Deployment strategies for FTTH networks and their impact on the business case: a comparison of case studies

Albert Domingo[*†], Marlies Van der Wee[*‡], Sofie Verbrugge[‡], Miquel Oliver[†]

[*]Corresponding author. [†]Universitat Pompeu Fabra, Spain. [‡]Ghent University – iMinds, Belgium.

albert.domingo@upf.edu , marlies.vanderwee@intec.ugent.be
sofie.verbrugge@intec.ugent.be , miquel.oliver@upf.edu

Abstract

Although it is clear that the evolution of fixed access networks requires the installation of Fiber-to-the-Home (FTTH) to all households, the business case for deploying such networks is very uncertain. It requires significant upfront investment, while not being assured of sufficient timely revenues to cover for it. Although many studies focus on modeling the costs and forecasting the revenues, limited research deals with how both sides can impact the overall business case.

This paper compares different deployment strategies used in current FTTH network rollouts, and examines their impact on the overall business case. Deployment strategies are defined as ways to plan the installation of the network and uptake over time, influenced by a variety of situation-dependent characteristics. By studying the different parameters that allow characterizing and grouping ongoing FTTH projects worldwide, we can analyze what drove the choice for the deployment strategy, and how the latter impacts both cost and revenue side of the business case. The paper concludes that deployments driven by demand are less risky and therefore more sustainable. On the other hand, publicly funded or initiated projects obey to different goals than demand and can be unsustainable if they are not able to engage the planned penetration rates.

Keywords: *Fiber-to-the-Home, techno-economics, business case, deployment strategy*

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1 Introduction and motivation

Although it is clear that the evolution of fixed access networks requires the installation of Fiber-to-the-Home (FTTH) to all households, the business case for deploying such networks shows in most cases a set of uncertainties. It requires significant upfront investment, while not being assured of sufficient timely revenues to cover for it. Many recent publications study the deployment cost of an FTTH network ([1]-[5]), or study the adoption forecasts and revenue potential ([6]-[10]). As such, the focus lies on providing a good estimation of the different cost segments [1] and comparison of different topologies (e.g. Point-to-Point versus Point-to-Multipoint) and technologies (e.g. Time versus Wavelength Division Multiplexing over Passive Optical Networks) [2]-[3]. Other studies propose measures to reduce the costs. Sharing the physical infrastructure among different service operators in an open access or unbundled network, for example, avoids duplication of the most costly part of the investment [4], while deploying in synergy with other utility network owners can reduce rollout costs between 5 to 21% (depending on the deployment type) [5]. On the revenue side, many studies aim at estimating the end users' willingness to pay and demand or adoption curves for FTTH [6]-[8]. Other studies focus on identifying the drivers and barriers to FTTH uptake, both in terms of services and policy stimuli [9]-[10]. When drawing conclusions about the business case for FTTH deployment and operations, these cost and revenue sides should however be combined to see the impact of potential improvements on both sides. To the best of the authors' knowledge, only limited research combines both costs and revenue improvements [11].

When investigating the business case for FTTH deployment, it is frequently labeled as economically hard, due to the combination of high upfront investment in infrastructure deployment with the uncertainty of timely uptake guaranteeing sufficient Return On Investment. However, as many successful deployments exist worldwide, their employed strategies can be investigated and generalized to draw conclusions about best practices for investment in FTTH networks. This paper targets a selection of successful deployment cases in both a qualitative and quantitative way, thereby focusing on the applied deployment strategy. In this paper, a deployment strategy is defined as an implemented measure that impacts the cost and/or revenue side of the investment in FTTH networks. Examples on the cost side are a reduction in upfront capital expenditure by improving the deployment method (e.g. direct buried or micro-trenching) or reducing the digging costs (by for instance re-using existing ducts). On the revenue side, the business case can be improved by using demand aggregation (making subscribers sign up to a broadband offer before

deployment starts) or by assuring sufficient timely revenues by first deploying to guaranteed customers, such as schools, hospitals or larger businesses.

The next section will first give some context about the selected cases: the Ultra-Fast Broadband (UFB) initiative in New Zealand, Reggefiber in the Netherlands, Google Fiber in the USA, Guifi.net in the area of Barcelona, Spain, the deployment by the incumbent NTT in Japan and the dark fiber network operated by Stokab in Stockholm, Sweden. These cases will then be analyzed quantitatively in section 3, after which section 4 will conclude the paper by giving some recommendations for future FTTH initiatives.

2 Different deployment strategies worldwide

FTTH has been currently deployed in various regions by different companies and public institutions [12]. This section will describe the context and approach taken by a selection of operational FTTH networks, which were chosen based on the difference in both background and deployment characteristics (location, population density, the initiator (mainly differing between public and private) and of course the deployment strategy (or the lack thereof)).

2.1 A government-initiated Public Private Partnership in New Zealand

Following an election promise, the government in New Zealand started up a tender procedure for participation in a FTTH deployment to 75% of households in New Zealand. Four Local Fiber Companies (LFCs) were chosen as private partners in this deployment, commonly referred to as the Ultra Fast Broadband (UFB) initiative [13]. Each of the four LFCs was granted their own geographical coverage area, in which they operate on a wholesale-only basis, offering bitstream access to Retail Service Providers (RSPs), who in turn offer services to end-customers. These four LFCs are Chorus, the former DSL incumbent, granted about 70% of the total coverage area, Enable (15%), UltraFast (13%) and Northpower, rolling out in a specific area in Northern New Zealand, thereby passing 1.5% of targeted houses.

Deployment started in 2011 and has now already passed 39% of targeted households (517,000 households, June 2014, [14]). As the LFCs are only allowed to offer wholesale services, they have to rely on RSPs to contract end customers. The two largest RSPs, Telecom and Vodafone, owning more than 75% of the retail market, are reluctant to change to invest in marketing for fiber services before a minimum market in terms of coverage is reached. Therefore, uptake still remains low (7.5% of homes passed as of June 2014, [14]).The smaller LFCs (Enable, UltraFast and Northpower) can tackle this problem by using the advantage of local branding and local RSPs. They are subsidiaries of

local utility companies, thereby having the advantage of customers' loyalty, while the local RSPs have a personal approach in convincing end-customers. Chorus, not only deploying fiber but also owning the legacy DSL network, has a harder business case, as it cannot incentives the RSPs to set up offers on the FTTH network [15].

