants a partnership with the owners of fiber[194].

Kinch emphasizes that there is still the individual company that own its own infrastructure. He adds that the content is going to be an important part of what ATB network will offer. As co-owner of the company you get access to a palette of content providers to choose from, so that individuals can choose what they want to offer to their customers[195].

---

[192] Source bmp TC, 2010

[193] bynett.no, atb i ferd med å se dagens lys, November 2009

[194] Source bmp TC, 2010

[195] Source bmp TC, 2010

- We will not have a huge top-heavy organization, and believe in local ownership. This is sharing the cost with a high degree of voluntary commitment from each partner, "said Kinch[196]. Kinch believes cooperation form ATB network has chosen is the way to go for start-ups, and says that he hopes for similar collaboration elsewhere in the country.

4.3.2: Karlstads City Network

Infrastructure ownwer	Karlstads Stadsnät is part of Karlstads Elnät, a 100% owned subsidiary to municipal of Karlstads.
Network operator	OpenNet is communication operator (www.opennet.se)
Country	Sweden
Location	Karlstad
Network/service status	Fully operational. Currently expanding network to residential market and the rural area of Municipality of Karlstad
Business model	Open network access at fiber, capacity and service level
ISP	16 ISPs using the network
Network technologies	P2P Point-to-point FTTH and Ethernet
First phase	17 May 2003
Budget forcasted	€ 1.8 millions
Cost per House	Connection cost SEK 10.000 – 20.000 depending on location. Monthly Network cost of SEK 60
Subscribers	4800
Home passed	35000
Main suppliers	Packet front and Cisco Systems
Internet Speed	100Mbit/s
Package	30 Internet services, Open platform for IP-TV (OC-1), 180 channels cable TV (16 HDTV), 13 IP telephony services.

[196] Source bmp TC, 2010

Price	€ 22 for 10 Mbits Internet services, € 35 for 100 Mbits. € 16 for 26 channels cable TV and telephony from € 3 to € 10[197]
Local background	Karlstads Stadsnät is wholly owned municipal fiber network offering not only open network services but also fiber acces to operator and public sector.

Karlstad Stadsnät is among the most successful urban networks in Sweden in terms of high market share and penetration. The company has turned around from being a provider of dark fiber only (which still is its best revenue source), to provide a diversity of services to the consumer market and to the employees of Karlstad municipality[198].

- We don't believe that the need for reliable and high capacity communication services can be solved by the market forces alone. We see ourselves as important player to fill the gaps that the market leaves behind, both in a rural and an urban context, says Hafsteinn Jonsson, CEO of Karlstad Stadsnät[199].

Karlstad Städsnat is organized as a pure fiber operation, and has outsourced its network operations and service provisioning to OpenNet. – For us, OpenNet is a good match, providing us with operational support and supply of total of 110 services dispersed in various categories as IPTV, ISP, telephony, network storage etc[200].

- This means that we can focus on sales and marketing of our services, resting assure that OpenNet will take care of the day-to-day operation and support[201].

But Karlstad Stadsnät has discovered that IPTV not necessarily is the killer app for FTTH. It turns out that providing analog TV (RF over fiber) is one of the best selling services in their network, Karlstad Stansnät moves in to MDUs and replaces coax

---

[197] t3.se, Bonnemang KARLSTAD - Karlstad stadsnät (Opennet), 2010

[198] .mynewsdesk.com, Fibernät blir verklighet på Karlstads landsbygd, November 2008

[199] Source bmp-tc, 2010

[200] www.karlstad.opennet.se

[201] Source bmp TC, 2010

cables with fiber connections, and offer TV services from Sappa[202]. The end user has a residential gateway (RG) manufactured by PacketFront, offering an analogue RF-outlet for TV in addition digital ports for other network services[203]. This eliminates the need for connecting the TV to a STB, and has proven to be very popular among a customer segment that is reluctant to apply new technology.

