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Critical Factors of High-Speed Broadband Investments in Rural Areas from Perspective of Operators

School of Electrical Engineering

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ABSTRACT OF THE MASTER'S THESIS

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Abstract:

A fast broadband connection has become a vital service for everyday life and entrepreneurship. However, the profitability of high-speed broadband investments is a significant problem in rural areas. For this reason, the Finnish government has launched the Broadband 2015 Project, which aims to assist the extension of fiber networks in the rural areas of Finland by providing a public subsidy. However, this subsidy has not encouraged activity among all operators. Based on this situation, this research probes the critical factors of high-speed broadband investments from the perspective of operators. The underlying aim of the research is to define generally the characteristics of different operators in the rural area broadband investments as well as find tools for understanding and improving the Broadband 2015 project.

The research was performed using the theme interview method and techno-economic evaluation. Eight different Finnish operators were interviewed for the research. In addition, several experts were interviewed in the government and other organizations.

This research found three main critical factors affecting high-speed broadband investments in rural areas. The first factor, co-ordination with overall strategy, is emphasized in the rural area investments, which usually require flexible profitability targets and product tailoring. The market penetration is the second critical factor which usually becomes the most significant risk in the rural area broadband investments. The penetration is often hampered by low population density, which also increases costs per subscriber. Moreover, the penetration risk is increased in a network planning phase because demand is hard to forecast based on generally used methods in rural areas. The last critical factor, local activity, stresses the importance of local inhabitants and municipalities who can significantly affect the profitability of rural area broadband investments. Their activity is usually needed to facilitate profitable rural area broadband investments.

The results show that the high-speed broadband investments in rural areas could be improved by diminishing the penetration risk. This risk could be reduced, for example, by moving toward more demand based network structure using advanced demand surveys and by promoting the preferential pricing of early connections.

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Tiivistelmä:

Nopeasta tietoliikenneyhteydestä on tullut elintärkeä palvelu jokapäiväiselle elämälle ja yritystoiminnalle. Nopeita laajakaistoja on kuitenkin vaikea saada kannattamaan haja-asutusalueilla. Tästä johtuen Suomen hallitus käynnisti ”Laajakaista 2015” -hankkeen, jonka tarkoituksena on tukea julkisen tuen avulla nopean laajakaistan leviämistä haja-asutusalueille Suomessa. Julkinen tuki ei ole kuitenkaan saanut aikaan odotettua investointiaktiivisuutta kaikkien operaattorien keskuudessa. Tähän tilanteeseen liittyen tämä tutkimus selvittää nopea-laajakaistainvestointien kriittisiä tekijöitä operaattorien näkökulmasta. Tutkimuksen taustalla oli tavoite määrittää eri operaattorien ominaisuuksia haja-asutusalueiden laajakaistahankkeissa ja löytää välineitä ymmärtää ja parantaa ”Laajakaista 2015” -hanketta.

Tutkimus toteutettiin teemahaastattelumetodin ja tekno-ekonomisen arvioinnin avulla. Tutkimusta varten haastateltiin asiantuntijoita kahdeksalta suomalaiselta operaattorilta. Lisäksi muutamia muita asiantuntijoita kuultiin eri organisaatioista kuten Viestintävirastosta.

Tutkimuksessa nousi esille kolme keskeistä kriittistä tekijää nopea-laajakaistainvestoinneissa. Ensimmäinen tekijä, yhteensopivuus kokonaisstrategian kanssa, korostuu haja-asutusalueiden investoinneissa, jotka usein vaativat joustavia kannattavuustavoitteita ja tuotteiden räätälöintiä. Toinen kriittinen tekijä on penetraatio, joka muodostaa tavallisesti merkittävimmät riskit haja-asutusalueiden laajakaistainvestoinneissa. Alhainen asukastiheys nostaa kustannuksia tilaajaa kohden, mikä puolestaan laskee penetraatiota. Lisäksi penetraatioriskin merkitystä usein lisää todellisen kysyntätiedon puuttuminen verkon suunnitteluvaiheessa. Kolmas kriittinen tekijä, paikallinen aktiivisuus, tuo esille alueen asukkaiden ja kuntien merkityksen haja-asutusalueiden laajakaistainvestointien kannattavuudessa. Paikallinen aktiivisuus on yleensä jopa edellytys investointien kannattavuudelle.

Tulosten perusteella haja-asutusalueiden nopea-laajakaistainvestointeja voitaisiin tehokkaimmin kehittää vähentämällä penetraatioriskiä. Tämä voitaisiin käytännössä toteuttaa esimerkiksi siirtymällä enemmän kysyntäperusteiseen verkkorakenteeseen ennakoivien kysyntäkartoitusten ja aikaista liittymistä suosivan hinnoittelun avulla.

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List of Acronyms

3G	Third Generation Mobile Systems
4G	Fourth Generation Mobile Systems
ADSL	Asymmetric Digital Subscriber Line
AON	Active Optical Network
CAPEX	Capital Expenditures
CEO	Chief Executive Officer
CO	Central Office
DCF	Discounted Cash Flow
DSL	Digital Subscriber Line
EU	European Union
FICORA	Finnish Communications Regulatory Authority
FTTB	Fiber-to-the-building
FTTC	Fiber-to-the-curb
FTTH	Fiber-to-the-home
FTTN	Fiber-to-the-node
FTTP	Fiber-to-the-premises
FTTx	Fiber-to-the-x
GPON	Gigabit PON
IPTV	Internet Protocol Television
IRR	Internal Rate of Return
ITU	International Telecommunication Union
LTE	3rd Generation Partnership Project Long Term Evolution
NGA	Next Generation Access
NPV	Net Present Value

OPEX	Operational Expenditures
P2P	Point-to-point
PON	Passive Optical Network
PVCC	Present Value of Cumulative Cash flow
ReTV	Record Television
VDSL	Very high bit rate DSL

1. Introduction

1.1. Motivation and Background of Research

The telecommunication business has developed fast during the last decades. The need for bandwidth increases steadily. The amount of internet traffic will quadruple from 2010 to 2015 (Cisco, 2011). Moreover, an internet connection is often necessary for everyday activities and entrepreneurship (Finnish Government, 2010; Olivarez-Giles, 2011).

The Broadband 2015 Project was launched by the Finnish Government in 2008 to ensure the development of high-speed broadband networks throughout Finland (FICORA, 2011a; Finnish Government, 2008). However, promoting high-speed broadband development in rural areas is difficult due to the long distances and low profitability. The general interest of all actors would be to deploy fast broadband everywhere; however, the low profitability limits this vision in practice. The subprojects of the Broadband 2015 Project have been challenging for operators and the government according to the unwanted projects and the small activity of some operators. The lack of activity reveals a gap in the interests of different actors.

The earlier research of fiber networks has mainly focused on the more profitable urban and sub-urban areas. Moreover, rural area research has not considered the situation where fiber broadband has been strongly supported over a short time span. Fiber businesses have usually failed in rural areas unless provided with subsidies. Thus, this research examines this new challenging situation in rural areas by defining the critical factors of high-speed broadband investments from the perspective of operators. The research gives vital information to understand and improve the subsidized projects, as well as, other high-speed broadband investments in rural areas.

1.2. Research Questions

This research defines the critical factors of rural area high-speed broadband investments from the perspective of different operators. These critical factors are needed in a rural area broadband investment or the profit potential of the investment will be limited. The subject is approached based on the experiences of the Broadband 2015 Project. The critical factors are measured by two main research questions:

- What are the factors that affect the profitability of rural area high-speed broadband investments? The question includes various facets.
    - How do operators estimate the profitability of rural area high-speed broadband investments and what instruments and indicators do they use?

  - How do they use these instruments and indicators, and what kind of limits do they have for the indicators?
  - How do operators analyze the risks and opportunities of the investments? This perspective also determines indirect benefits of the investments, such as some local welfare related interests which could be important factors especially for smaller operators.

- Why have some operators participated in the subsidized projects while others have not? What are the main differences between operators with respect to rural area broadband investments and what are the reasons for these differences?

In addition to determining the critical factor, the research is guided by the two related questions:

- How can the research results be used to improve the attractiveness and profitability of the subsidized projects?
- Can the results be widely applied in the high speed broadband investments of rural areas?

1.3. Research Method

The research data was collected by interviewing eight different operators. The operators answered primarily based on their experiences with the Broadband 2015 Project. The interviews were performed by using the theme interview method (Hirsjärvi, et al., 2000) and techno-economic model, while the analysis is based on techno-economic evaluation and risk analysis. The qualitative theme interview and quantitative techno-economic model well complement each other in the research. The research methods are more exactly described in chapter 3.

1.4. Structure of Thesis

Chapter 2 discusses research frameworks from the perspective of concepts, technology and legislation. Chapter 3 presents the research methods. Chapter 4 analyzes the research results from a general perspective and from the perspective of different operator groups and techno-economic model. Chapter 5 summarizes the main results and draws conclusions.

2. Research Framework

2.1. Conceptual Framework

2.1.1. Broadband 2015 Project

The research is based on the Broadband 2015 Project of Finnish government. The project has a goal to rollout fast broadband network in rural areas which is not reached by market based high-speed broadband network investments in the near future. The target aims to expand the fast 100 Mbit/s broadband network to less than two kilometers away from 99,9% of permanent settlement and offices in Finland. 95% of the Finnish population is assumed to be reached by the normal market based investments by 2015. The public subsidy is used for the rollout of the last 5% of the target penetration. The Broadband 2015 Project has been divided in regional project programs which are comprised of 800 smaller projects. The subsidy is allotted to the area of the last 5%; however, an operator pays always 34% of building costs at minimum. If only one operator is interested in some project, operator pays always this minimum, 34% of costs, in practice. The operators are meant to compete for the projects by offering to pay a bigger part of the costs. The subsidy can be applied through a two-stage applying procedure and it is paid by the Finnish government, the municipalities of a project area and the European Union (EU) through a countryside program. In the first stage of the applying procedure, operators compete for a project with proposals. In the second stage, a winner operator can apply the subsidy. (FICORA, 2011a)

About 230 projects had been in the applying procedure by the spring of 2011. However, proposals were offered only in about a half of those offered projects. (The applying procedure is participated by offering a proposal, not an offer.) In addition to unwanted projects, participation activity has also varied among operators. The operators of the Finnet Group were clearly the most active by offering about 50% of the offered proposals. Small operators, like cooperatives, were the second most active by offering over a quarter of the proposals. The big operators; Elisa, DNA and TeliaSonera; offered together only less than 10% of the proposals. Thus, the big operators estimated projects at no financial and other way attractive, whereas the smaller actors estimated the projects at more attractive according to the number of the offered proposals.

2.1.2. Geographical Segmentation

Broadband investments are roughly made in two different areas. The public subsidy cannot be got for the first area. This area is estimated to cover about 95% of broadband penetration in Finland by 2015 when the penetration is calculated based a fast fiber network which is less than two kilometer from residence. This 95% area includes population centers and their neighboring areas. This area is estimated to be profitable without subsidies. In this research, the area is called the commercial area or the urban area even the most of the area is not really urban area in wider sense.

The second area, 5% area, covers almost the rest of Finland which leaves out of the 95% area. In this area, the subsidy can be got for broadband investments which extend two kilometers apart from subscribers. The last two kilometers, the subscriber line, must be also built without the public subsidy in this second area. The subscriber line indicates the part of the network where the line goes just for one subscriber in the subsidy legislation and this research. If the part of the line consists of fibers for multiple subscribers, the part of the line is denoted as the backbone which could get the subsidy. The Finnish law (1186/2009, 3§) describes the 5% area as a geographical area, the population density of which is so sparse, that 5,4% of Finnish population lives as sparse or sparser area in maximum. The fast broadband network has been estimated to not reach these areas without a subsidy by 2015 due to the sparse population. In this research, the area is called the subsidized area or the rural area.