In summary, the deployment in New Zealand is performing very well in terms of uptake, but misses the link between the revenue-generating end-customers and the fiber-deploying partners.

2.2 Demand aggregation by a private firm in the Netherlands

Although the first FTTH initiatives in the Netherlands were taken up by municipalities, deployment of fiber-based access networks in the country is now mainly driven by Reggefiber, a subsidiary of the private investment company Reggeborgh, founded in 2005 [16]. In the first stage, Reggefiber was involved as an investor in certain municipality networks (e.g. Glasvezelnet Amsterdam, OnsNet Nuenen, etc.). By acquiring the backbone provider Eurofiber, Reggefiber links the various isolated municipal initiatives. Now, Reggefiber is 40% owned by KPN, the DSL incumbent in the Netherlands. This joint venture was granted by ACM (Autoriteit Consument en Markt, former OPTA - the national regulatory authority [17]), on the condition that Reggefiber only operates on the passive infrastructure level, leaving the installation of active equipment and offering of services to other, competing providers on a non-discriminatory basis.

Reggefiber uses a demand aggregating strategy to ensure itself from enough revenues from the start of each deployment. The company determines the next deployment area based on a pre-subscription level: once a certain level (30%-40%, depending on the area) is achieved, the company is assured of sufficient revenues to make a viable business case in that area, and start deployment. Their online platform allows households to check how close their area is to reaching this subscription level, thereby stimulating convinced families to persuade their neighbors. Following the latest update, 1.82 million households in the Netherlands are covered, while 586,000 are connected to a service provider on FTTH, thus showing the positive effect of the demand aggregation strategy on the uptake [18].

On the cost side, Reggefiber also uses several measures to ensure a positive business case. First of all, they apply a cheaper way of deploying the fiber in the streets, using an "innovative brush technique with rotating plastic brushes". This method is much faster than traditional deployment techniques (up to eight times) and almost does not affect the soil density [19]. Furthermore, they have set a maximum of €1000 per home passed for private investment (Reggefiber

only). In areas where the costs exceed this €1000, they communicate to need a different source of aid, frequently getting support of the local residents or the municipality [20].

Reggefiber thus is an example of a successful private deployment, their business case secured by assured revenues upfront (demand aggregation) and a limit on the cost per home passed. Having the incumbent KPN as a shareholder furthermore limits infrastructure-based competition.

2.3 Demand aggregation by a private firm with municipal involvement in the USA

Google, a well-known search engine company that gets its revenues from advertisement and pay-per-click, started a new department in early 2010: Google Fiber[1]. The main purpose of this department was to find an area to deploy a fiber access network under the best conditions possible: maximizing the value of every dollar spent on the new network and to provide an outstanding broadband symmetric offer (a symmetric 1Gbps connection). Municipalities from all around USA answered to a public contest launched by Google and provided as much data as possible about their already existing facilities and some proof of engagement of their population to the project. After the first contest in 2010, Google received data from over 1,100 communities and local governments, endorsed by more than 194,000 individuals [22], all of them applying to get fiber deployed in their towns and cities.

From these applications, Google selected Kansas City. There, Google divided the city into fiber-hoods (smaller than neighborhoods) that allowed them to set some goals of pre-engagement before starting any deployment. If a fiber-hood does not reach the minimum engagement needed, Google does not deploy fiber there (similar to the demand aggregation model used by Reggefiber). Having those levels of pre-subscribed users allows a better planning to deploy the new fiber network (passing and connecting houses at once) while it reduces the risk of investment. Google's model seems to be reaching more than the minimum pre-subscription goal per fiber-hood. According to Sanford C. Bernstein it could reach 50 to 60% of possible subscribers in two years after deployment [23], [24], [25].

The model, although not being a true Public Private Partnership, has a strong commitment from the public administration. The latter provides access to any existing telecom infrastructure, if available (poles, dark fiber, conduits), and eases as much as possible the provision of rights of way needed to deploy the

[1] 1Gbps experiment was announced before having the idea of becoming the operator Google Fiber. Retrieved <http://googleblog.blogspot.com.es/2010/02/think-big-with-gig-our-experimental.html>.

network. On the other hand, the city council gets involved in the demand aggregation process by stimulating residents to subscribe, thereby reaching the minimum pre-subscription level, and in return gets a fiber connection to schools, churches, hospitals or other public buildings in the fiber-hood from Google for free. The Google Fiber model seems to be working as after Kansas, Google now is expanding into other cities along the US like Austin and Provo (in the states of Texas and Utah respectively) and has also another active contest to expand the network to some other 14 locations.

The keys to obtain such a quick revenue project are not only obtained from applying a pre-engagement of end users'. The cost-effective deployment is obtained by having the pre-engagement of public administration to support this private firm network. The combination of both commitments – user and public administration – leads to seek new deployment areas by a public contest methodology that inquires for specific details about already existing infrastructure and actions that will give support to participate and contract the new network services of Google Fiber.

2.4 A community-built FFTH (Fiber-From-the-Home) model in Spain

When a group of neighbors in a small rural community in Catalonia, Spain, decided in 2009 to deploy a fiber network by themselves, they realized that they did not know about the deployment methods and associated costs. They met with the Guifi.net Foundation, which was active in deploying community wireless networks, currently with more than 25.000 wireless active nodes [26], for some help into the fiber deployment. This neutral operator calculated the costs and also gave them the recommendation that they should reach more than 60% of take-up before deploying if each household wanted to pay 1000€ or less for the network installation and connection.