Nevertheless, MDUs prove to be the hardest places to break through barriers set up by the incumbent and cable operators. With agreement structures spanning over 10 to 12 years, it is a serious challenge for a player as Karlstad Stadsnät to even come to the negotiation table. Despite its diversity on services, dark fiber is still the most solid source of income for Karlstad Stadsnät... Currently Karlstad Stadsnät rents dark fiber to companies like Bredbandsbolaget, TeliaSonera, and will continue to focus on this part of business.

[202] www.sappa.se

[203] karlstad.opennet.se, Att ansluta en fastighet till Karlstads Stadsnät och bygga ett fastighetsnät

4.4: Synthesis of the choices made in the 4 Best Practices projects

	Pays Chartrain	Amsterdam	ATB-Nett	Karlstads
Network Operator type	Privat Public Partnership	Privat Public Partnership	Utility Partnership	Municipal Authority
FTTH Organizational Choice	Neutral carriers' which sells the services to any operator in a neutral and non-discriminatory way. (wholesales)	Horizontally separated Consortium of private investors, to deploy an Open Access fiber. Any ISP is allowed to use the infrastructure and deliver ultra-fast internet access.	6 Utilities have formed the new company ATB Services is provided by 3rd party providers	Karlstad Städsnat is organized as a pure fiber operation outsourced its network operations and service provisioning
Network Access	OPEN (Layer 3)	OPEN (Layer 2-3)	OPEN (Layer 3)	OPEN (Layer 2-3)
Number of Fiber per homes	1	2	1	1
Financing	Subsidies: 49% From: government for rural areas Ultra Broadband	Subsidies: 33% From: From: municipality+housing association	0% Financed 100% by utilities involved.	Financed by the Municipality
Technological Choice	FTTH Point to Point AON	FTTH Point to Point, The technology is Ethernet with analogue cable TV on a second fibre	FTTH Point-to-point and Ethernet, a small portion of GPON	FTTH P2P Point-to-point Ethernet
Fiber Deployment	Network consist in the right mix of methods: overhead fibre lines were laid, ducts were used as much as possible	Miniature direct burial cables, special high-rise cables with break-out windows to allo fast builds inside MDUs.	Massive usage of the 6 utilities ducks and capacities.	The end user has a residential gateway (RG) offering an analogue RF-outlet for TV in addition digital ports for other network services

CHAPTER 6

CONCLUSIONS

Traditional copper-based access-networks will not be able to support anymore the recent increase in internet traffic for much longer, especially when we see new application coming in a very close future, requiring even more bandwidth (3D TV, Smart Homes...). Throughout Europe we see major investment in Ultra-Broadband with new projects taking off, in order to replace the existing copper-based infrastructure in the local loop by fiber and thus bringing more bandwidth to private customers and businesses**. In this framework, we aimed to indentify the key factors for a viable and enticing FTTH deployment in Europe.**

Basically, those elements are:

- Regulatory framework and governmental incentives
- A combination of policies oriented towards network deployment, network financing, and service competition through network access
- The local authorities and utilities involvement.
- The Private Public Partnership option
- The organizational choice (3 layers)
- The network access, Open/Close Access
- The technological and architectural choice
- The Capex optimization.

In term of limits, such study cannot by nature claim to be exhaustive and fully comprehensive. In fact, each European country has great differences in term of already existing infrastructure, regulation paradigm and telecom's actor. Even in the same country, Greenfield scenarios have nothing to compare with FTTH deployment in old cities/old buildings. So all the remarks, analyses and advices given during this report have to be balanced and understood as a lead idea and not like a postulate. We tried to be as accurate and up-to-date as possible with the last freely available sources of information.

This thesis shows that **long-term effect of investment in FTTH-infrastructure depends on the regulatory framework and governmental incentives**. There are various approaches to FTTH-regulation and incentives for service competition. And this is important to understand that bad decisions would defer infrastructure investments and decrease cost-effective network structures and finally would constrain the potential for future competition on all network layers. Therefore, active FTTH-policies need to be carefully designed with a **combination of policies oriented towards network deployment, network financing, and service competition through network access.** As a matter of fact the European Union plays an active role within FTTH market through the structural funds it allocated. Thanks to these funds, many local authority broadband projects in Europe can be implemented more easily, enabling open neutral FTTH networks.