2.1.3. Operator Groups

Broadband operators can be divided into three groups in Finland: big operators, Finnet operators and small operators. There are similar fundamental characteristics inside of these groups, thus it is natural to discuss them in groups. This segmentation is also mandatory for this research to reach anonymity and confidentiality which enabled the nearest undisguised answers. Thus, the results of the research are presented in these groups.

The big operator group consists of the three large national operators. In addition to fixed broadband services, they also provide countrywide mobile services which include mobile broadband services. The goal of the big operators is to make a profit for their owners who are national and international investors. These three characteristics; the nationality, the competing mobile technologies and the demanding owners are the reason for many specific results of the big operator group.

The second group, the Finnet operators, is a middle size group which consists of operators of the Finnet Group. “Finnet group is a Finnish telecommunications group, which consist of 29 local telephone companies with their affiliated and associated companies and Finnet Association.” (FINNET, 2009) The Finnet operators act locally and their owners are also often local. The Finnet operators do not serve own mobile services and they do not have a wireless communication business, or it is quite limited. The most of their business rest on fixed networks. The goal of the Finnet operators is to make a profit for their owners which are not usually as demanding than the owners of the big operators.

The small operator group consists of small local zero-profit operators, such as network cooperatives. The structure of the small operators is really flat and the most of their operations are usually outsourced. The target of the small operators is to serve and secure cheap developed services for the inhabitants of their area with zero-profit.

2.2. Technical Framework

This chapter discuses technical options for fast broadband network. The options are described in the three categories: copper, wireless and fiber.

2.2.1. Copper Based Technologies

The first fast broadband option is copper based technologies including Digital Subscriber Line (DSL) technologies such as Asymmetric DSL (ADSL). These technologies mainly use the old telephone networks, and they have widely spread due to the wide copper networks. However, the copper networks have been diminished due to the wired phone decreasing and a cellular increasing, as it can be seen in the Figure 1. The copper networks have been gathered up in rural areas of Finland (Aaltonen, 2008). In addition, the capacity of the copper networks is significantly limited compared to the fiber network capacity. (Jensen, et al., 2006) ADSL2+, one of the most advanced used copper technologies, can theoretically transmit 24 Mbit/s in the downlink and 2 Mbit/s in the uplink with the distance of 2 kilometers. However, this is theoretical maximum, thus really downlink connection speed lays from 8 to 24 Mbit/s and the uplink speed is between 512 Kbit/s and 1 Mbit/s (TeliaSonera, 2011). Higher speeds can be reached with Very high bit rate DSL (VDSL) technologies; however their distances are even shorter than the distances of ADSL (Jensen, et al., 2006). Due to the long distances and the interference of the old copper networks, the fast broadband network execution would become expensive with the copper based technologies in the rural areas.

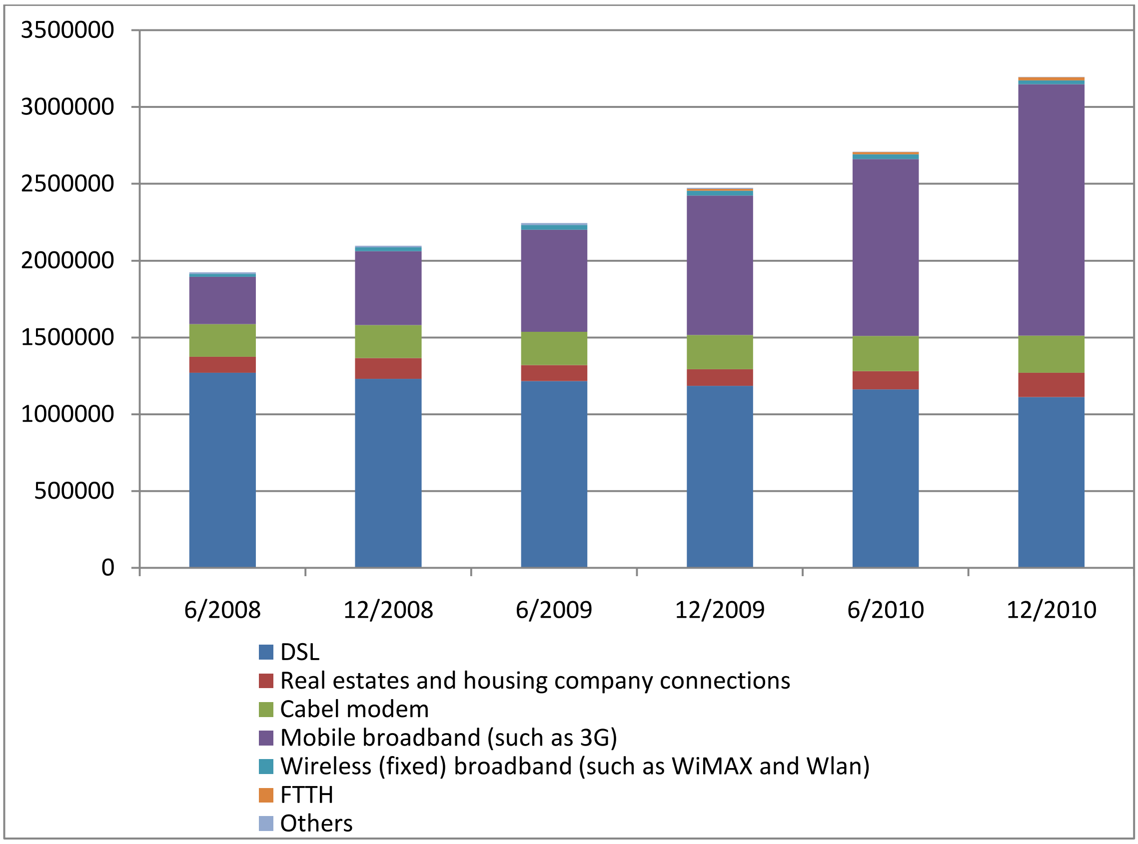

Figure 1. The development of the broadband connection numbers per technology in Finland from 2008 to 2010 (FICORA, 2011b)

2.2.2. Wireless Technologies

The second option for fast broadband, wireless technologies, has significantly increased its broadband connection share due to inexpensive contracts in Finland. The number of the third Generation mobile system (3G) connections has specially exploded, which is also shown in the Figure 1. Instead, the number of the more fixed wireless broadband connections has stayed in the low level. The 42 Mbit/s connections have been served by using 3G technology Evolved High-Speed Packet Access (HSPA+). Another 3G technology, 3rd Generation Partnership Project Long Term Evolution (LTE), can provide theoretical 100 Mbit/s peak rate (Ericsson, 2009). An upgraded version of LTE, LTE Advanced which seems to be the strongest 4G technology of future, can reach theoretical 1 Gbit/s downlink speed (Radio-Electronics.com, 2011). Furthermore, the wireless technologies have got new opportunity, when an old analog frequency band, 800 MHz, became recently free for mobile broadbands. The big obstacle for using of the band had been Russian army that used the same band; however it withdrew from the band at the end of 2010 (Vaalisto, 2010). Thus, the operators will have new cost effective band to use in the near future.

However, the presented connection speeds are theoretical, and many practical factors limit really connection speeds which could often leave in few percent of the theoretical speed (Järvinen, 2010). Thus, the Finnish operators guarantee only 0,4 Mbit/s minimum connection speed for the mobile broadband in the coverage area at the present (DNA, 2011; Saunalahti, 2011; Sonera, 2011). In addition, over 80% of the Finnish mobile broadband connections had slower than 4 Mbit/s nominal connection speed in 2010 (FICORA, 2011b). The capacity of mobile technologies is also limited due to high use rates in urban areas. In rural areas, interference is significant challenge for mobile broadband due to the large cell sizes of a network. The mobile connections are very susceptible to the interference; however, they can serve good connection for almost any service in good circumstances.

The future practical capability of the mobile broadband are estimated very differently by different operators and experts, thus the mobile is much speculated technology option for the fast broadband. When the fast broadband is defined with a 100 Mbit/s stabile connection, as in the Broadband 2015 Project and this research; the mobile broadband cannot be a real option yet. However, the role of the mobile broadband is increased when the definition of the high-speed broadband is expanded and the future capabilities of the mobile broadband are accounted for.

2.2.3. Optical Fiber Technologies

The optical fiber technologies can be divided based on a few different factors. The first divide is made by the distance between a fiber and a user, and it is named by different fiber-to-the-x (FTTx) terms. Figure 2 presents differences between different FTTx architectures. Fiber-to-the-home (FTTH) comes closest to a user by reaching a single apartment. The next architecture, fiber-to-the-building (FTTB), is usually used in old apartment houses where a fiber comes into the house but not into a single apartment. These first two architectures are also called the common term, fiber-to-the-premises (FTTP). FTTP architectures are the most commonly used the fiber architectures. The fiber leaves outside of a building in the last two architectures: fiber-to-the-curb (FTTC) and fiber-to-the-node (FTTN). The distance between a user and the fiber is less than 300 meters in FTTC, while the distance is more than 300 meters in FTTN. The last meters are performed with the copper based technologies in FTTC and FTTN, thus these are also known as hybrid architectures. The last two architectures have disadvantages in the rural areas due to the long distances and the great interference of old copper networks. (Chamberland, 2010; Van der Berg, 2008)

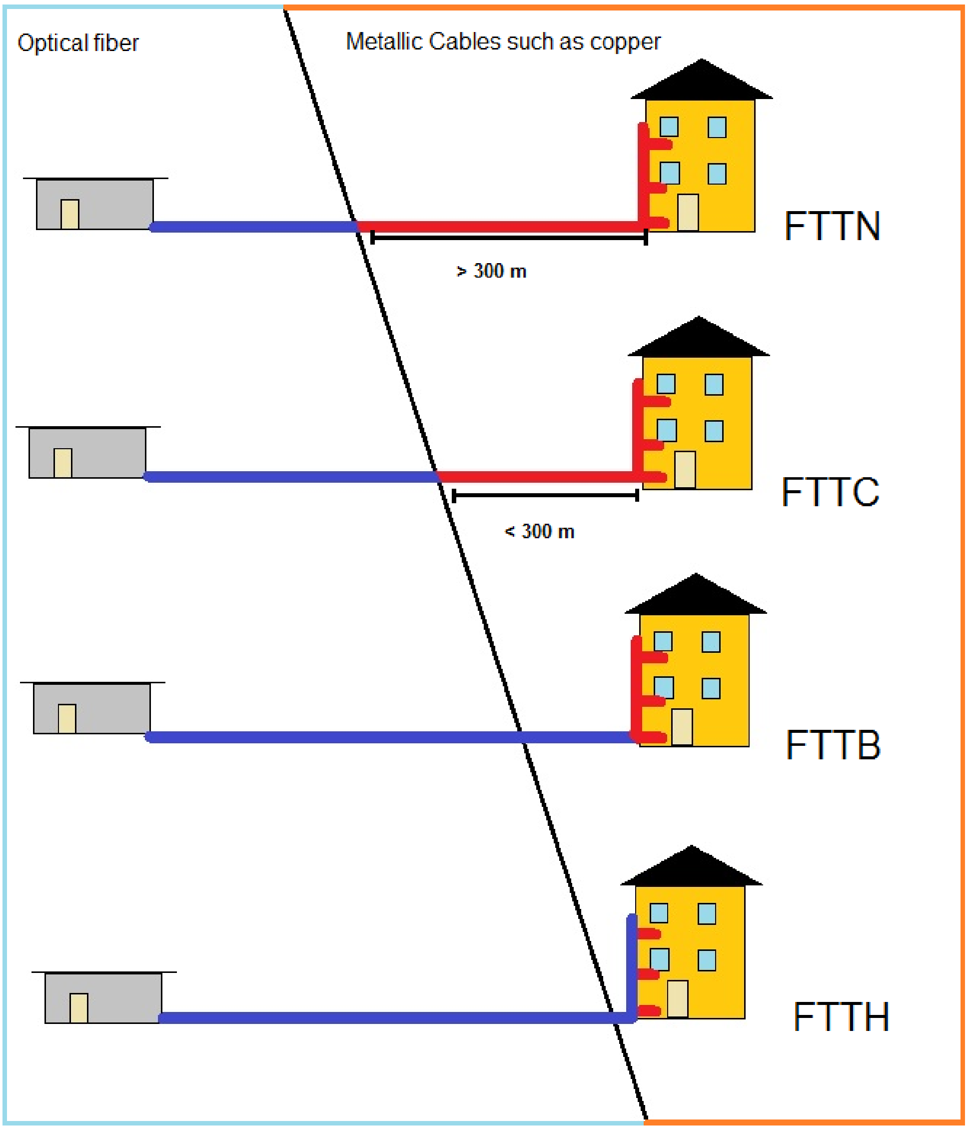

Figure 2. Description of the different fiber-to-the-x (FTTx) architectures

The second dividing option of the fiber technologies segments the technologies into direct connections and shared connections. A network topology is star in the direct connection architecture, thus the direct connections are point-to-point (P2P) type and they can be produced only in FTTP architectures. Every user has an own fiber directly from central office (CO) in the direct connection, thus a user can use all the possible capacity of a fiber with this connection. The direct fiber connection can already serve over 10 Gbit/s connection speed. (Van der Berg, 2008)