This case thus follows a bottom-up scheme: the network is fully paid by the final user, hence is referred to according to the new term "Bottom-up Broadband network" [27]. The fiber network itself belongs to the Guifi.net community, where the user becomes one of the associates after paying for his own deployment. Volunteers carry out the installation, thereby significantly decreasing the overall project installation costs. The pre-subscribers pay all the equipment and material to get connected [28]. The deployment has been named Fiber From the Home/Farm, giving special attention in the direction of its construction From the Home/Farm as the deployment starts from there.

While Guifi.net runs the maintenance of the network and active equipment connected to the network, it does not interact with the final client. Contracts with the end customer in Gurb village are signed through a separate service

provider; Gurbtec was the first to offer broadband services of 1Gbps symmetrically over the open and neutral network of Guifi.net.

Currently Guifi.net is exporting this model to other communities, such as Calldetenes or Mataró, which are also aiming to entry the Gigabit connection era and want to mirror their future deployment to the one done in Gurb. They have already illuminated more than 120 buildings reaching around 80% of take-up rate in the deployed areas, with plans of reaching 240 buildings (120 new ones) during 2014[2]. Currently, there are two service providers competing over this free network, Gurbtec and Gaufix, offering a range of services (telephony, television, Video on Demand, etc.) with price differentiation. Gurbtec offers the service for 24€ per month to each connected household, VAT included. From this monthly payment Gurbtec pays 8€ to Guifi.net as it runs over its open and neutral network. The ARPU to the Service provider (Gurbtec) is kept around 8 to 10€. This separation in different layers helps to analyze why Guifi.net, as infrastructure operator, can obtain a quick profit that is kept to repair, maintain and upgrade the network if needed.

The two main positive effects of the applied bottom-up broadband deployment strategy are the pre-engagement of the final user (thereby having certainty of the uptake rate to expect) and a lower deployment cost by the help of volunteers. Finally, the competing service providers are also key as they are necessary to get services over the network.

2.5 A fiber solution to skip the unbundling in Japan

The Nippon Telegraph and Telephone Corporation (NTT) is the incumbent of Japan. From 1985, it was gradually privatized as a way to promote competition in the telecom market and include the possibility to mandate unbundling obligations. It is important to remember that the Japanese state still holds a third of the shares, and thus still has a significant influence on the company's strategy. Organized as a holding in 1999, it keeps three branches in the fixed telecom market: NTT Communications, NTT East and NTT West.

With the unbundling of copper lines in place, competitors emerged (e.g. Softbank BB[3]), rapidly reaching a similar market share as NTT. Driven by this threat, and encouraged by "favorable Government tax and interest treatments" [29], NTT announced, in 2004, that it would start to deploy fiber by replacing the copper lines to their customers' homes [32]. That way, every upgrade to a fiber line is removed from the legacy network. Soon, however, unbundling of the fiber lines became mandated as well, although not much alternative

[2] Guifi.net provides maps and plans in Catalan, available at < http://guifi.net/ca/gurb_FFTF >.

[3] Owner of Sprint in the US broadband market since 2012, and Vodafone in Japan since 2006.

operators have succeeded to gain significant market share on the fiber network (e.g. Softbank reached 237.000 subscribers over the NTT's unbundled fiber in 2010). All of this has made Japan to be one of the leading countries in all the fiber rankings, and to become one of the countries with nearly 30% of the entire world fiber deployed. Currently Japan has more than 25 million homes connected with fiber solutions, on a total coverage of more than 36 million homes.

NTT thus still is the dominant operator on the fiber network, reaching a combined (East and West) fiber market share of over 70% of take-up in December 2009 [33]. When investigating the reasons for this low competitive entry in the fiber market compared to the DSL market, there are two that should be stressed. First, NTT offered a 100Mbps connection on fiber for the same price as the comparable, yet lower-speed xDSL offers, disrupting the market with a differenced offer in peak speed. Secondly, the unbundling price for fiber was set at nearly five times the price for the copper unbundling as a way to increase facility-based competition[4].

In general, the business case for FTTH deployment in Japan currently has a positive outlook, as uptake is very high (all DSL customers migrate to fiber) and so thus is ROI. The threat of lowering the fiber unbundling price is however imminent, and might drastically impact the business case outcome for NTT.

2.6 A public company leasing dark fiber in Stockholm, Sweden

In 1994, the city of Stockholm in Sweden decided to found a public company, Stokab, for deploying a passive fiber infrastructure to all households and businesses in the region. The goal of this FTTH rollout was to enhance the economic attractiveness of the region, especially the knowledge-intensive business area of Kista for high-tech companies. Important to mention is that Stokab only deploys and maintains the passive, dark fiber infrastructure, the lighting up of the fiber and the offering of services is left to other operators, who then lease the fiber links from Stokab (Stokab thus uses a business model similar to that of Reggefiber). As a trial phase, the first connections targeted public and educational institutions, after which private businesses were connected on a point-to-point dark fiber, thereby ensuring a revenue stream and hence a viable business case. In a later stage, Stokab started to deploy fiber to all households, thereby relying on contracts with housing organizations who wanted to increase the value of their property. These contracts allowed Stokab

[4] Monthly unbundling price for copper was set as an average at YJP 1,367 (USD 13,1) on September 2000, and monthly Fiber unbundling was set at a minimum of YJP 5,186 (USD 49,8) on April 2001, [30]; the current price has decreased to 40 USD based in costs from 2001 to 2007, [31].

to deploy fiber to the basements of the multi-dwelling units, in which a dedicated space is provided to install racks (for Stokab) and other dedicated active equipment (for the so-called communication operators providing end-to-end connectivity).

The first phase of the network deployment was funded using publicly-backed loans, but soon, the customers' revenues provided the necessary funds to expand the network. Reaching break-even in 2001, Stokab now is a profitable company, although the main part of the profits is spent in maintaining, upgrading and expanding the existing network. Now, Stokab's network covers 100% of businesses and over 90% of households, and has about 90 active operators, as well as over 500 direct business customers, the latter providing about 50% of Stokab's revenues.