It also appears clearly that the future of **FTTH is closely linked to local authorities and utilities ambitions**. In fact, we observe local authorities often with their local utilities (especially energy utilities) getting more and more involved in FTTH. Because utilities very often owns their ducts, (led in parallel of their distribution network), it makes them able to put fiber at a much lower cost than digging another underground network. Also local utilities have easy access to rights of ways and depending. In term of financing the project, local utilities have access to low cost capital. Furthermore, most of the deployments operated by utilities or local authorities are Open Access with the intention of **creating a competitively neutral platform that other service providers can use** t**o deliver voice, video, and data services.** This particular combination is an important driver for the development of these local networks and it really helps to create affordable FTTH access for all. The involvement of the local government will lead to an early and widespread deployment (contrary to the 'cherry picking' that the private operators are doing today). Also private players are expected to build the lowest cost networks and networks that facilitate as little competition as possible. It comes as no surprise that most of the private FTTH deployments in Europe today are PONs. We believe that

public-private strategic partnership seems like to be the best option, which would lead to a competitive industry structure.

Making the right technology choice for a new FTTH network project can be a daunting task. Indeed, concerning the roll-out itself, many questions arise when starting a new project. Which technology or network topology should be used? There is a real religion war between those in favor of Active Optical Networks with a Point to Point topology and those in favor of Passive Optical Networks with a Point to Multi point topology. As we previously said, all have advantages and disadvantages. If cost is a primary consideration for a new FTTH network project, PONs could be seriously considered, even though operating cost occurs to be higher than his concurrent technology. Indeed in another hand OAN with P2P architecture is a real future proof Fiber to the Home deployment, with more capital expenditure at the start but with a lower operational and maintenance life cycle costs. To make a good decision, the choice has to be made with a careful consideration and a clear objective. **But the real good news is that there are really no bad choices**. **All of the choices are proven technologies that can support a wide array of services. It is just a matter of choosing the solution that best meets the needs of the project.**

The paper shows that when it comes to the infrastructural choices for operators we **see the most viable long-term competitive market structure would involves the presence of a wholesale supplier** (that is not vertically integrated) and its efficient functioning as a regulated common carrier. With the presence of a 'neutral' firm that builds and owns the fiber infrastructure and offers non-discriminatory access to all service providers will significantly lower entry barriers to firms intending to provide video, voice and data services. Indeed, because 'neutral' firm do not provide retail services, they have no incentives for discriminatory behavior against new service providers. Consequently, **the exclusively wholesale and neutral nature of such a firm allows the market to sustain multiple service providers.**

And the last requirement to allow better FTTH penetration in Europe would be the necessity to give better incentives (in term of content and application) for the end-

user. FTTH actors need to **find killer applications making full usage of the 100 Mbps**. Of course 3D TV is leading new bandwidth requirement with also Multi-HD TV configuration in the households. But, we see as a necessity an increase of new contents requiring more bandwidth. Customer demand for FTTH will clearly create a positive dynamic for further FTTH deployment in Europe.

GLOSSARY

ADSL Asymmetric Digital Suscriber Line

AON Active Optical Network

APON A Passive Optical Network built around ATM technologies
ARCEP Autorité de Régulation des Communications Electroniques et des Postes

BPON Broadband Passive Optical Network is an APON modified to allow additional services, such as video or additional data
BSA Bitstream Access

CAPEX Capital Expenditure
CPE Customer Premises Equipment, the equipment portion of a distribution or access network that is located on the customer's premises

EPON Ethernet PON, a PON built around Ethernet technologies
EP2P: Ethernet Point to Point

FTP cable foil screened twisted pair cable

FTTx A generic way of expressing the whole concept of high-performance optical fiber networks
FTTB / P Fiber To The Building / Premises is an access network where fiber is deployed to a central point of the building or home
FTTC Fiber To The Curb is an access network in which fiber is used for part of the link from the central office to the end user
FTTH Fiber To The Home is an Optical Access Network in which the ONU is on the customer's premises
FTTN Fiber To The Node is an access network in which fiber is used for part of the link from the OLT to the end user