The shared connection architectures are wider group compared with the direct one. The shared connections can be divided into Active Optical Network (AON) and Passive Optical Network (PON). The differences of these two and P2P architectures are illustrated in the Figure 3. A single fiber is distributed for different customers by passive splitter in PON. The splitting can be implemented in multiple points and without any extra energy. Thus, the distribution of a network can be performed cost effectively with PON. Two most advanced and competing PON standards are the Gigabit PON (GPON) of the International Telecommunication Union (ITU) and the Ethernet PON by the Institution of Electrical and Electronics Engineers (IEEE). The advanced versions of the both PON techniques are capable 10 Gbit/s connections with 20-to-60-kilometers distance. The both standards are developed constantly. (Van der Berg, 2008)

Network distribution with AON needs an active device, which needs energy, in a splitting point. The distance between CO and user can be increased by AON; however the active splitters also increase costs and relatively long distances can be also reach with PON. Thus, PON architecture has recently extended faster than AON. (Chen, et al., 2010)

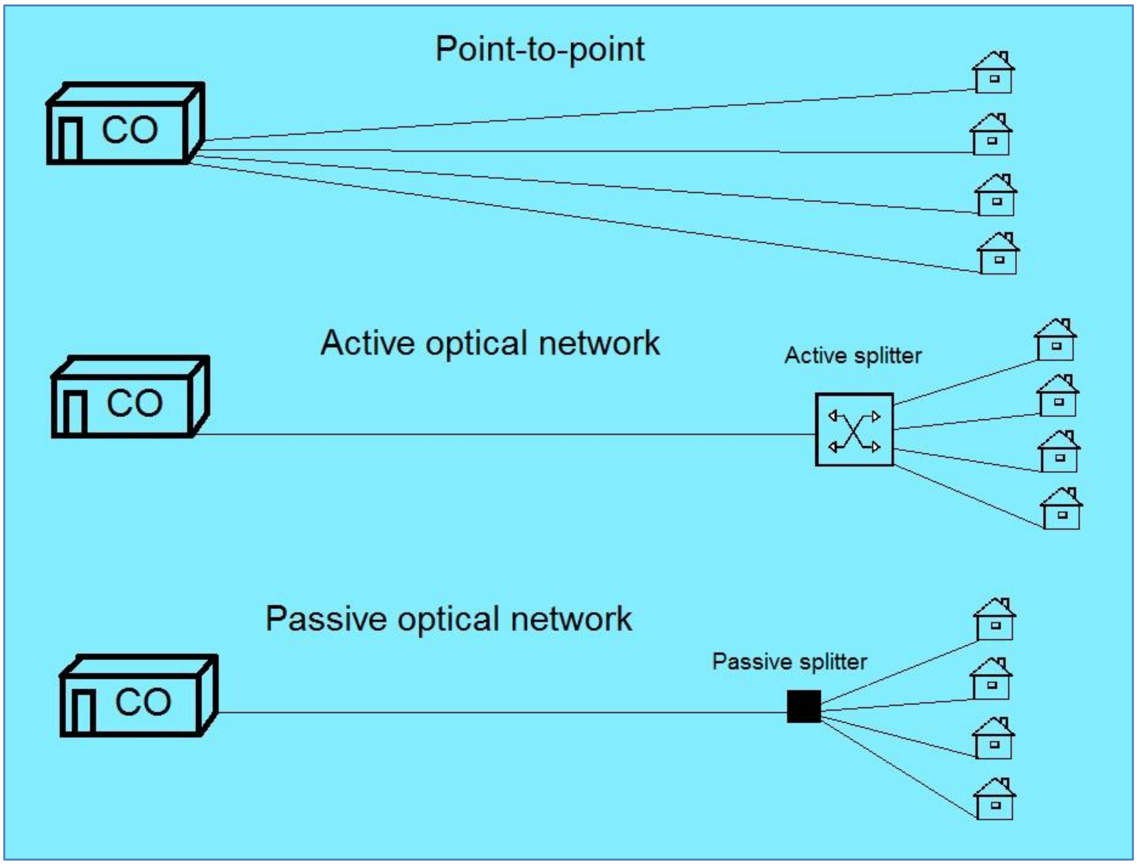

Figure 3. Illustration of P2P, AON and PON from the central offices (CO) to the customers.

2.3. Legal Framework

The public subsidy is used in the Broadband 2015 Project, thus different laws and regulations have been enacted related to the project. The most significant laws and guidelines are described in this chapter. The legislation of the project are first discussed from the perspective of the EU legislation and secondly from the perspective of the Finnish legislation. The EU legislation concentrates on a state aid which is wider concept compared to the public subsidy of the project.

2.3.1. European Union Law

The legal foundation of the subsidized projects is enacted by the laws of the EU. The European Commission has set the broadband strategy as one of important strategic sectors in the Commission adopted a European Recovery Plan (European Commission, 2008d). Thus, the EU has allocated funds for broadband development and also enabled state aids for this purpose. Because of the EU founds and EU aid regulations, the whole subsidized part of the Broadband 2015 Project must have been also accepted by the European Commission with a notification (N62/2010; Finnish Government, 2011).

The legal basis of the state aid is found in the laws about aids granted by states (European Commission, 2008a; European Commission, 2008b). Article 107 defines the state aid in the internal market and describes it following in Article 107(3)(c): "aid to facilitate the development of certain economic activities or of certain economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest" (European Commission, 2008a). This statement also functions as primary legal basis for the accepting notification of the Broadband 2015 Project.

The secondary important legal basis of the project and its notification is found on the "Community Guidelines for the application of State aid rules in relation to rapid deployment of broadband networks" (2009/C 235/04). It defines state aid principles in the broadband business and states the three main targets of the EU supervision: ensures that the aid will develop broadband services, ensures that the positive effects of the aid are greater compared with its negative effects, and regulates use and access of the broadband networks. Furthermore, the guideline defines requirements for the state aid (2009/C 235/04):

- *Detailed mapping and coverage* analysis defines unambiguously aided areas.
- *Open tender process* ensure fear possibility for all actors to participate.
- *Most economically advantageous offer* ensures cost effective investing.
- *Technological neutrality* enables development in any technologies. Quality for the requirements only maters.
- *Use of existing infrastructure*, when it is possible, supports the sustainable development.
- *Wholesale access* improves network leasing possibilities and competition in the market.
- *Benchmarking pricing exercise* forbids market skewing.

In addition to the frameworks for general broadband aids, the guideline also describes special guides for the aids of fiber networks based on New Generation Access (NGA) term which are defined in the EU legislation (2010/572/EU) following: “NGA networks mean wired access networks which consist wholly or in part of optical elements and which are capable of delivering broadband access services with enhanced characteristics (such as higher throughput) as compared to those provided over already existing copper networks. In most cases NGAs are the result of an upgrade of an already existing copper or co-axial access network.” The NGA-guidelines specify the general guidelines for NGA network investments, for example by defining the requirements of state aid in the NGA investments. One of the most significant requirements limits the NGA aid to cover investment areas which are not reached by the fiber network without aid in the near future. The near future is considered as a three years period in the guide. The guideline also gives examples for state aid using, such as how to support NGA building in practice. (2009/C 235/04)

Finland got approval for the information of the Broadband 2015 Project defined in the Article 108 (European Commission, 2008b) and the Commission accepted the state aid of the project by the notification (N 62/2010). The notification perceives the project to accomplish the targets of the EU by fulfilling the requirements of the previous defined EU legislation.

Much other EU legislation is also related to the project in some way and some of this legislation has been challenging in the practical situation of the Broadband 2015 Project. One latest challenging issue has been the guarantee of the co-operative and other small operator investment loans. The over 80% guarantee of municipalities can be regarded as a state aid based on the Commission notice (European Commission, 2008c). Thus, these municipality-guaranteed projects can get no public subsidy because the EU interprets the projects to get more than 100% public aid for the building costs. This has been the vital issue for small operators because municipalities have often functioned as an important guarantor for their loans. The Ministry of Transport and Communications has clarified the situation by asking a council from the Commission. The commission answered in spring 2011 (Wouter, 2011), and the answer was positive for the small operators. However, the answer was informal, thus a formal and legal notification are still lacked for the municipality guarantee. This issue demonstrates well the slowness and challenges of the public aid system in the new or specific situations.

2.3.2. Finnish Law

The Finnish broadband strategy is based on the decision in principle of the Finnish Government which has three main targets: develop general telecommunication network, ensure reasonable broadband service pricing, and organize the state funding part of actions. The targets are clarified by setting the goal levels of 2010 and 2015 in the decision. The most significant goal is 100 Mbit/s connections which should be available for everyone in Finland in the end of 2015. The decision is strongly connected with fiber networks and NGA because of its high requirements; however, many of the goals are also related with mobile technologies, or they are technological neutral. (Finnish Government, 2011)

The most significant Finnish law related to the Broadband 2015 Project is the subsidy law of broadband building in rural areas (1186/2009). The law is the legislative foundation of the project and it concentrates on the NGA networks. The aim of the law is to promote the building of fast broadband networks in the rural area and ensure versatile communication services everywhere in Finland. The law defines the guidelines of the project, such as the definition of the subsidized area (described the chapter 2.1.2), the project program, applying procedures, amount of the subsidy, and the payers of the subsidy. The law also includes some forward duties and limitations for the subsidized projects. The holder of the subsidized network has duty bound to provide developed communication services with a reasonable price in the area, lease the extra capacity of the subsidized network and report asked information to the government during the next ten years from the last subsidy payment. Furthermore, a holder can profit 12 % per year in maximum by a subsidized project during the next three years from the last subsidy payment. The subsidy or the part of it has to be paid back if the profit is higher or some duties are not fulfilled. One change has been made for this law in 2010 (538/2010), which specified some articles, such as the comparison principles of subsidy applications and the definition of subsidy eligible costs. The subsidy eligible costs are not maintenance costs, building costs which are created by subscriber line parts less than two kilometers from a subscriber, and building costs in an area which is less than two kilometers from the connection point of a NGA network. In addition, the subsidy eligible costs must be created after subsidy application filing and the subsidy can be applied from network parts which serve permanent housing and offices. (1186/2009)

3. Key Research Methods

3.1. *Theme Interview*

The main research method is the theme interview method, which belongs to the half structured interview methods. The theme interview is well defined and guided by Hirsjärvi and Hurme (2000). The theme interview has a planned structure which is in general issue level. The method discovers well objective opinions by using no leading question forms. However, the themes enable the interview to focus on wanted issues. The method enables interviewees to have very different experiences and do not limit the interview in one view. Thus, same structure and themes could have been used in all interviews in spite of the different interviewees.

The results of the interviews are analyzed by the qualitative analysis defined by Dey (1993). The qualitative analysis has three phases: describing, classifying and connecting. The first phase prepares data for further analysis; the second phase categorizes the data; and the last phase processed the data and creates or improves the model of a subject.