Important in the case of Stockholm is the way revenues are handled in the business model. Stokab does not contract with end customers, they only interact with communication operators or large businesses that each install their own active equipment. As such, Stokab does not charge these operators and businesses on a per-premise basis, but calculates its fees based on the distance covered – the amount of (kilo)meters of dark fiber leased.

As will become clear in the next section, our developed model is not applicable to the business model of Stokab. Therefore, this case study will not be included in the quantitative analysis. Instead, real figures from Stokab will be included to allow comparison.

2.7 Summarizing the case studies

Once each case has been described individually, this point compares their main characteristics in Table 1. This table shows that all of them – except Reggefiber – have some type of support from the public administration (e.g. helping them easing bureaucracy, leasing some existing public infrastructure, reaching the citizens in a broader way). Public involvement (direct involvement considered in terms of some sort of funding) is not so common, and it is included in the cases that have wider area goals than only connecting the profitable ones. Private involvement, on the other hand, is observed in all cases except for Stokab, and helps to understand the need for a technically skilled operator that will manage the network. The user pre-subscription model is followed by some projects and the ones that are doing it also aim to involve the user as a stakeholder of the fiber network (way beyond of being a final subscriber). Wholesale service is also one of the characteristics that these projects have in common. Only Google deploy its own private network without a wholesale service, because NTT was mandated to unbundle the fiber as it has been explained in point 2.5.

Table 1: Overview of the characteristics per case

	Google, USA	Reggefiber, the Netherlands	UFB, New Zealand	Guifi, Barcelona	NTT, Japan	Stokab, Stockholm
Public involvement	✗	✗	✓	✗	✓	✓
Public support	✓	✗	✓	✓	✓	✓
Private involvement	✓	✓	✓	✓	✓	✗
End user as a stakeholder	✗	✓	✗	✓	✗	✗
Pre-subscription	✓	✓	✗	✓	✗	✗
Wholesale only	✗	✓	✓	✓	(*)	✓

(*) NTT Japan was mandated to unbundle its fiber and provide wholesale offer service.

3 Evaluating the business case

After having described the different cases, this section will focus on comparing them using a cost-benefit model. First, the model and the used input parameters will be shortly described, after which the results will be shown and analyzed.

3.1 Cost-benefit model for comparing the success of FTTH deployments

In order to compare the economic success of the FTTH cases in this paper, a cost-benefit model was developed. This model calculates costs and revenues over time, taking into account the take-up rate and deployment strategy used. The costs are calculated as the sum of a fixed cost per home passed (the cost to deploy the fiber in the street, which is fully taken upfront) and a cost per home connected (which is included in the equation at the moment of subscription). These costs vary on a case-to-case basis, as they take into account the local economic environment (e.g. manual labor is cheaper in Asia than Europe) as well as possible savings from deployment strategies (such as reusing of existing ducts). On the revenue side, the model uses three main parameters: the monthly ARPU (average revenue per user), an estimated adoption curve and a level of demand aggregation. The monthly ARPU is based on the fees charged by the respective operators in their commercial offers, while the demand aggregation is applied only for those cases that use it (Google, Reggefiber, Guifi). The adoption curves shown in Figure 1 are based on forecasts for representative countries [35]. These adoption curves were matched to the respective cases based on historic and current available uptake rates, with the goal of respecting reality as closely as possible.

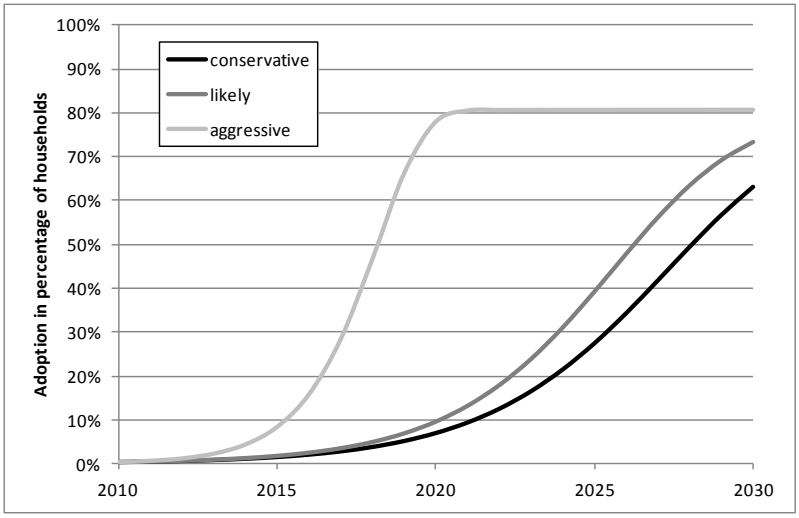

Figure 1: The adoption curves used in the cost-benefit model

An overview of the input parameters used for the different cases can be found in Table 2 (all values in US dollars, reference included between brackets). Please note that, as mentioned before, Stokab is not included in this table because of its different business model concerning revenues charged.

Table 2: overview of input parameters per selected case. Prices are included in USD.

	Google, USA	Reggefiber, the Netherlands	UFB, New Zealand	Guifi, Gurb Barcelona	NTT, Japan
Cost per home passed	616 [37]	1300 [41]	2348 [42]	700 [39]	344 [30], [32]
Cost per home connected	250 [37]	N.A.	1104 [42]	250 [39]	38 [30]
Monthly fee received from subscribers	36 [37]	19.5 [41]	30 [13]	10 [39]	9.1 [34], [40]
Demand aggregation percentage	28% [23],[24],[37]	30% [41]	0%	60% [27],[28]	35% [34] (FTTB/FTTH)
Total homes passed	150,000 [37]	1.8 mln [18]	517,000 [15]	300 [27],[28]	36 mln [34]
Adoption curve	Aggressive [23],[24],[37]	Aggressive [18], [41]	Likely [13], [15]	Aggressive [27],[28]	Conservative [31], [32]

3.2 Observations based on comparison of input parameters

Before applying the cost-benefit model to the different cases, a first analysis of the input data allows for drawing some interesting conclusions.