GEPON Gigabit Ethernet Passive Optical Network

GPON GigaBit Passive Optical Network is built around SONET and TDM

HDTV High definition television

IP Internet Protocol

IPTV Internet Protocol Television
ISP Internet Service Provider

LAN Local Area Network

LLU Local Loop Unbundling

Mbps: megabit per second

OAN Optical Access Network is an access network made up of optical transmission links
OLT Optical Line Termination is the network-side interface of the OAN and connected to one or more ONUs
ONU Optical Network Unit is the user-side interface of the OAN
OPEX Operational expenditures
Optical splitter A passive optical component which can split or combine optical signal power

P2MP Point to MultiPoint is a network architecture in which an OLT is optically linked to multiple ONUs through passive means
P2P Point to Point is a network architecture in which optical links are from one point to another without optical branching
Passive A component that requires no electrical power to operate
PON Passive Optical Network is an OAN in which each OLT is connected with more than one ONU by means of passive intermediate elements

RBOC Regional Bell Operating Company (RBOC) is a term describing a U.S. regional telephone company

SMP Significant Market Power

TDM Time Division Multiplex

VDSL Very High Speed Digital Subscriber Line

VoIP Voice over IP

WLR Wholesale Line Rental

APPENDICES

FTTH Council - Definition of Terms

INTRODUCTION

The mission of all the FTTH Councils in North America, Europe and Asia-Pac includes the communication to stakeholders in our respective regions of the extent of usage of FTTH throughout the world and forecasting the growth of FTTH.
This task has been made difficult by the proliferation of terms and acronyms that, while no doubt useful to individual organisations for their specific purposes, lack precise definitions.
This is of particular concern when different research organisations choose their own definitions when conducting research. As a consequence it becomes impossible to compare the research on FTTH between different regions, or between different studies of the same region.
This document defines the terms used by all the FTTH Council's (North-America, Europe, Asia-Pacific). To promote consistency when commissioning or commenting on research the Councils' members will confine themselves to those terms defined in this document.
This document specifically aims to reduce the terms used to a subset that are well defined, adequate and useful.

THE TERMS

Fiber-to-the-Home (FTTH)

"Fiber to the Home" is defined as a telecommunications architecture in which a communications path is provided over optical fiber cables extending from the telecommunications operator's switching equipment to (at least) the boundary of the home living space or business office space.

This communications path is provided for the purpose of carrying telecommunications traffic to one or more subscribers and for one or more services (for example Internet Access, Telephony and/or Video-Television).

This definition excludes architectures where the optical fiber terminates in private space before reaching the home living space or business office space and where the access path continues to the subscriber over a physical medium other than optical fiber (for example copper loops).

This definition excludes architectures where the optical fiber cable terminates in public space (for example an operator's street-side cabinet) and where the access path continues to the subscriber over a physical medium other than

optical fiber (for example copper loops). It is acknowledged that other parties such as the US FCC make specific concessions for such architectures.
However, for the formal communications of the Councils, architectures that are excluded by this definition are NOT Fiber-to-the-Home.

Fiber-to-the-Building (FTTB)

"Fiber to the Building" is defined as a telecommunications architecture in which a communications path is provided over optical fiber cables extending from the telecommunications operator's switching equipment to (at least) the boundary of the private property enclosing the home or business of the subscriber or set of subscribers, but where the optical fiber terminates before reaching the home living space or business office space and where the access path continues to the subscriber over a physical medium other than optical fiber (for example copper loops).
FTTB construction is a transitional form commonly used as a means to deliver services to existing buildings in conjunction with associated FTTH construction (for example for new buildings). By introducing fiber cables from the fiber termination point to the home living space or business office space FTTB can be converted to full FTTH. Such a conversion is desirable as FTTH provides better capacity and longevity than FTTB.
This communications path is provided for the purpose of carrying telecommunications traffic to one or more subscribers and for one or more services (for example Internet Access, Telephony and/or Video-Television).
This definition excludes architectures where the optical fiber cable terminates in public space (for example an operator's street-side cabinet) and where the access path continues to the subscriber over a physical medium other than optical fiber (for example copper loops).
However, for the formal communications of the Councils, architectures that are excluded by this definition are NOT Fiber-to-the-Building.