3.2. *Techno-Economic Evaluation*

The techno-economic evaluation is used in two levels in this research. First, the whole research is a techno-economic evaluation process. Second, this process also includes techno-economic model which was created in the table and it was filled with the operators. The general structure of the evaluation and model is discussed in this chapter, and the research specific structure of the evaluation and model are more defined in the next main chapter. In addition, the risk analysis, which is the part of the techno-economic evaluation, and key economic methods, which are the part of the techno-economic model, are described in this chapter.

3.2.1. Structure of Techno-Economic Evaluation

The techno-economic evaluation process functions as a basis for the techno-economic model and the interview. In addition, it is a framework for the analysis of the research. (Verbrugge, et al., 2008a; Verbrugge, et al., 2008b) The Figure 4 presents the structure of the Verbrugge & all's techno-economic evaluation process which consists of the four phases: plan, model, evaluation and refine (Verbrugge, et al., 2008b; Verbrugge, et al., 2008c). The plan phase corresponds to the construction of the techno-economic evaluation. In the model phase, the data is collected and the model is structured, for example based on interviews. The evaluation phase includes the analysis of results and a structured model. The last phase of the process consists of conclusions and evaluation of the results. (Verbrugge, et al., 2008b; Verbrugge, et al., 2008c)

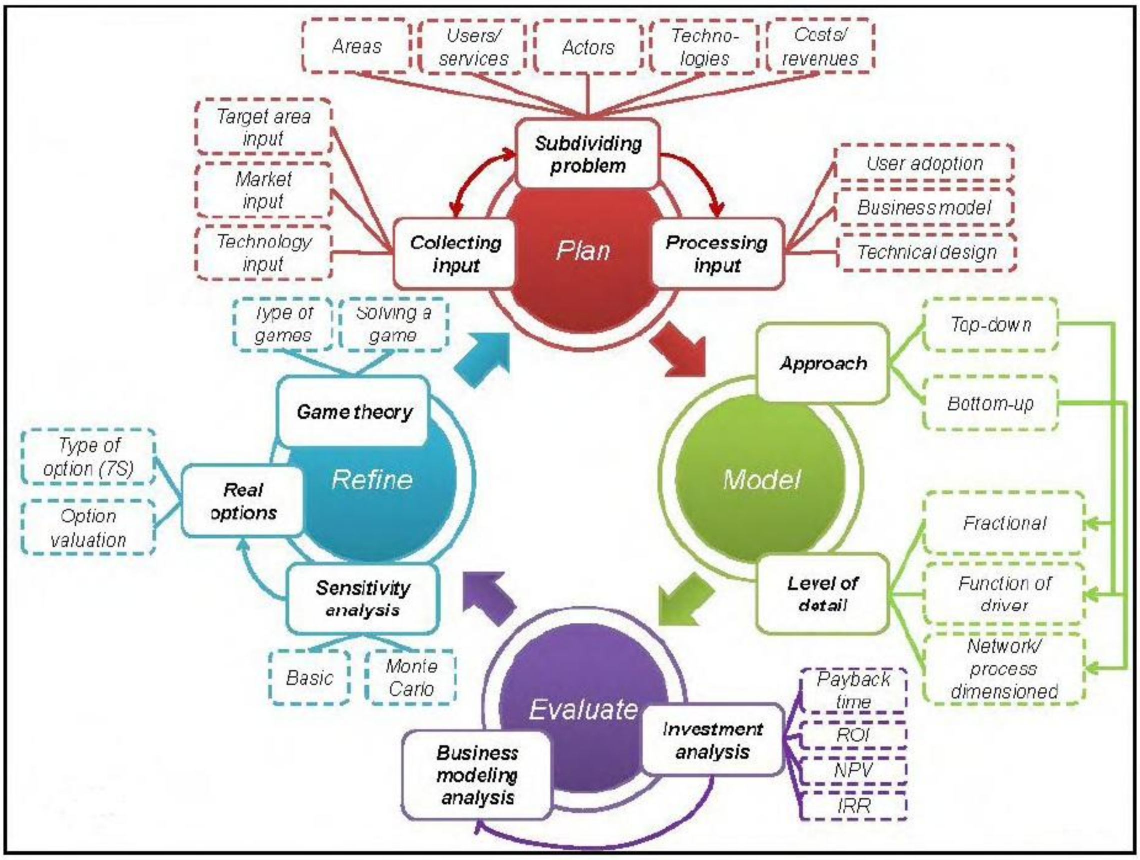

Figure 4. Practical steps in techno-economic evaluation of network deployment planning (Verbrugge et al., 2008a).

In addition to the techno-economic evaluation process, Verbrugge & all's cost breakdown approach for FTTH rollout cycle, showed in the Figure 5, has been used in the planning and modeling phases of the techno-economic evaluation. The approach includes four phases: plan, deploy, service migration and up & running. Planning is the simplest phase of the process, even though it usually consists of many phases, such as profitability analysis, network structure planning and clearance applying. The next two, the connection and deploying, phases model the capital expenditures (CAPEX) of a rollout. The last phase of the approach, up & running, describes the operational expenditures (OPEX) of a network. The CAPEX and the OPEX are defined more accurately in the following chapters. (Verbrugge, et al., 2008b, c)

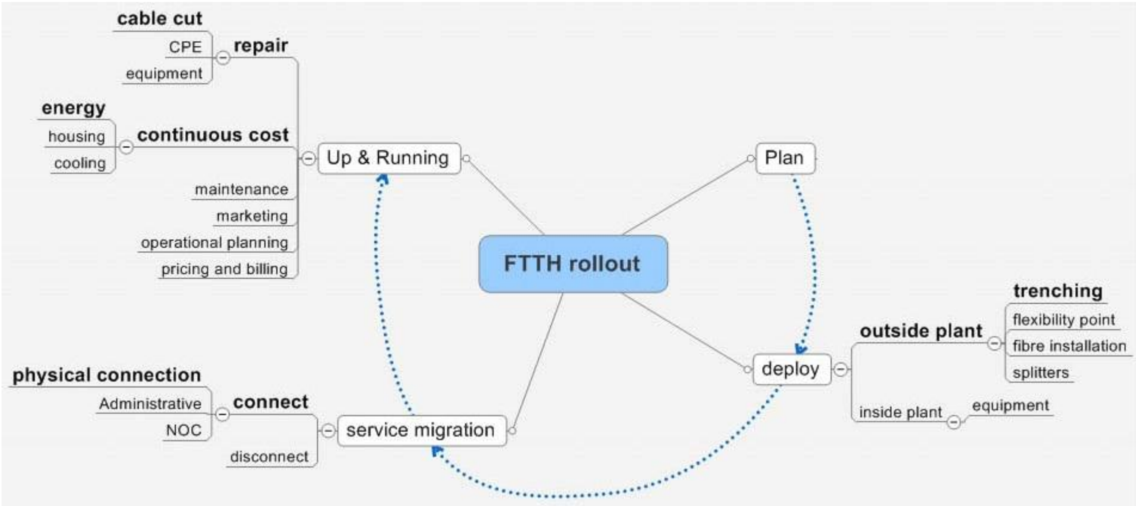

Figure 5. Cost breakdown approach for FTTH rollout cycle (Verbrugge et al., 2008b,c).

3.2.2. Risk and Sensitivity Analysis

The risk analysis concentrates on the fundamental issues of a risk assessment in this research. The risk assessment is founded on three basic questions (Modarress, 2006):

- What can go wrong?
- How likely is it?
- What are the losses (or consequences)?

The risk analysis of the interview is based on these three fundamental questions. The first question describes the different challenges of broadband business and investments. In the second and third questions, the probability and power of risks are qualitatively estimated. These estimates are quantitatively evaluated in the techno-economic model by estimating optimistic, probabilistic and pessimistic values for some variables of the model. The sensitivity analysis is implemented by varying some variables and observing the results of the model at the same time. The sensitivity analysis of this research is based on the one-at-a-time method which studies the effect of one variable at a time. Amount and accuracy of the techno-economic model data could have not been enough for more complex sensitivity analysis, such as the Monte Carlo analysis. (Modarres, 2006)

3.2.3. Key Economic Methods

The economic analysis of this research is based on few general economic methods (Horngren et al., 2009). The first economic method, the cash flow analysis, calculates all incomes and the cost of an investment in a defined time period, and it functions as base for other economic methods. (Horngren et al., 2009)

The next two methods, the Net Present Value (NPV) and the Internal Rate of Return (IRR), are the Discounted Cash Flow (DCF) Methods, which measure all expected future cash flows of an investment discounted to the present time. The NPV calculates all these cash flows together, and the investment is profitable if the NPV is positive. The result depends much on the required rate of return parameter which illustrates the time value of money in the NPV. The IRR measures the required rate of return value which gives the zero result for the NPV. In this research, the time period of the DCF is limited in 20 years due to unreliable forecasting over two decades. In addition, the cash flows of future affect less in the DCF due to the time value of money. (Horngren et al., 2009) Beside the NPV, the profitability of an investment can be measured by plotting the accumulation of the NPV. This measuring is called the Present Value of Cumulative Cash Flow (PVCC) in this paper.

The fourth method for the economic analysis is the payback period, which measures a time that it takes an investment to yield as much it costs. A target payback period, also called a cutoff period, can be compared to the calculated payback period of the investment. If the payback period, calculated with the measures, is less than the target period, the investment is considered acceptable. And if the payback period is longer, the investment is considered unprofitable. (Horngren, et al., 2009)

4. Results

4.1. Theme Interview Analysis

4.1.1. Introduction of Interviews

The interviews were performed in two phases. In the first pilot interview phase, one small operator and one Finnet operator were interviewed. In addition to the actual interview questions, the pilot interviewees were also asked improvements for the interview itself. In the second phase, the rest of the operators were interviewed. The second phase consists of three national big operators, one Finnet operator and two small operators. Thus, as a whole, the interviewees include three big operators, two Finnet operators and three small operators. The interviewees of the big operators consist of a project manager, a head of networks, a senior advisor, a product manager and a technology manager. In the Finnet operators; a CEO of an operator, a project manager and a network manager were interviewed. The interviewees of the small operators consist of a chairman of a cooperative, an advocate of a project municipality and two CEOs of operators.

The interviews were performed by face to face meetings or virtual meetings with a video-conference program. The themes of the interview and the form of the techno-economic model were previously given to the interviewees. However, the more exact question list or content of the theme interview were not earlier told. Earlier planned answers were aimed to avoid with this secrecy. The interviews lasted from one and half hours to three hours, and all of them were recorded. The records were used to finish the notes of the interviews afterwards. The notes were sent to the interviewee or the interviewees, and they revised those notes. The interviewees were also guided to check the notes in that they could be published. Thus, the confidentiality and right interpretation were ensured.

The theme interview was divided in the three main themes: strategy, risks and profitability measures. The themes were especially discussed from the perspectives of the subsidized projects and fixed broadband in general. The extension of the perspective was important due to the strong connections of the subsidized project with other businesses of the operators. The first theme determined the creation of an operator broadband strategy and its relations to other strategies and publicly subsidized projects. The center content of the broadband and subsidized project strategies were also clarified in this theme. The second theme examined the challenges of broadband investments and especially the subsidized projects. Used and possible solutions for the challenges were also asked from the operators. The last theme discovered practical methods which are used in the exploitation of investment profitability evaluations. The question outline of the theme interview is found in the appendix 1.

The second phase of the interview, the techno-economic model filling, was performed after the theme interview phase. In some cases, the filling was finished afterwards by an operator due to a tight schedule. The model table was shared in a demand model, capital expenditure model, operational expenditure model and revenue model. The structure of the techno-economic model is shown in the figure of the appendix 2. The techno-economic model and its sub-models are described more exact in the Techno-Economic Analysis Chapter.

4.1.2. General Results of Interviews

In this chapter, the results are discussed in a general level over the different operator groups. Differences between the groups and the group specific results are discussed more in the Operator Group Specific Results Chapter.