Difference in cost per home passed

The first striking fact is the large range in cost per home passed: from a couple of hundred dollars in Japan to over 2000 dollars in New Zealand. The

deployment by NTT clearly has the lowest cost, which can be explained by three factors. The main explanation is the high density of inhabitants per area to be covered, but also the possibility to connect condominiums with one sharing point, instead of connecting each of the households with a single fiber. This offer is called a shared fiber (and is, according to the authors, best categorized as Fiber-to-the-Building instead of Fiber-to-the-Home). Although it will get to each household less speed than a dedicated fiber connection, the offer's price can also be kept lower. The third and last reason for this lower cost is the use of aerial deployment (along poles or facades), which significantly reduces deployment cost [36]. Google's fiber deployment cost is higher, but still very low compared to other cases. They obtained really good deals on already installed infrastructure that is owned or managed by the Public Administration (e.g. poles, conduits, etc.). Moreover, the rights of way are directly obtained from the city council, something that really eases the deployment and bureaucracy at the planning stage of a fiber deployment. In Guifi.net, there exists a symbiosis between the company and the final users. Users want to deploy the fiber connection to their homes, which is mainly installed by themselves. Guifi.net helps to obtain the material and machinery, and also interconnects this network to the local interconnection point. It is this collaboration model that allows for an inexpensive budget for deployment.

On the other hand of the deployment cost range, we find the UFB initiative in New Zealand. Costs there are relative high because of lower population density (mostly urban, or even rural, all single homes), high trenching cost (volcanic soil), and the Right-of-way issues that follow from shared driveways (multiple owners have to give permissions to trench).

Cost per home connected

A second parameter that shows a large range in the table is the cost per home connected. It is rather high for the UFB in New Zealand most probably because connecting a home there requires interaction with multiple parties (RSP, LFC). For Reggefiber, the cost per home connected is set to zero, as Reggefiber is not involved in installing the active equipment (in reality, there will be a cost for connecting the homes, but as it is not the responsibility of Reggefiber, it is not included in the business case analysis here). For NTT, finally, we observe a rather low cost per home connected, which can be attributed to the large number of MDUs.

Monthly fee charged to subscribers

Thirdly, there is a significant difference in the average revenue received per user. For Reggefiber, Guifi.net and the UFB, these fees only cover for wholesale (meaning that the operators under study here do not interact with the end users to offer services). On the other hand, the fees are also significantly lower

for NTT, which can be explained by the unbundling obligation and how they charge per fiber and not per number of subscribers, something that allows to obtain a bigger number of subscribers over one rented fiber to each building. They also want to force everyone to change to the new fiber deployment (migration by removing the copper cabling), which also includes a cheaper retail offer when a shared fiber model (FTTB) is the solution that a user is provided with.

3.3 Evaluation and analysis of the economic viability of the business cases

In this last section of the quantitative evaluation, the parameters listed above are used to evaluate the economic outcome of the different cases. A forecast of the Net Present Value (NPV) can be found in Figure 2. When comparing these NPV results with published data about the economic health of the different companies, we can conclude that the results found here are realistic. The deployment by Google reaches break-even after 5-6 years, the profit is still limited due to the limited number of homes passed so far. The projection of Japan, outstanding all the other cases may have a different result if the unbundling price for fiber will be decreased. The Guifi case with a flat line confirms that the aim of this operator is only charging its users to sustain the network and not making profit from it. Reggefiber turns positive after some years, as it has accomplished its deployment phase and has the users/stakeholders still connected to it. The outlook for New Zealand looks rather bad, but may have a different projection if they later reach a better penetration or create a plan to incentivize fiber usage and adoption.

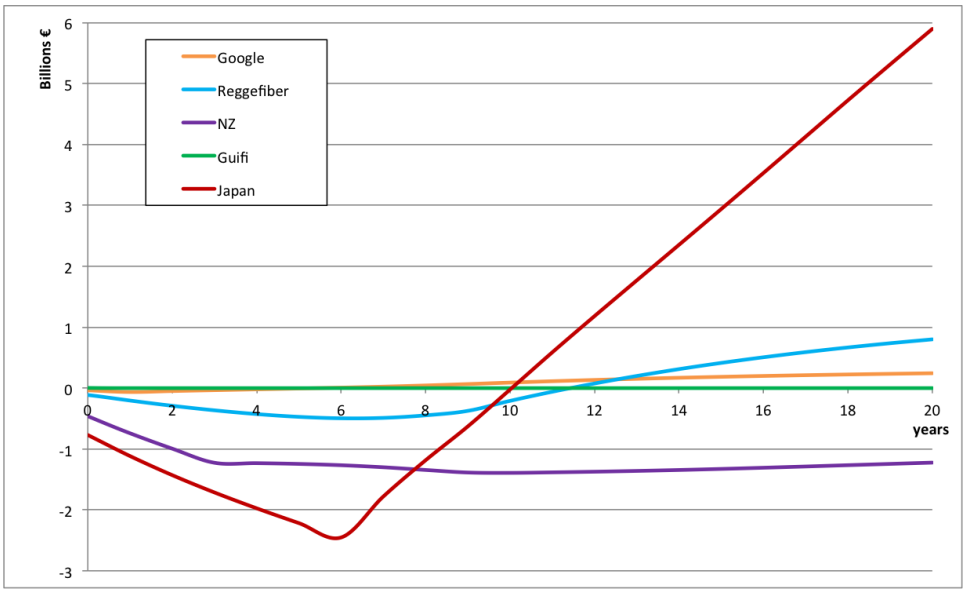

Figure 2: Overview of NPV curves based on the specified adoption forecasts for the different cases

When investigating the business cases for the different cases under study, we can distinguish three categories: NTT in Japan, who is outperforming all others, three “median” cases: Reggefiber, Guifi and Google, and thirdly, the UFB in New Zealand, for which the business case outlook is rather negative.