Cable Plant Topology

The cable plant which connects the operators' premises and subscribers' premises can be deployed in the following different topologies:

"Point-to-Point" (P2P) cable plant provides optical paths from the telecommunications operator's switching equipment to a single contiguous location such that the optical paths are dedicated to traffic to and from this single location. In generic terms this is a star topology.

"Point-to-Multipoint" (P2MP) cable plant provides branching optical paths from the telecommunications operators switching equipment to more than one contiguous location such that portions of the optical paths are shared by traffic to and from multiple locations. In generic terms this is a tree topology.

"Ring" cable plant provides a sequence of optical paths in a closed loop that begins and ends at the telecommunications operators switching equipment and connects a series of more than one contiguous location such that portions of the optical paths are shared by traffic to and from several locations.

A location is identified as being within the boundaries of the private property enclosing the home, business or premise of the subscriber or set of subscribers.

Note that from these definitions it is not possible to identify the access protocol used over the cable plant.

It is possible for a network to be built so that a common cable plant can include a mix of different topologies, or be re-configured over time to support different topologies, to allow for mixed user categories, to allow access diversity for reliability, and for future flexibility and network longevity.

Access Protocol

Access Protocols are the methods of communication used by the equipment located at the ends of the optical paths to ensure reliable and effective transmission and reception of information over the optical paths. These protocols are defined in detail by the standards organisations that have created them, and are recognized and implemented by manufacturers around the world.

The Access Protocols in use today for FTTH Networks and the optical portion of FTTB Networks are:

"EP2P" defined as Ethernet over P2P 100baseFX, 100baseLX, 100baseBX, 1000baseLX and 1000baseBX in IEEE 802.3ah

"EPON" defined as Ethernet PON 1000basePX in IEEE802.3ah (Note that the expression Gigabit EPON is synonymous with EPON.)

"BPON" defined as Broadband PON in ITU-T G.983

"GPON" defined as Gigabit PON in ITU-T G.984

"OTHER" access protocols such as proprietary or pre-standard access protocols may be noted for the purpose of completeness in research.

Network Usage

FTTH/FTTB Networks may be dedicated to the services of a single retail service provider, or made available to many retail service providers, who may connect to the network at the packet, wavelength or physical layer.

"Exclusive Access" refers to the situation where a single retail service provider has exclusive use of the FTTH network.

"Open Access (Packet)" refers to the situation where multiple retail service providers may use the FTTH Network by connecting at a packet layer interface and compete to offer their services to end users.
"Open Access (Wavelength)" refers to the situation where multiple retail or wholesale service providers may use the FTTH Network by connecting at a wavelength layer interface and compete to offer their services.

"Open Access (Fiber)" refers to the situation where multiple retail or wholesale service providers may use the FTTH Network by connecting at a physical layer ("dark" fiber) interface and compete to offer their services.

"Open Access (Duct)" refers to the situation where multiple retail or wholesale service providers may share the use of a duct network covering a substantial region by drawing or blowing their fiber cables through the shared ducts, and compete to offer their services.

User Categories

FTTH/FTTB Networks may deliver services to the following categories of users:

"Residential" refers to private users in their homes. Residential users may live in **"MDU"** (multi-dwelling units such as apartments/condominiums) or **"SFU"** (single family dwelling units such as stand-alone houses/villas/landed property).

"Business" refers to large (corporate), medium, and small (Small Business, Small Office Home Office) business users. Businesses may occupy **"MTU"** (multi-tenanted units such as office blocks/towers) or **"STU"** (single-tenanted units such as a stand-alone office building or warehouse).

Network Size

The size of FTTH/FTTB Networks is described in the following terms:
The number of **"Homes/Premises Passed"** is the number of residential and business premises to which an operator can currently deliver FTTH access within the operator's standard service activation period (for example 30 days) should the owners/occupiers sign a contract for an access service. Typically new service activation will require the installation and/or connection of a drop cable from the street or basement to the home or office, and the installation of subscriber premises equipment.
This definition excludes premises that cannot be connected without further installation of substantial cable plant such as feeder and distribution cables to reach the area in which a potential new subscriber is located.