4.1.2.1. Investment Strategy and its Creation

The first issue, which was determined in the interview, is the broadband strategy and its creation. Even though this research concentrates on publicly subsidized broadband projects, it is important to understand how the subject is found in the unity of an operator business.

All interviewed operators regard positively the Broadband 2015 Project in general. The development of fiber broadband networks and telecommunication infrastructure are seen as the right direction of development and the important part of Finnish future. However, details and practical issues are seen differently by different operators. Thus, all operators want to engage in the Broadband 2015 Project, at least, in a principle level.

Every operator has own strategy for subsidized projects and it has been defined by the highest decision making body of an operator in Finland. In addition, single projects or, at least, the bundles of the projects are approved in the same high level of operators based on the presentations of middle management. The strategies of the subsidized projects are closely related to the overall strategy and business of the operators. The subsidized projects don't affect much on the overall strategy except the strategy of the small operators which of strategy is usually based on the subsidized projects. These investments are made in the frames of the overall strategy. A single subsidized project is generally measured equally with other investments. Thus, the subsidized projects would not be performed without the subsidy. However, the lack of experience has pitched the subsidized projects into a special position in the operator strategies, where a lower profitability is accepted in the beginning.

The technology strategies of the operators were mainly equal with the exception of mobile technologies. Mobile technology strategies are more discussed in the operator group specific results. All operators agreed that the fiber is needed in the backbones of networks. The new fixed subscriber lines are also produced with fiber if a fiber backbone is available. Thus, the FTTH is the mainly used optical network architecture. Almost all operators also use the P2P as the main connection solution. The PON solution is usually a secondary option for connection, and it would be used if demand significantly increases later. The AON are not used due to relatively high maintenance costs.

4.1.2.2. Profitability Factors

Profitability factors can be roughly divided into two categories: direct and indirect benefits. The first category, direct benefits, can be usually measured financially unlike the second category. The direct benefits of the subsidized projects can be also divided in the three parts:

- *The revenue of a fiber broadband connection* includes the connection fee, which doesn't usually cover the connection costs of an operator and is just a nominal fee in some cases; and monthly network fee, which is usually connected permanently with Internet connection fee.

- *Revenue through fiber connections* is generated by additional services. Some of these services, such as Internet Protocol Television (IPTV) and Record Television (ReTV), are also permanently included in the services of the monthly fee in some cases.

- The third part of the direct benefits, *the leasing of network*, has three main target groups: the other big operators, large and middle companies and the government. The most significant group is the other operators who have to lease capacity for their mobile network base stations in the rural area where they don't have their own fiber network. The roles of the two other groups are not usually significant in the rural area; however, some operators believe this business to grow among the development of new virtual services.

The fiber connections and services through them are over 60% of subsidized project profitability for all the operators, excluding one operator. Furthermore, these factors were more than 90% of the project financial profit for many operators. The network leasing has a different role for different operators. For some operators, the leasing is such a small side business, while some operators expect the leasing to grow into the significant role of business with 30 percent increase of revenue in the near future.

The direct benefits are mainly determined in the project areas in the subsidized projects. However, revenue is also gained outside of the project areas. This is specifically important fact in the projects which are close to commercial area. However, the significance of this factor is relatively small in the most of the subsidized projects due to the remote location of the projects. The subsidized projects must be generally profitable with the revenue of its own area according to the interviews.

The second profitability category, the indirect benefits, is more challenging to measure and compare in contrast to the first category. The single reasons and their magnitudes under the indirect benefits are hardly assorted due to the complicated effect of numerous issues on the result. The indirect benefits can be divided into two parts:

- The first part is indirect benefits for an operator. These benefits consist of different own benefits of an operator, such as old network renewing, new commercial area reaching by using a subsidized project, and presence confirming in the own area of an operator.

- The second part of the indirect benefits is got by the interest groups of an operator. The most significant interest groups are municipalities and local inhabitants that can increase their service level and competitiveness by supporting and investing fast broadband networks in their own area. The magnitude of the interest groups is emphasized with the more local operators.

4.1.2.3. Profitability Measuring in Publicly Subsidized Broadband Projects

The profitability measuring of the operators concentrates on cost measuring and the direct benefits, as it was already mentioned in the last chapter. The indirect benefits are taken into account only roughly and not numerically in the measures.

The cost measuring is usually the most accurate part of the whole profitability measure. The cost measurement bases on the building plan of a network and contracts with contractors. The building plan is made before subsidized project applying, because the offered price of the application is based on it. The experience of an operator increases the accuracy of the measurement. Some operators also use field investigation for measure improving in some cases; however, the surveys are not usually performed due to their high expenses. In addition, winter and snow impede the field investigation. An accurate field investigation is usually performed only just before the rollout. This encourages operators to measure costs in a high level, because an operator must pay the whole overrun part of the costs by themselves if the measured costs are overrun. In the other hand, municipalities, which approve a subsidy application, do not necessarily accept the high cost measures of the applications, even though the subsidy is paid based on really costs. This situation increases the challenge of the cost measure especially for inexperienced operators.

The building contracts are made in a unit price level before subsidized project applying. However, the really price of a rollout depends on the geography of a project area which can vary significantly. Label costs per meter can vary from few Euros to dozens Euros depending on the geography. Moreover, though the unit costs are usually quite stable, they can increase due to lacking supply if a lot of projects are launched in a same time.

The second part of the profitability measure is a direct benefit evaluation which mainly consists of a revenue measure based on demand forecasting and pricing.

- *Demand forecasting* is the very challenging part of the whole profitability measure in the rural area broadband investments. The most of the demand forecasts have been roughly done based on history without any sure information about the demand of a specific area. Some municipalities have made a demand survey in their own area; however, the answers have not been usually firm due to unknown pricing. Local operators have been able to use more municipalities in the measuring and planning of the projects. All the operators were of one mind in the demand surveys being too heavy and expensive to perform for the operators.

- The other part of the revenue measure, *the pricing*, has been made in two ways. The monthly connection fees are quite equally constructed in the both of the pricing methods, even though some operators also attach some generally additional services under the monthly fee. In contrast, the connection fees differ between the methods. First, the pricing of connection can be based on fixed fees which are same in spite of the length of the subscriber line. This method encourages subscribing widely in the whole project area. A price level is usually so low that the connection fee covers only the fraction of the connection costs. The other pricing method notices the length of the subscriber line in the connection fee. Thus, the connection fee will be higher for longer lines. Therefore, the connection fee easily increases in too high level for subscribers. However, this method follows better the really costs of the connection, thus it is widely used in the midst of the bigger operators.

The last part of the profitability measure is the measure of indirect benefits. The indirect benefit measuring is really challenging as it is the comparison of the indirect and direct benefits. One method for the indirect benefit measuring is to estimate the cost of a necessary substitutive investment. For example, if the backbone of a base station can be renewed among subsidized network building, the costs of the pure new base station backbone renewal can be measured as savings in the project. Strategic benefits and the benefits of interest groups must be estimated based on their magnitude and value for an operator. These factors are catered in the limits of the profitability measuring. For example, a project can have a longer payback time if it has strategic special value for an operator based on its location.

4.1.2.4. Risks of Broadband Investments

4.1.2.4.1. General Risks of Broadband Investments

Broadband investments are related to many different risks which vary depending on different factors, such as an operator and the structure of an investment area. Next, these risks are presented the most significant risks first.

The most significant risk of the broadband investments is too low revenue. This risk can be down to two reasons: too low prices or penetration. The low prices risk is found more in the commercial and urban areas where a competition could press price level low. The low penetration is more the risk of rural areas where a population density is low. The both risks cause no profit business which is crucial problem for any operator.

The other really significant risk is the selection of invested technology. This risk can cause even larger losses for an operator than the low revenue risk; however, this risk is more improbable. Investing to totally wrong technology, which would die soon for example, could become pure loss in the worst case. The wrong launch timing of a technology can also cause significant losses. A too early launched technology could stand idle without making profit; for example, until supplementary technologies are developed enough. A too late launched technology could not necessarily reach a large enough market share due to earlier arrivals' lead.

The third broadband investment risk is related to the uncertainties of rollouts. The unit prices of building can usually be assured accurate enough beforehand. The type and amount of different labels are more challenging to define in a planning phase. For example, a rocky geography can increase per meter labor price from about 5 Euros to dozens of Euros. Network rollout experience and field surveys help to decrease this risk. The most experienced operators did not considered this risk as significant, while some inexperienced operators considered it as one of the most significant risks in the subsidized projects.

The fourth risk, or actually the uncertainty and challenge, of the high-speed broadband investments are new services. Three fundaments must match in a working network business: demand, technology and services. Fiber technology is suitable; however, the services and the demand are not strong yet in the high-speed broadband business. Based on a user research of TNS Gallup (2011), 68% of internet users attach their present connection to fast enough in Finland in 2010. And according to Ficora's market survey (2011b), 74% of internet users have 10 Mbit/s or slower connection in Finland. Thus the most of users do not yet have demand for connection speeds which can be served only by fiber or other expensive advanced technologies. One reason for the low demand could be that the most of present services can be used with a 10 Mbit/s or even slower connections. The connection speed is mostly needed for the fluent use of basic services (FICORA, 2011c). This needed speed will grow with developing basic services; however, operators is challenging to sell expensive connections by little bit faster services, while these services also works with half cheaper connections. This challenge is emphasized in large broadband investments which must be performed predicting. The investment must be ready before large actual demand, not at the same time with it. Single services, which need a fast connection, could quickly increase the demand. However, this kind of key services, which affect wide demand, are not found yet, and their creation is hardly forecasted.

4.1.2.4.2. Risks of Publicly Subsidized Broadband Projects

The most significant risks of the subsidized projects are related to the fact that the projects are located in rural areas where population density is very low compared to needed investments. The risk of the low penetration is even greater due to the structure of the population in the project areas. The population is usually decreasing and its age structure is old in the project areas. The both of these facts decrease a probabilistic penetration and the number of potential subscribers. In the worst case, the number of the subscribers can decrease in time instead of increasing.

The risk of the low penetration is stressed by the lack of real demand information in the planning phase. Due to the lack of the demand information, the networks must be currently planned mainly to cover all the housing in a project area because any inhabitant would become subscribers. Thus, the subsidized backbones are planned to be as close as possible all the housing of the area, and the unsubsidized subscriber lines would stay short. Therefore, the length of networks increase, and the network backbone are also built for those housings which will never take a fiber connection. Thus, the lack of the demand information also leads to higher building costs in general.

The building risks are also stressed in the subsidized projects due to predefined building costs. The total maximum costs must be defined in the subsidy application. And if those costs are overrun, all overran costs fall for an operator. And on the other hand, a high cost estimation does not past the subsidy process, even though the subsidy is paid based on the really costs. Thus, the cost estimation must be accurate in order to avoid the extra costs and the declining of the subsidy application.

The predefined building costs and the lack of demand information together forbid the technological neutrality of the subsidized projects in practice which is specially risk for larger operators. If mobile broadband is also aimed to serve in a subsidized project, the backbone is usually first built to base stations due to lacking demand information. Fiber connections are later served to new subscribers through these base stations. However, the average length of subscriber lines would significantly increase with this model compared to the FTTH based network structure, thus the connection costs of one subscriber would also increase significantly. This inflicts high connection fees on subscribers or unprofitable connections on operators which is more probable option due to defined maximum fees in the subsidy application. Thus, based on the subsidy legislation, subsidized networks are profitable to build with the FTTH structure, while the technological neutral network needs to be built based on demand in order to avoid the double backbone building or long subscriber lines.