As mentioned before, the most probable reason for the positive outlook for Japan is the assurance of subscribers, as they move all DSL customers to fiber when rolling out the new network. Although reaching the best take-up rate of the carriers analyzed that deploy an FTTH solution and getting the more profitable network projection, it is also the one that assumes the highest risk of all of the analyzed carriers in its first three years. It has been already explained in this article that the Government’s ownership (36.50% of NTT) may have some effect in the outcome, and especially on the way of assuming risk and not failing at explaining why the first years of the network have so negative results. Our appreciation of state subsidizing networks and taking risk can also be seen in the New Zealand case. In this case, the projection of the risk does not show a better future projection, although it may change if prices start to decrease to likely ADSL retail offers, a smart move that Japan did in its way to increase the shift to the new fiber network.

In the median cases, we all see the influence of demand aggregation, be it on city-level in the Netherlands, or on smaller neighborhoods in the US. For the case of Google Fiber, dividing a city into smaller neighborhoods that rally to compete and obtain fiber first is a new way to incentivize the fiber desire (increase of demand) and its deployment. Their success can be explained by the combination of this rally with the power of Google’s well-known brand and their high competitive retail offer of 1Gbps that they put in the US broadband market at prices comparable to the regular broadband offer of 50 and 100Mbps from other big firms [37]. The point here is that this case is the only private case in a facility competition-based regulation that starts to be profitable before the first three years after its implementation. Only the Guifi.net project is in the same category, as the project also starts to be deployed after reaching a 60% of presubscription. The case of Reggefiber has a slightly lower business case outlook, but does also reach break-even within the time span of 11-12 years. In conclusion, all three median cases, Reggefiber, Guifi and Google, do not deploy an entire network to the entire community: they only deploy the network where demand is.

The third category is the UFB deployment in New Zealand, which is very ambitious, but only supply-driven. Coverage targets are more than reached, but not met by uptake. Although the project is still in its rather early stages, this observed uptake rate might increase over time. However, at the moment, there is a mismatch between the promoting the UFB offer by the RSPs and the

deployment by the LFCs. The former have no real incentive to start offering services over fiber, as this is more costly (both in terms of software and marketing), while they cannot reach the entire population.

Furthermore, we should also take a look at the scale of deployments. The more risky ones are implemented with a State goal (Japan and New Zealand). The Japan one though seems to have a better projection, but competition will be gradually introduced by lowering the fiber unbundling price as shown by comparing prices from 2001 and 2008 ([30] and [31]). The smaller initiatives are private and all demand-driven: these operators avoid areas where there is not a high demand. In the case of Guifi, as the final user is the one who pays the deployment, it may reach some detached areas, as long as the user covers the deployment with his initial investment. In the case of Reggefiber, more expensive areas are only targeted if supported by government aid.

Finally, although not included in the quantitative analysis above (because they do not charge per household), the case of Stokab in Stockholm should also be tackled in this discussion. Publicly available data about their financial situation is available (Figure 3), which clearly shows that the company is performing well. Their main reasons for success are the involvement of the city in the deployment stage (rights-of-way and reuse of existing ducts), as well as their two-sided business model: they target large business users directly, and connect residential homes through leasing out dark fiber to communication operators by signing a contract with the housing organization.

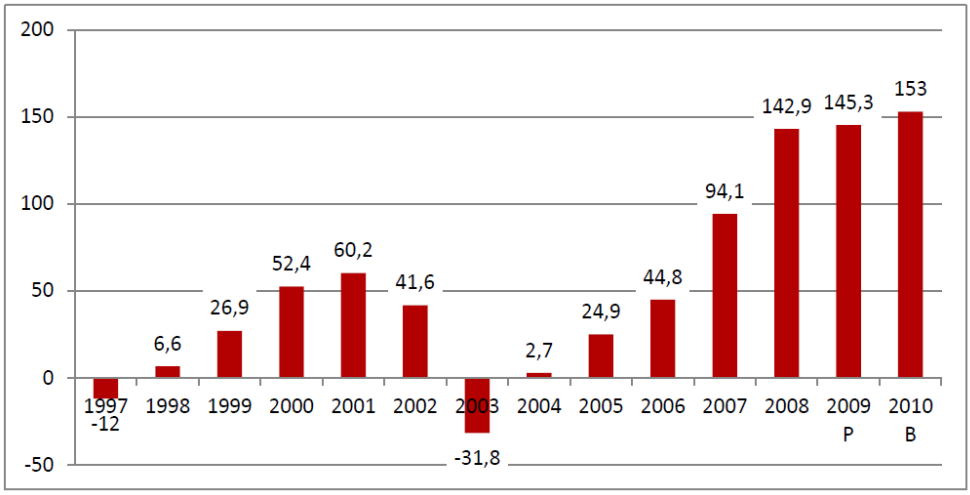

Figure 3: Yearly profits for Stokab (in million SEK) [38]

4 Summary and recommendations

The demand for more and higher-quality services requires a constant upgrade of telecommunication networks. The next step in upgrading the access network is the installation of optical fiber all the way to the end customer, thereby reaching Fiber-to-the-Home – FTTH. This upgrade is however frequently postponed by current operators, as it requires a significant investment and long payback periods. By studying several operational FTTH networks worldwide, this paper provided insights in the different strategies and roadmaps for successfully deploying a FTTH network.

Six cases were tackled: 4 private initiatives (Google, Reggefiber, Guifi and NTT) and two public ones (Stokab and the UFB). Google Fiber, the example of a big firm in search and advertisement, becomes a new entrant access network's carrier with a 1Gbps retail offer, while carefully analyzing how to obtain a profitable network in the first years after deployment. Reggefiber, borne from a private investment company, enters a new market and uses demand aggregation to assure their business case of FTTH deployment. Guifi.net is a private operator that helps end users to deploy and sustain their own fiber networks by following a bottom-up model; starting the deployment from the users' home to the internet. NTT as a big firm, state participated, had a country goal of upgrading the network to optical fiber and is now reaching its deployment end with some profits after a huge investment to do so. Stokab is a public company that leases out dark fiber connectivity, thereby gaining about 50% of their revenues from connecting private businesses, thus keeping the price for households affordable. Finally, the UFB initiative in New Zealand is based on four tender winners deploying fiber for wholesale offerings.