The number of **"Homes/Premises Connected"** is the number of residential and business premises to which an operator is supplying FTTH access under a commercial contract.
The **"Take-up Rate"** or **"Take Rate"** for a network is calculated by the simple division of "Home/Premises Connected" by "Home/Premises Passed", and is expressed as a percentage.

Services

FTTH/FTTP Networks are used to deliver the following services.
"Internet" refers to use of the Public Internet for exchanging email, web-browsing, etc..
"Voice" refers to the exchange of human conversations by use of **"IP"** or **"Other"** encoding and transport protocols. (This category does not include Voice carried over the Public Internet.)
"Video" refers to the exchange of visual material by use of **"IP", "RF"** (carried via a separate optical wavelength) or **"Other"** encoding and transport protocols. (This category does not include Video carried over the Public Internet.)

Current remedies across member states

Country	Incumbent NGA	Passive				Active	
		In-building fibre	Duct access	Dark fibre	SLU	Wavelength	Ethernet Bitstream
Belgium	FTTC		✓ (MDF to cabinet)	✓ (MDF to cabinet)	✓		✓
Denmark	FTTC DOCSIS 3.0		✓ Industry agreement	✓ Commercial offer by TDC	✓		✓
France	FTTH GPON	✓	✓				
Germany	FTTC		✓ (MDF to cabinet)	✓ (MDF to cabinet)	✓		
Italy	FTTC FTTH		✓ (TI equal access)	✓ (TI equal access)	✓		✓
Netherlands	FTTC FTTH P2P		✓	✓ (ODF access for P2P)	✓ (no business case)		FTTC: ✓ FTTH: ✓
Spain	FTTH GPON	✓	✓	✓	✓		✓ (Up to 30 Mbps)
UK	FTTC FTTH GPON				✓		✓

Figure: Next Generation Access Networks: the European approach

Cancun, September 25, 2009

Author: Elena Scaramuzzi

Parameter	ACTIVE (Point to Point /P2P)	PASSIVE OPTICAL NETWORKS (Point to Multi Point /P2M)
Topology	Ethernet Switched Optical Networks (ESONs) contain an active electronic element, a switch aggregator, between the central office (CO) or head-end switch and the Customer Premise Equipment (CPE).	Passive Optical Networks (PONs) do not contain any electronics between the CO switch and the CPE. In a PON, the active optoelectronics are situated on either ends of the passive network .
Standards	It is based on IEEE 802.3 standard The recent completion of the 10 Gigabit Ethernet standards (802.3ae) provides a seamless transition from 1 Gigabit to 10 Gigabits.	There are three main varieties of PON today. APON/BPON : ITU-T G.983, EPON : IEEE 802.3ah, GPON : ITU-T G.984
Networks Supported	IP	IP, ATM, TDM
No of Homes Served	ESON systems can serve up to 48 homes, on each fiber run, and isolate information streams and faults to each subscriber. As more homes are served additional bandwidth is added and up to 50,000 homes can be served from a single core switch centrally located.	Conserves fiber resources. It uses a technique called power splitting and can only serve 32 homes from one fiber run with BPON and EPON. 64 homes with GPON technology.
Bandwidth	Only the content destined for a particular CPE is delivered to that subscriber. Even if a rogue CPE device is installed in an active network, no content is delivered to it.	In a PON the entire downstream bandwidth is transmitted to the power splitter, and a portion of the optical power is delivered to each subscriber. Since bandwidth in a passive system is not dedicated to each subscriber, each user shares the total capacity of the system.
Content Distribution and backhaul bandwidth utilization	Video stream is launched from the core switch to the aggregation switch when a service is ordered. If multiple subscribers order the same service, it is electrically split at the aggregation switch and delivered to the second subscriber – and only to the second subscriber. Thus, backhaul bandwidth is more efficiently used and content is not delivered to unintended CPE devices.	All subscribers are exposed to all downstream content, however, the OLT communicates with valid ONT only by verifying the password. When a subscriber orders a video service of 5 Mbps, for example, a separate information stream is launched from the OLT to each subscriber. Therefore, 10 orders for the same content spawn 10 streams of 5 Mbps down to all subscribers.
Range	Ethernet to the Subscriber platforms can be located up to 120 km from each other without any geographic restrictions, or variations in the platforms. Active Ethernet use standard-based Small Form Factor Pluggable (SFP) optical transceivers.	Two main factors restrict the total reach of PON deployments. The first is the total available optical power budget, which is a factor of the OLT laser port and the total loss budget, including the fiber feeder and splitters. Secondly, because ONUs share the optical feeder and OLT port, a sophisticated algorithm is required within all the devices to prevent more than one ONU from transmitting at the same time, which would cause traffic collisions rendering applications like video unusable. APON and EPON are limited to a maximum of 20 km between the OLT and the ONU.
Scalability	ESONs can be initially provisioned to deliver 20 Mbps to each subscriber and later remotely upgraded to 100 Mbps.	PONs must physically restrict the number of subscribers on a power splitter to achieve higher throughputs. If the total network capacity is exhausted, then the electronics at each end (CO and CPE) must be upgraded to a newer technology.