The public subsidy also brings some commitments including the leasing of a subsidized network, service commitments, and reporting. The interviewed operators did not conceive commitments as risks in general. Especially, the leasing commitment is not seen as a risk from the viewpoint of any operator. Actually, some operators hoped even tougher leasing commitments which would better support the open access principle. The reporting and long term service commitments were risks for some larger operators. In the worst case, own management processes must be made for the subsidized projects. Thus, the bureaucracy of the subsidized projects is attached too heavy by some operators compared to gained benefits. In addition, the significance and exactitude of the long term commitments are uncertain yet. The commitments are so long-lasting that their full significance is impossible to predict. Markets can significantly change during the over ten year commitments, and the commitments could become obstacles for change reacting. In the worst case, the commitments become too heavy for an operator and the operator must pay subsidies back.

4.1.2.5. Attraction Factors of Publicly Subsidized Projects

The theme interviews ended with question about factors which are basis for profitable publicly subsidized projects. The interviewees had a possibility to condense the most important factors here in the end of the first part of the interview. The two factors rose most clearly out of these answers:

- The first factor is local interest in fiber networks and fast connections. This is revealed by demand and activity in a project area. An attractive and profitable project needs active municipalities and inhabitants according to all the operators. Municipalities and inhabitants must actively want to get the network in their area. In practice, this can be seen in the willingness of municipalities to make demand surveys or arrange information meetings about a new network for inhabitants in a project area. Municipalities can also support marketing. And for small operators, municipalities are often also in the role of a funding guarantor.

- The second factor is related to the relationship between the subsidized projects and the overall strategy of an operator. First of all, an attractive project must mesh with existing and planned networks in the sense of geography, technology and business. The building of deviant networks would be unreasonable and expensive due to tailored and overlapping operations.

Operators want to use same kind of products, models and processes everywhere to keep costs in a low level. An investment, including its profitability, must mesh with the strategy.

4.1.2.6. Challenges of Broadband 2015 Project Beginning

The interviews revealed some challenges which are strongly related to the beginning phase of the Broadband 2105 Project. Some of these challenges were partly solved during this research, such as the impact of municipalities guarantee to the amount of the subsidy from the perspective of the EU legislation (Wouter, 2011). The long term of the projects inevitably creates uncertainties which are hardly defined in the beginning of the project. The following challenges of the project beginning came up in the interviews:

- The duties of the projects and their weight will be specified and realized in the future when developing markets and environment create new unexpected situations which would change the weight of the duties. For example, the operators are obligated to serve fiber connections with earlier specified prices in the project area during next ten years; however, the subsidy would not be paid afterwards according to the current subsidy legislation, even though the subscriber line would be longer than 2 kilometers.
- The continuation of the project has also been unclear due to new Finnish government and the limited subsidy which are expected to finish short because of the higher per meter costs of the rollout compared to the estimated costs of the Broadband 2015 Project (Vaalisto, 2011). The possible additional subsidy as well as the possible changes of the subsidy legislation depends on the new government. The legislation changes are expected due to the unaccepted projects and the upcoming intermediate control of the Broadband 2015 Project.
- The lack of experience can be seen in the first projects and their subsidy processes. Some of the big operators participated in the first projects just to gain experience. All the operators will probably evaluate again their relation to the subsidized projects after the completing of first projects. For example, some operators had estimated to face more competition in the first projects compared to the realized situation, thus some projects were participated, even though their profitability had been strongly uncertain. Therefore, these operators will possibly determine more critically the profitability in the future due to the realized poor competition.

4.1.3. Operator Group Specific Results

This chapter discusses the differences between operators and operator group specific results. The results are presented on a group by group basis by going through themes. These themes include strategy, profitability factors, profitability measuring, risks and mobile vs. fixed broadband. The comparison table of the operator groups is presented in the appendix 3.

4.1.3.1. Big Operators

4.1.3.1.1. Strategy

The big operators have own strategy for the subsidized projects which is approved by a national management group level of an operator or a government of an operator. Moreover, single projects or, at least, the bunch of projects are approved in the management group level. The strategy of the subsidized projects is closely related to an overall strategy which also gives guidelines for single projects. The big operators mainly concentrate on projects in their own area and next to them where they have already own fixed network. The projects of other areas are differently assessed and in different accuracy depending on a big operator. Until now, the subsidized projects have been in a special position compared to other investments. The first pilot projects have not been qualified with the general profitability requirements of investments. However, the projects will be qualified equally with the other investments in the future if the big operators participate on them in a larger scale.

4.1.3.1.2. Profitability Factors

The main profitability factor of the big operators is revenue generated by the connections and services of a project area. 80%-95% of project revenue is expected to come from them. The most of the big operators expect the fiber connections to be the main part of subscriber connections in the subsidized project areas for the present. In addition to these direct benefits, the big operators could indirectly benefit from the subsidized projects by using the projects for other network projects, such as renewing base station backbones, the larger strategic expanding of network or the rollout of back-up connections. The big operators aim to expand their 3G/4G network to cover almost the whole country and replace GSM technology with these new technologies during upcoming years (Prieur, 2009; Sajari, 2008). This fact has surely been taken into account in estimating the benefits of the projects. However, the remote location of base stations has become an obstacle for this indirect benefit, because the backbone network of the base stations is difficult to connect cost effectively with the FTTH-type topology of the subsidized network.

4.1.3.1.3. Profitability Measuring

The profitability measurement of the subsidized projects has been performed equally with other investments by the big operators. The subsidized projects compete an investing budget with other investments. This fact pitches high requirements for the profitability of the projects. The target payback times of network investments are from 5 to 12 years. The target penetration of the big operators is almost always higher than the expected penetration in the subsidized projects. The expected penetration of the big operators is from 10% to 30% level, while the target penetration is 50% or more. The expected penetration is based on historical data and a statistical estimation, which is a great uncertainty factor in the profitability measuring. However, the first subsidized projects had not had equally tough target values, thus low profitability of the pilot projects has been expected and accepted before hand by the big operators. Nevertheless, the big operators participated in some subsidized projects because they wanted to gain experience. If the big operators participate in a larger scale in the upcoming subsidized projects, the projects must fulfill totally same profitability requirements than other investments.

4.1.3.1.4. Risks

The greatest risk of the subsidized projects for the big operators is too low revenue level. This results from the low penetration which is challenge in rural areas where low population density is also decreasing. Furthermore, the impact of this risk is increased by the less accurate demand information of the big operators in a single project area. The penetration risk has been diminished by adding the penetration limits in the subsidy application. The limits allow an operator to cancel the project if a demand has stayed in a low level before the rollout. However, the demand is known until just before the rollout, and thus the planning costs become losses in the case of a rollout cancelation.

4.1.3.1.5. Mobile vs. Fixed Broadband

The big operators mainly assess the mobile and fiber broadband as supplementary technologies to each other. However, these technologies also appear as alternative solutions for the big operators in some cases, such as in sparsely populated rural areas. The fiber connection is not a reasonable solution in the most of rural areas according to the big operators. Instead, the connections should be primarily arranged by the mobile broadband which can reach higher bit rates due to development. In addition, the new low frequency bands, the former analogical TV bands, are expected to enable the larger cell sizes of mobile networks which improve the profitability of the rural area mobile broadband. These mobile technologies do not reach the same bit rates compared to the fiber; however, the big operators believe the developing mobile technologies to be enough for the most of used services. However, the fiber network is wanted to enlarge relatively close to all settlement, to base stations in practice, due to the increasing capacity demand of backbones.

4.1.3.1.6. Conclusion of Big Operator Results

The greatest challenge for the big operators is a low profitability in the subsidized projects. The high required rate of return and the short target payback time set profitability requirements in a high level, thus few subsidized projects can only reach this level from the perspective of the big operators. Furthermore, the big operators have challenges to get subscribers in the project areas which decrease the profitability of the projects even more. The low penetration is caused by the lack of local advantages, slight co-operation with municipalities, and the higher connection fees compared to the other operators. Moreover, the subsidized projects inflict much extra work and tailoring for the big operators compared to the benefits of the projects which decrease the attraction of the projects. The mobile broadband expansion targets of the big operators also affect on the fiber network investments, thus the big operators want to connect the targets of the mobile and subsidized projects. Nowadays, the connection is hardly implemented due to the requirements of the subsidy legislation. Instead of subsidized project participation, the big operators are seemed to concentrate on serving the mobile broadband and building or renting the needed backbone capacity in the rural areas.

4.1.3.2. Finnet Operators

4.1.3.2.1. Strategy

The Finnet operators have an own strategy for the subsidized projects which as well as single projects are accepted in the board level of the operators. The strategy of the Finnet operators seems to be the combination of the big and small operator strategies according to this research. The strategy of the Finnet operators could be closer either of the other strategies. The Finnet operators generally aim to participate in all the subsidized projects in their own area and next to it. The profitability is aimed to affect by controlling the extent of the projects. The Finnet operators usually gain a local monopoly position due to their strong presence and lacking competition. The local monopoly position is also the significant target for the Finnet operators according to the intensity of their local presence.

4.1.3.2.2. Profitability Measuring

The project profitability measurement of the Finnet operators is most significantly affected by fiber connections and services through them. However, some Finnet and small operators also estimate the impact of network leasing as 30 % of project revenue in the future. In addition to these factors, the profitability measurement of the Finnet operators is affected by the local interests which are significant factor for some of the Finnet operators.

The Finnet operators measure the profitability of the subsidized projects equally compared to other investments. The costs are most accurately estimated in the profitability measurement, while the accuracy of revenue estimations differs between the operators. The target profitability values are placed between the values of the small and big operators. The target payback time of the Finnet operators is about 10 years which is little more compared to the target of the big operators. The required rate of return also varies between the values of the small, 5 %, and the big operators, 10 % depending on the Finnet operator.

4.1.3.2.3. Risks

The low penetration also forms the most significant risk for the Finnet operators. However, the Finnet operators have decreased the risk by co-operation with municipalities which has provided more accurate information about demand and the settlement structure of the area in the future. Instead, the stretching of projects funding is a challenge for the Finnet operators for whom the size of the projects is relatively large. Thus, the Finnet operators must have delayed some other broadband investments to get enough founding for the subsidized projects. In addition, the after paid subsidy increases the funding challenge. This limitation will more strongly affect in the future due to unpaid subsidies of already performed projects and increasing pressure to launching the new subsidized projects and the delayed investments.

4.1.3.2.4. Mobile vs. Fixed Broadband

The Finnet operators assess the fiber as the only technology option for the fast broadband networks in the future. The mobile broadband is not believed to fulfill the needs of future developed services by the Finnet operators. However, the mobile broadband and its base stations are noticed in the network planning from the perspective of the network leasing.

4.1.3.2.5. Conclusion of Finnet Operator Results

The Finnet operators have actively participated in the projects resulting from three main factors according to the research:

- The Finnet-operators have well used their local benefits, local information and local contacts. Networks can be planned more responding with the demand and the penetration can be increased due to the co-operation. The locality is also a strong absolute value for some of the Finnet-operators which affect on the profitability target levels.
- Some of the Finnet and small operators estimate the leasing of networks to increase revenue about 30% in the projects. This is significant addition to the profitability of the subsidized projects.
- The Finnet operators estimated the expected penetration in the clearly highest level according to the research which affect greatly on the estimated profitability of the projects.

The Finnet operators will probably re-evaluate the projects more strictly when the Broadband 2015 Project progress. The lack of competition and limited investing capital direct the Finnet operators to discard projects or limit the extent of projects in their own area at least. The future will show how the Finnet operators can reach their high target penetration and exploit the network leasing. Thus, the activity of the Finnet operators depends on many still uncertain factors which can change the operational principles of the Finnet operators in the future.

4.1.3.3. Small Operators

4.1.3.3.1. Strategy

The strategy of the small operators is usually formed around of the subsidized projects and it focuses on rural areas where competition does not exist. The small operators do not want to start compete with the larger operators in the commercial areas according to the interviews. The strategy of the small operators is usually forced and created by local actives and municipalities whose activity is lifeline for the small operators in practice. The small operators are usually cooperative which also rules the decision making process of an operator.