In this concluding section, we want to include some recommendations about dos and don'ts for an FTTH deployment. We would like to stress that these recommendations are based on the conclusions reached from the selection of case studies. We do believe that this selection covers a range of different types of deployments, with different socio-economic and political background, which makes the recommendations below generic as well.

Demand-side measures

- Assure the economic viability of the business case by securing sufficient return on investment upfront. This can be done by demand aggregation (mainly for private initiatives), direct subscriber investment (for bottom-up projects) or by having access to public funds (publicly-led deployments).
- Ensure sufficient revenues by incentivizing households to switch to the fiber offer: make sure the offer is competitive in both speed and price.

- Target both residential and business customers, while differentiating your offers significantly.
- If not allowed to directly interact with subscribers, ensure incentives for service providers to start fiber offerings.

Supply-side measures

- Try to reduce costs by getting access to installed public infrastructure (reuse of existing ducts, poles, collocation space) and by negotiating ease right-of-way.
- Try to minimize costs by opting for aerial deployment if possible and legally allowed.
- If upfront investment for FTTH is too high or too risky, then first target FTTB installation, but prepare the FTTB with enough fibers to later evolve to FTTH.

From all the analyzed cases, a general perception is that the ones that reached enough demand before starting are the ones that become profitable before 8 years after deploying the first tram of the network.

We expect that these general cases may help to deploy any new fiber network, either from a big firm to a group of users that joint in a common network deployment.

References

[1] K. Casier, S. Verbrugge, R. Meersman, D. Colle, M. Pickavet, P. Demeester (2008). A clear and balanced view on FTTH deployment costs. *The journal of the Institute of Telecommunications Professionals*, vol. 2(3), pp.27-30.

[2] S. Jay, K.-H. Neumann, et al. (2011). Comparing FTTH Access Networks based on P2P and PMP Fibre Topologies. In *Conference of Telecommunication, Media and Internet Techno-Economics (CTTE)*.

[3] T. Monath, N. Kristian, et al. (2003). Economics of fixed broadband access network strategies. *Communications Magazine, IEEE* vol 41 (9), pp. 132-139.

[4] Domingo, A., and Oliver, M. (2011, September). Modeling the Effect of Duct Sharing in a NGAN Competition Market. TPRC. In proceedings of *Telecommunications Policy Research Conference*. Available at SSRN: http://ssrn.com/abstract=1985783

[5] Tahon, M., Casier, K., Verbrugge, S., Colle, D., Pickavet, M., Demeester, P., Improving the FTTH business case - a joint telco-utility network rollout model. *Telecommunications Policy*, Available online 23 April 2013, ISSN 0308-5961.

[6] Stragier, J., Evenepoel, S., Seys, C., Evens, T., Van Ooteghem, J., Casier,K., *A priori forecasting of FTTH uptake - connecting segmentation forecasting to timing forecasting*, 11th Conference of Telecommunication, Media and Internet Techno-Economics, CTTE 2012.

[7] Samanta, S. K., Guild, K., Pan, H., and Martin, R. (2011). Adoption of FTTx Broadband: A Cross-Country Analysis. *Available at SSRN 1843397*.

[8] Felten, B. (2012) NGA Services Study. Presentation at the FTTH Council Europe, Munich, Germany.

[9] Falch, M. (2007). Penetration of broadband services–the role of policies.*Telematics and Informatics*, *24*(4), 246-258.

[10] Mirza, F., and Beltran, F. (2014). Consumer Resistance Factors for the Adoption of FTTH Ultra-Fast Broadband in New Zealand. *Journal of Information Policy*, *4*.

[11] Van der Wee, M., Verbrugge, S., Tahon, M., Colle, D. and Pickavet, M. (2014) Evaluation of the Techno-Economic Viability of Point-to-Point Dark Fiber Access Infrastructure in Europe*. Journal of Optical Communication Networks, 6,* 238-249.

[12] Van der Wee, M., Mattsson, C., Raju, A., Braet, O., Nucciarelli, A., Sadowski, B., Verbrugge, S. and Pickavet, M. (2011) Making a success of FTTH. Learning for case studies in Europe. *Journal of the Institute of Telecommunications Professionals (ITP), 5*(4).

[13] Beltrán, F. (2012). Using the economics of platforms to understand the broadband-based market formation in the New Zealand Ultra-Fast Broadband Network. *Telecommunications Policy*, *36*(9), 724-735.

[14] Beehive (2014, June 14th). Broadband deployment update. Available at http://www.beehive.govt.nz/sites/all/files/Quarterly-Broadband-Deployment-update.pdf

[15] Howell, B. E. (2014). Separation Anxieties: Structural Separation and Technological Diffusion in Nascent Fibre Networks. *Available at SSRN 2418599*.

[16] Reggefiber (2014). Eindelijk glasvezel. Available at http://www.eindelijkglasvezel.nl/corporate/

[17] ACM - Autoriteit Consument en Market (2014). Available at https://www.acm.nl/nl/

[18] Telecompaper (2014). Reggefiber-netwerk bestaat eind Q2 uit 1,82 miljoen lijnen. Available at http://www.telecompaper.com/nieuws/reggefiber-netwerk-bestaat-eind-q2-uit-182-miljoen-lijnen--1029744

[19] Reggefiber (2014). An example of innovation. Available at http://www.eindelijkglasvezel.nl/corporate/innovatie/?sc_lang=en&preflang=en

[20] Reggefiber (2014). Step by step, everybody is supplied with fibre-optic. Available at http://www.eindelijkglasvezel.nl/corporate/innovatie/stap-voor-stap/?sc_lang=en&preflang=en

[21] Davids, J. (2012). Reggefiber. General Overview. Available at http://www.slideshare.net/INCA_NextGen/Reggefiber

[22] Rao, L. (2010, March the 27th). The final tally: More than 1100 cities apply for Google's fiber network. Article published in Techcrunch. Available from < http://techcrunch.com/2010/03/27/the-final-tally-more-than-1100-cities-apply-for-googles-fiber-network/ >.