Authors: Jani Saheb Shaik, janisaheb@sterlite.com

Sterlite Optical Technologies Ltd

National FTTH plans in France, Italy and Portugal

	France	Italy	Portugal
Regulated access to ducts	Yes (limited to incumbent operator)	Yes (limited to incumbent operator)	Yes (any duct apt to carry fibre)
Regulated access to dark fibre	No	Yes	No
Regulated access to in-building fibre	Yes	No	Yes
Subsidies for the deployment of fibre	2 billion Euros for "viable" and "less viable" areas	Subsidies planned at some point, but suspended	800 million Euros credit line and subsidy contests
Cooperation between competitors	Yes (for fibre deployment in buildings)	Yes (between Telecom Italia and Fastweb for civil engineering)	Yes (joint venture Sonaecom--Vodafone for building network)
Regulation of agreements	Yes	No	No

Authors: Marc BOURREAU Telecom ParisTech, Paris, France Carlo CAMBINI, Politecnico di Torino, Turin, Italy Steffen HOERNIG Universidade Nova de Lisboa, Lisbon, Portugal; CEPR

BIBLIOGRAPHY

ARCEP – Autorité de Régulation des Communications électroniques et des Postes. (2008) *Décision n° 2008-0835*. République Française. Retrieved July 1, 2010, from http://www.arcep.fr/uploads/tx_gsavis/08-0835.pdf

ARCEP – Autorité de Régulation des Communications électroniques et des Postes. (2009) *Décision n° 2009-1106*. République Française. Retrieved July 1, 2010, from http://www.arcep.fr/uploads/tx_gsavis/09-1106.pdf

Bouras, C., Gkamas, A., Papagiannopoulos, J., Theofilopoulos, G., & Tsiatsos, T. (2009). Broadband Municipal Optical Networks in Greece: A Suitable Business Model. *Journal of Telematics and Informatics*, 391-409.

Bouras, C., Gkamas, A., Theofilopoulos, G., & Tsiatsos, T. (2008). Business Models For Municipal Broadband Networks. *Encyclopedia of Information Science and Technology*, 457-465. .

Bourreau, M., Cambini, C. and Hoernig, S. (2010) National *FTTH plans in France Italy, and Portugal*. Robert Schuman Centre for Advanced Studies, Florence Scghool of Regulation European University Institute. Italy: European University Press.

Breitbandstrategie. Retrieved March 1, 2010 from http://www.bmwi.de/BMWi/Navigation/Technologie-und-Innovation/Telekommunikation-und-Post/breitbandstrategie,did=257532.html

Broadband Properties. Retrieved July 2, 2010 from http://www.broadbandproperties.com/2006issues/mar06issues/vienna_march.pdf

Citynet Amsterdam. Retrieved June 28, 2010, from http://www.citynet.nl/ Cook Network Consultants (2005). Building Regional Open Access Fiber Infrastructure in Catalonia (Northeastern Spain). *The COOK Report on Internet September-October 2005*. Retrieved March 1, 2010, from http://www.cookreport.com/catalonia.pdf

Czernich, N., Engl, F. Falck, O., Kiessl, T., and Kretschmer, T. (2009), Regulatory framework for next-generation access networks across Europe. CESIfo Dice Report 1/2009.