4.1.3.3.2. Profitability Measuring

The revenue of subsidized projects is expected to be mainly generated by the fiber connections. However, some of the small operators as well as some Finnet operators expect to gain about 30-percent extra revenue by the network leasing. In contrast, some of the small operators have noticed the network leasing only as a possibility which do not have significant effect on the profitability of the projects. In addition to the revenue, the profitability of the small operator projects is affected by local orientation and the local benefits of the fiber network. Thus, the mission of the small operators is to produce inexpensive developed services for the inhabitants and companies of its area and improve the competitiveness of the area, instead of gaining financial profit.

The small operators measure profitability with some critical values. One significant factor is amount of the needed loan and its requirements. A project is simplistically profitable for the small operators when the estimated revenue of the project can cover the loan during the planned time. The small operators usually use 20 years or even longer payback times. This payback time is estimated to reach with 30-40 percent penetration by the small operators. A project is participated if the penetration is believed to reach the minimum level in the project. The penetration estimation and also demand surveys are usually supported by the simple pricing of services in which even connecting fees could be fixed for all subscribers in spite of the subscriber line length.

4.1.3.3.3. Risks

The small operators also estimated the low penetration as the most significant risk; however, relatively accurate local information and low profitability targets decrease the possibility of this risk. Instead, the long-term forecasting becomes a challenge for the small operators due to the long payback times and commitments. For example, the development of investment loans are impossibly forecasted over decades, thus the final price of the investment is uncertain.

4.1.3.3.4. Mobile vs. Fixed Broadband

The small operators assessed the fiber broadband as the only real technology option for the broadband services of the future which is important assumption and factor under the whole operation of the small operators. The small operators aim to ensure developed services with own fiber networks in their area without the dependence on the larger operators which have recently collected off some copper networks in rural areas and replaced them with mobile solutions.

4.1.3.3.5. Conclusion of Small Operator Results

The small operators can turn the projects profitable due to their zero-profit principle and long payback times. The small operators also have strong information about local actors and demand which assists to measure and gain penetration. In addition, the small operators estimate the building costs of the subscriber line in the low level compared to the other operator groups. This can be a good advantage or a surprising extra cost for the small operators in the rollout phase. The fiber networks of the small operators seem to be most profitable and also most inexpensive for the subscribers. However, their operation requires the local activity and commitment of municipalities and inhabitants for a long term.

4.1.4. Co-Building and Publicly Subsidized Projects

Co-building is strongly related to the broadband rollouts and the Broadband 2015 Project, thus it is also accounted for in this research, even though the subject cannot be thoroughly discussed in the limits of the research. The co-building is already mentioned in the subsidy law of broadband building (1186/2009, 6§). The law obligates the operators to make an explanation about the co-building in the subsidy application. However, co-building opportunities have been rarely exploited in the subsidized projects according to the research. In addition to the tele-operators, the two experts of an electric company were interviewed about the co-building for this research. The co-building was discussed with the experts from two perspectives: the pure co-operation and the business expanding of the electric company.

The co-building is not only co-operation between electric and telecommunication operators, but for example the builders of roads, district heating and municipality engineering also participate in the co-building. About 30% savings can be gained by co-building; however amount of the savings depend much on the number of participants. The co-building between electric and telecommunication companies is also forced by ageing electric networks and expanding fiber networks. In spite of these co-building benefits, the co-building are rarely exploited due to challenges related to it. Following challenges came up in the research:

- The law about electric network building is a challenge for the co-operation of electric companies. The law denies electric network building on the inner verge of a road, while the communication networks can be built there. Building costs are higher in the outer verge of the road, thus the communication network building alone becomes cheaper for the tele-operators on the inner verge than the co-building on the outer verge.

- Scheduling is challenging in every project in which many operators are participated. Common schedule finding requires much co-operation and advance for all participants.
- Building means are differentiated between the participants. The electric network can be renewed in piece by piece; however the fiber network is reasonable to build in an area at a time.
- Some electric companies still build electric networks as air cables which method is not used in fiber networks.

Thus, a successful co-building requires much co-operation, activity and bending for every participant. This co-operation can be and has been furthered by municipalities. Some municipalities already deny co-building in the infrastructure building of their area. The co-building is easier performed in the smaller municipality level when different actors are already familiar in this level. A co-operation system for co-building is also under development by the government.

The other perspective of the electric company interview concentrates on the opportunity of the electric companies to expand their business into the communication business. Fiber adding increases only marginally costs in electric network rollouts, thus the combination of these two businesses is very attractive. However, the combination is rare in Finland nowadays; even though it has become more common in some other countries, such as Denmark among electric network renewing and fiber network expanding (Pedersen, et al., 2009). In addition to challenges discussed with co-building, differences between these two businesses are considered challenging according to the interviewed experts. The new business cannot be just added to the old business, but this old business must be also modified. Furthermore, the experience about both businesses are needed combining which increases threshold to expanding. The expanding requires risk-taking and experience for the leaders of the company to move the company into new direction and markets.

4.2. Techno-Economic Analysis

4.2.1. Construction of Techno-Economic Evaluation

This chapter describes the research specific details of the techno-economic evaluation. The specific details are specially found in the planning and evaluation phases of the Verbrigge & all’s techno-economic evaluation process described in the method chapter. All the sub-phases of the Verbrugge’s evaluation process and the cost approach have not been used in the research; however the research has mainly followed the structure of the process. The used techno-economic model and its structure are found in the appendices 2 and 4.

The planning of the techno-economic evaluation included three phases: a literature research, expert interviews and pilot interviews. The literature research helped to produce the first versions of the model and interview. The second phase of the techno-economic evaluation construction, the expert interviews, improved the first versions of the models, and it was partly performed in the same time with the literature research. The interviewed experts consist of few public servants, who are dealing with the Broadband 2015 Project, and few communication researchers in the Aalto University. They evaluated and proposed improvements for the interview and model. The last phase of the construction, pilot interviews, is partly described in the previous chapter. From the perspective of the techno-economic evaluation, the pilot interviews enabled testing and improving of the interview and model. The techno-economic model and its structure were specifically improved in this phase when the possibilities and limits of the model were tested with real interviewees.

The analysis phase of the techno-economic evaluation includes a few special aspects that were important to account for in this research. The first aspect is a wide enough focus. Important facts are passed unnoticed in the decision process of the broadband projects if FTTH investments and their profitability are only analyzed in the subsidized projects. Same mistake happens if direct economic values and parameters are only considered. Thus, indirect benefits and motivators must be also accounted for in the interview and analysis (Verbrugge, et al., 2008a). Another aspect about the analysis is related to options for direct FTTH-type network investing. The operators have more than just two options: invest or not invest. Three options can be found for them at least. The first option, delaying a project, enables diminishing uncertainties, for example with better planning. The second option is different technologies, such as 3G and 4G, and leasing of backbone networks from other operators in the area. The last option is the combination of the previous options and straight FTTH-type network investing.

4.2.2. Sub-Models of Techno-Economic Model

4.2.2.1. Demand Modeling

The demand significantly affects on the profitability of the projects and the results of the model, however its estimation is challenging for the operators in the subsidized projects. The operators normally estimate demand by using their historical data about demand and statistical data about the area. Thus, the operators actually have no really demand information in this specific situation, and the estimation is realized only if the demand follows the statistical average. The market of the Broadband 2015 Project is new, thus the demand do not follow a general statistic in the projects and also in the case model situation of the research. Thus, the operators had to estimate the demand based on the experiences of few pilot projects and the general statistics.

The subscribers are divided into four groups in the techno-economic model: the customer A of permanent housing, the customer B of the permanent housing, impermanent housing and offices. Only the subscribers of a subsidized project area are observed in the model. The subscribers of subsidized networks can be also found outside of a project area and their effect on profitability is accounted for by the theme interview. The subscribers of the permanent housing are divided in the two groups in order to observe better differences between subscribers. The customer A is a basic user who uses slower connections and only few additional services. The customer B is a more advanced user who uses faster connections and also regularly some additional services.

The demand is defined with three variables per a subscriber group in the techno-economic model. The first variable, penetration in the beginning, describes how many percentages of the project area housing and offices are estimated to take a fiber connection in the same time with the backbone rollout. The second variable, penetration in the end, estimates what will be the penetration after a transition period. The last demand variable, the transition period, defines time to move from the beginning penetration to the end penetration.

4.2.2.2. Cost Modeling

4.2.2.2.1. Capital Expenditures (CAPEX)

Capital expenditures (CAPEX) are fixed investment costs which are expended for future businesses such as machines, equipments or infrastructure (Horngren, et al., 2009). The benefits of the investment are achieved in a long-term. These CAPEX are the significant part of the broadband business total costs, because of the CAPEX of the first rollout year could be thirty times larger compared with the annual operational expenditures according to the case-research. The CAPEX of a broadband investment can be divided in two main categories: subscriber-specific costs and backbone costs. This categorization is specifically needed when the publicly subsidized projects are discussed. The subsidy mainly covers only the CAPEX of backbone network. Over 2 kilometers long subscriber lines make exception, then the subsidy also covers the over 2 kilometer part costs of the subscriber line.

The backbone rollout costs are estimated per a project in the subsidized projects, and they mainly consist of laboring, that is the most expensive part by covering over 50 % of the costs; fiber cables; accessories; and equipments. (Edgren, 2010; Verbrugge, 2008c) The rollout costs are estimated by per meter costs in the model. The operators were able to measure per meter costs based on the backbone length of their own real project and the total costs of the backbone which must be also defined in the subsidy application. The subscriber-specific CAPEX are defined in the model by the average length of subscriber lines, the fixed connection costs for a short subscriber line, and the extra costs per meter based on the length of the subscriber line. The subscriber-specific CAPEX consist of all costs which are needed for a ready-to-use connection including a network termination.

4.2.2.2.2. Operational Expenditures (OPEX)

Operational expenditures (OPEX) include variable costs generated by continuing operation, such as maintenance and salaries (Horngren, et al., 2009). The OPEX of broadband business consist of repairing, energy, housing, maintenance, marketing and billing (Verbrugge, 2008c). The OPEX are challenging to separate into project-specific parts or even more into subscriber-specific parts. The OPEX is not strictly dependent on the number of subscribers thus one new subscriber affects small or no increase in the OPEX. Only the larger increase of subscriber number clearly increases OPEX in the network business.

The OPEX were roughly estimated in the model by the annual stabile costs of the network and the additional monthly OPEX per subscriber. The OPEX were simplified just into the annual costs per project in the final model due to the challenges of the operator estimations.

4.2.2.3. Revenue Modeling

The revenue is income flow which is generated by selling goods and services. Subscribers generate usually the main revenue of operators in the rural area network business. The other source of incomes is the leasing of a network which could become a significant business for Finnet and small operators due to their local monopoly position. The leasing of a network could include serving of enterprises, operators and public administration customers.

Subscriber specific incomes are estimated by three fees in the model: connection fee, which is charged once; monthly flat rate fee; and possible additional service fees. The connection fee was usually defined with the fixed part and the per meter part of price by the operators. However, some operators had only a fixed fee for all connections regardless of a subscriber line length. The monthly flat rate fee of the model includes a network fee in addition to the internet connection fee. They are also usually charged together in practice. The additional service fees are generated by using extra services, such as IPTV, ReTV and movie renting.

4.2.3. Values of Techno-Economic Model

The operators were given starting values for the case project, which were the base of their evaluation. These starting values were formed with the experts of the government according to their knowledge about average subsidized projects which cover about the area of a municipality. A single subsidized project consists of one municipality area in the maximum; however no operator expands its network with smaller part than municipality according to the research. Thus, the reasonable unit for the subsidized projects is approximately the size of the municipality in the case model of this research. This area includes only the subsidized parts of the municipality. The starting values consist of the subsidized backbone length (230 km), the total number of permanent housing (600), the total number of impermanent housing (1000) and the total number of offices (100) in the project area. The structure of the model is described in the figure of the appendix 2 and the model table is presented in the appendix 4.