[23] Baumgartner, J. (2014, May the 6th). Google Fiber capturing 75% of homes passed in KC: Study. ISP having success in lower income areas, Bernstein Research Says. In web article published at Multichannel news. Available from < http://www.multichannel.com/news/technology/google-fiber-capturing-75-homes-passed-kc-survey/374365 >.

[24] Richmond, W. (2014, May the 6th). Analyst: Google Fiber adopted by as much as 75% of homes passed in KC neighborhoods. Based on Bernstein Research. In web article published at VideoNuze. Available from < http://www.videonuze.com/article/analyst-google-fiber-adopted-by-as-much-as-75-of-homes-passed-in-kc-neighborhoods >.

[25] Reardon, M. (2014, May the 6th). Is Google Fiber on track to become major broadband competitor?. Based on Bernstein Research. Available from < http://www.cnet.com/news/google-fiber-on-track-to-become-major-broadband-competitor/ >.

[26] Vega, D., Cerda-Alabern, L., Navarro, L., and Meseguer, R. (2012, October). *Topology patterns of a community network: Guifi. net*. In Wireless and Mobile Computing, Networking and Communications (WiMob), 2012 IEEE 8th International Conference on (pp. 612-619). IEEE.

[27] Barcelo, J., Bellalta, B., Baig, R., Roca, R., Domingo, A., Sanabria, L., and Oliver, M. (2012, July the 3rd). *Bottom-up Broadband Initiatives in the Commons for Europe*. Project arXiv. Preprint arXiv: 1207.1031. Available from < http://arxiv.org/abs/1207.1031 >.

[28] Roca, R. (2011). Nova estesa de fibra òptica FFTF escomesa Sant Andreu a Vespella. Slides presentation from Guifi.net. Available at < http://www.slideshare.net/RamonRoca/cat-2011guifinetfftf-gurbveinsfase2 >.

[29] MacMillan, R. (2014, October). NTT wholesaling its fiber network and reducing capital intensity could improve returns. Morningstar's Editorial Policies, 22/10/2014. Available at < http://analysisreport.morningstar.com/stock/research/c-report?t=XNYS:NTT&region=usa&culture=en-US&productcode=MLE&cur=USD >.

[30] Katagiri, Y. (2005, August). Interconnection system in Japan. MIC - Ministry of Internal Affairs and Communications, Japan. Available from < http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/pdf/presentation_Interconnection_Japan.pdf >

[31] Katagiri, Y. (2008, April). Recent regulatory reform in Japanese telecommunications. In *slide presentation at the International WIK Conference "Review of the European Framework for Electronic Communications", Bonn, Germany* (pp. 24-25). Available from < http://www.wik.org/fileadmin/Konferenzbeitraege/2008/Review_of_the_European_Framework/04_Katagiri_Reg_Reform_in_Japan__for_WIK_rev.pdf >.

[32] Akematsu, Y., Shinohara, S., and Tsuji, M. (2012, July). Factors of FTTH deployment in Japan: A panel data analysis. In proceedings of the *23rd European Regional Conference of the International Telecommunication Society*, Vienna, Austria. Available from < http://hdl.handle.net/10419/60361 >.

[33] MIC - Ministry of Internal Affairs and Communications, Japan (2011, November 4th). Broadband Competition Policy. Japan-UK ICT Policy Dialogue. London, United Kingdom. Available from < http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/111104_01.pdf >.

[34] MIC - Ministry of Internal Affairs and Communications, Japan (2014). 41st White paper on information and communications in Japan. Economic Research Office, ICT Strategy Policy Division, Global ICT Strategy Bureau, MIC, Japan. Chapter 4.

Available from < http://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2013/chapter-4.pdf >.

[35] Van der Wee, M., Verbrugge, S., Tahon, M., Colle, D., and Pickavet, M. (2014) Evaluation of the Techno-Economic Viability of Point-to-Point Dark Fiber Access Infrastructure in Europe. *Journal of Optical Communication Networks, 6,* 238-249.

[36] Casier, K., Verbrugge, S., Meersman, R., Colle, D., Pickavet, M., and Demeester, P. (2008). *A clear and balanced view on FTTH deployment costs. The journal of the Institute of Telecommunications Professionals (ITP), 2*(3), 27-30.

[37] Domingo, A., & Lehr, W. (2013). Will broadband pricing support 1Gbps services?. In: *Proceeding of the 24th European Regional ITS Conference*, Florence. International Telecommunications Society (ITS). Available from < http://hdl.handle.net/10419/88482 >.

[38] Felten, B. (2012). Stockholm's Stokab: A Blueprint for Ubiquitous Fiber Connectivity? Diffraction Analysis report.

[39] Beltran, J.A. (2013). Fiber from the home (FFTH). Final year project written in Castilian-Spanish. Universitat Pompeu Fabra, de Barcelona. Available from < http://bubforeurope.net/wp-content/uploads/2014/10/Fiber-From-The-Home_Jorge-Beltran_Memory.pdf >.

[40] NTT East - Nippon Telegraph and Telephone East Corporation (2013, March). Business operation plan for the fiscal year ending March 31, 2014. Slides presentation from NTT East.

[41] Burger, W. (2012) The Reggefiber model. Key elements of Reggefiber's strategy in the Netherlands. Available from < http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/Wouter.pdf >.

[42] Chorus (2013) Chorus announces FY13 full year results. Stock Exchange Announcement: 26 August 2013. Available from < http://www.chorus.co.nz/chorus-announces-fy13-full-year-results >.