Bmp-TC *FTTH in Europe 2010, Facts, Trends and KSF (2010)*: Multi-client study tailored to the central issues of the FTTH market. Scandinavian model confronted to European wide trends.

DGCIS - Direction générale de la Compétitivité, de l'Industrie et des Services (2010). Consultation publique - Programme national « très haut débit ». République Française. Retrieved July 1, 2010, from http://www.telecom.gouv.fr/fonds_documentaire/consultations/10/consthd.pdf

Digital Britain – the report. Retrieved March 1, 2010, from http://www.culture.gov.uk/what_we_do/broadcasting/6216.aspx

Dobers, P. (1999). *Netting the information infrastructure of Stockholm*. Paper presented at the conference of Managing the Big City, Göteborg University, Sweden.

European Information Society 2010. Retrieved June 28, 2010 from http://ec.europa.eu/information_society/eeurope/i2010/index_en.htm

FTTH Council. (2009) Definition of Terms. (Revision Date: January 9th 2009) Available at http://www.ftthcouncil.eu/documents/studies/FTTH-Definitions-Revision_January_2009.pdf , Accessed

FTTH in Vienna to all households. Retrieved July 2, 2010 from http://voipandenum.blogspot.com/2006/01/ftth-in-vienna-to-all-households.html

Hughes, G. (2003) Local & regional models for broadband deployment. In *Proceedings of eEurope: Broadband Local & Regional Best Practises Workshop*. Retrieved May 28, 2008, from http://europa.eu.int/information_society/eeurope/2005/doc/all_about/broadband/bb_regional/g_hughes.ppt

LocalRet. Retrieved July 1, 2010, from http://www.apd.cat/media/888.pdf

OPTA (2008) *Policy rules: Tariff regulation for unbundled fibre access*. OPTA/AM/2008/202874. The Hague. Retrieved July 1, 2010 from http://www.opta.nl/en/download/publicatie/?id=2832

Preparing 'Digital France 2012'. Retrieved March 1, 2010 from http://www.epractice.eu/en/news/284991

Sadowski, B., Nucciarelli, A., & Rooij M. (2009). Providing incentives for private investment in municipal broadband networks: Evidence from the Netherlands. *Telecommunications Policy, Vol. 33, Iss. 10-11, November-December 2009*, 582-595. Elsevier B.V.

Stokab in english. Retrieved March 1, 2010, from http://www.stokab.se/templates/startpress.aspx?id=1115

Stokab in english - About Stokab. Retrieved March 1, 2010, from http://www.stokab.se/templates/StandardPage.aspx?id=306

Stokab in english - The infrastructure. Retrieved March 1, 2010, from http://www.stokab.se/templates/StandardPage.aspx?id=775

Strategy for electronic communications and new technologies 2008 – 2013. Retrieved March 1, 2010 from http://www.yme.gr/index.php?tid=21&aid=1532 (in Greek)

Troulos, C., Merekoulias, V., Maglaris, V. (2009). A business model for municipal FTTH/B networks: the case of rural Greece. *Info - The journal of policy, regulation and strategy for telecommunications, information and media, Vol. 12, Iss: 3*, 73 – 89. Emerald Group Publishing Limited.

Organisation for Economic Co-operation and Development: Directorate for science, technology and industry committee for information, computer and communications policy - Working Party on Communication Infrastructures and Services Policy- DEVELOPMENTS IN FIBRE TECHNOLOGIES AND INVESTMENT Retrieved 1 March 2008

Internet pages:

Cf. footnotes

9 rue Charles Fourier
91011 Évry Cedex
France
+33 (0)1 60 76 42 18
www.telecom-em.eu