After the values were gathered for the model, the average values were calculated for every operator group. The group values are usually group means which is calculated with two values at least. Three exception values were measured differently due to the comparability and reliability of the results. The most challenging exception value, OPEX, was modeled as a fixed value which is same for all the operators. The used OPEX of the model is the mode and approximately median based on the reasonable estimates of all operators. The half of the operators were not able to give reasonable estimates for OPEX due to its complexity, thus the group specific values would have been no reliable. Other exceptions are the length of the subscriber line and the depreciation time. These values were also calculated based on all the estimates and the same values were used for every operator group. The equal values assist group comparing; in addition, all the estimates were very equal in these parameters. Almost every operator defines the deprecation time in the 20 years. The average length of the subscriber line was also estimated mostly around 300 meters which is the used value of the model.

4.2.4. Strength and Weaknesses of Techno-Economic Model

The used techno-economic model of the research was kept in a simple and rough level. The varying inputs and the limited extent of the research defined the level of the model. In addition, the most of the operators had not very specific information about different parameters. Instead, many of their values were rough estimations which were based on larger overall values. This simply model enables the calculation of the operator group averages when the values of the different operators can be presented in the same form. The average values enable the confidential data usage and the security of individual operator values.

Due to the rough model, some specific data could not be used when the data had to be generated in the same format than the roughest input data. In addition, some factors were omitted from the model because of the same reasons. For example, other than the fiber subscription revenues were omitted from the model. These other subscriptions varied widely depending on operators thus a same model would not have fit in all these cases. Information about these other income sources was also usually rougher. The income sources, which are not included in the model, consist of mainly mobile broadband subscriptions and the leasing of backbone for mobile operators. For some big operators, the mobile subscriptions and backbone using for base stations were notable factor in a profitability analysis of the projects. However, the value of these factors also differed between the big operators and their significance was usually marginal in general.

In spite of the rough model and missing factors, the model well accounts for the main factors of the subsidized projects and gives easily comparable results which is important for the analysis. In addition, the missing factors of the model were accounted for in the theme interview.

4.2.5. Results of Techno-Economic Model

The results of the model are discussed by presenting first direct estimates and next processed values, such as NPV.

The operators estimated probable penetration after ten years from the rollout in the case project. These measures are shown in the Figure 6. The Finnet Operators have clearly the most optimistic view about the probable penetration by estimating penetration twice as high as the big operators. The estimated transition times varied from four to seven years, and the median transition time was five years.

Figure 6. Penetration estimations after 10 years from the rollout in the case project.

CAPEX consist of the planning costs, the subsidized backbone rollout costs and the costs of subscriber line building. All the operator groups measured the planning costs of the case project in the level of 20000 Euros on average. The share of the planning costs is marginal compared to the total CAPEX of the project; however, if the project is not performed, the planning costs become just losses. The per-meter costs of the subsidized backbone network were measured on an equal level by the operators, as the Figure 7 describes. The measurement of the small operators was slightly higher, 12 €/m, while the others measured it in 10 to 11 €/m.

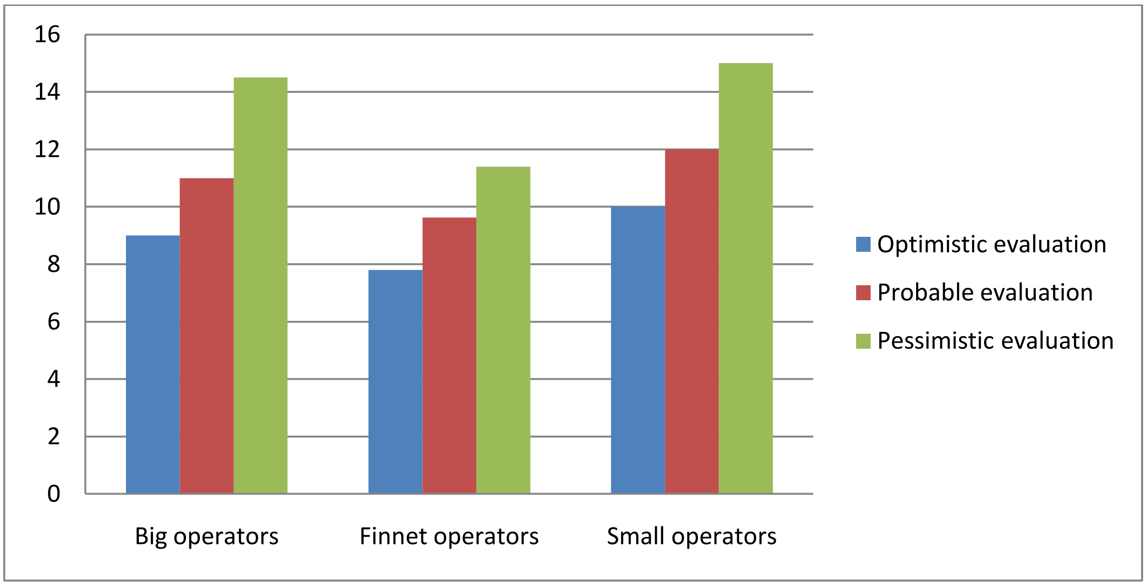

Figure 7. Estimated per-meter costs of the subsidized network (The total costs of the subsidized case network/ the length of the subsidized case network (€/m))

The cost of the subscriber line building clearly differ between the operator groups contrary to the estimated per meter costs of the subsidized network. The 300-meter-long subscriber line cost estimation of the small operators was significantly in a lower level compared with the estimations of the other operators, even though the small operators estimated the per meter building costs slightly higher level. The Figure 8 illustrates the estimation of the small operators to stay under 2000 Euros while the other operators estimate the cost in the 4000 Euros level. The estimations were asked including all necessary costs needed for a ready-to-use connection. The self building posibility was noticed separately in the interview, thus it could not also explane the difference. Due to the scale of the difference, the difference can result from no single anomalous estimation. Thus, eather the small operators can build subscriber lines inexpensively compared with the others, or they estimated too optimisticaly the building costs, or the other operators estimated too pessimistically.

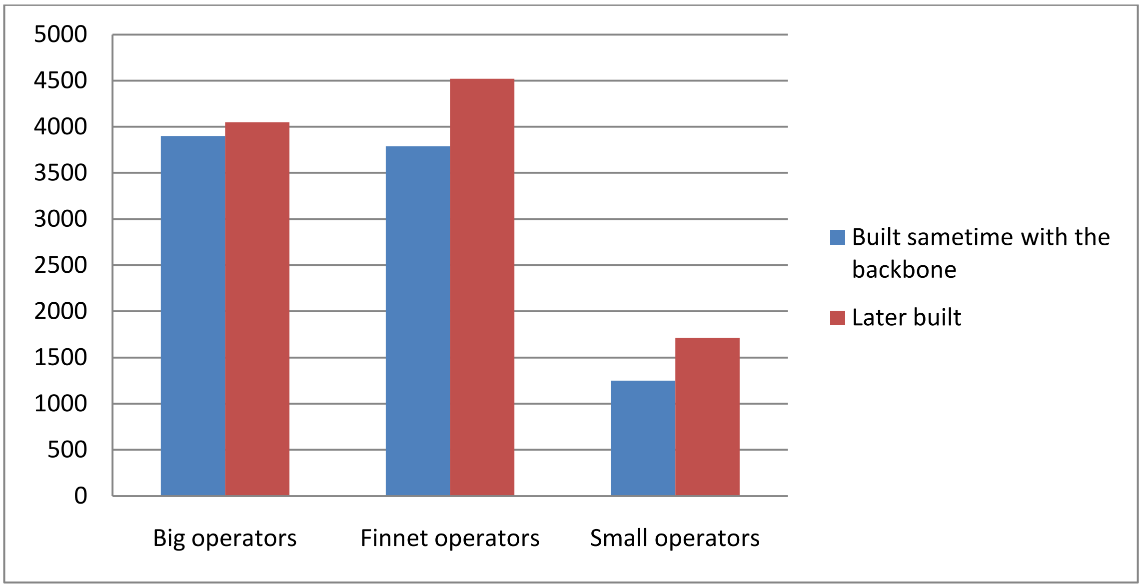

Figure 8. Estimated costs of a 300-meters-long subscriber line building.

The wider view about the demand and CAPEX estimations is given by the rate of the estimated total CAPEX and subscriber number. The costs per subscriber are estimated significantly higher by the big operators due to the low estimated penetration. The cost per subscriber of the small and Finnet operators are in the equal level, as it can be seen in the Figure 9, though the small operators estimated the penetration in the lower level. The lower penetration of the small operators is compensated by their low subscriber line costs in the costs per subscriber.

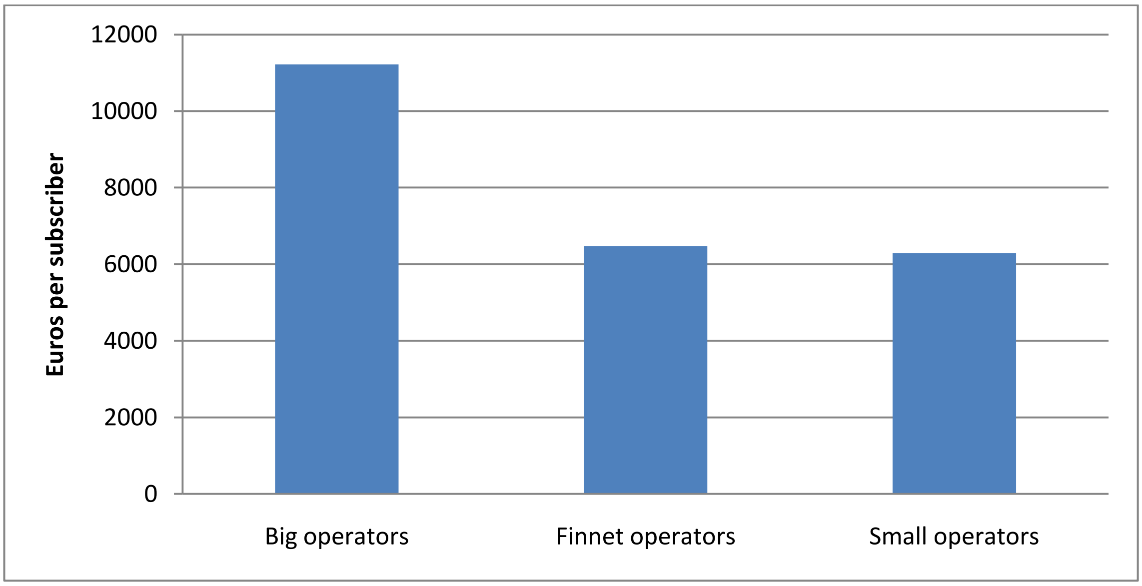

Figure 9. Estimated total CAPEX divided by the estimated number of the subscribers.

The challenges of the OPEX estimation were revealed during the interviews. Especially, the OPEX was hardly estimated in the level of the project or subscriber.

Moreover, the OPEX estimations significantly varied and some of the estimations were unusable in this research due to their inaccuracy. Due to these challenges, the fixed and equal OPEX are used for all the operator groups in the techno-economic model. The used OPEX value were created based on the most accurate estimations of the operators, and the used value, 125 000 Euros per year, is rough mean and mode of these estimations. In practice, the OPEX can be estimated little lower for the larger operators because they produce their services by themselves. In contrast, the OPEX of the smaller operators is probably higher due to wide outsourcing. The OPEX of the model stays in the same level, though the number of the subscriber increases in the model.

The most unexpencive connection of every operators can be got with the price of about 45-50 Euros per month. In contrast, the connection fees significantly differed between the operator groups. The Figure 10 demonstrates that the connection fees of the big operators is trible larger compared to the fees of the small operators. Some of the operators also use fixed connection fee pricing, in which the fee stays same, even though the length of the subscriber line differs. Thus, the difference between the fees of the operators increases even more when the length of the subscriber line increases. However, the operators, that have already participated in the projects, estimated the average lenght of subscriber lines on under 400 meters level. Thus, the fixed 300-meters-long subscriber line is used for all operators in the techno-economic model which also improves the comparability of the other results.

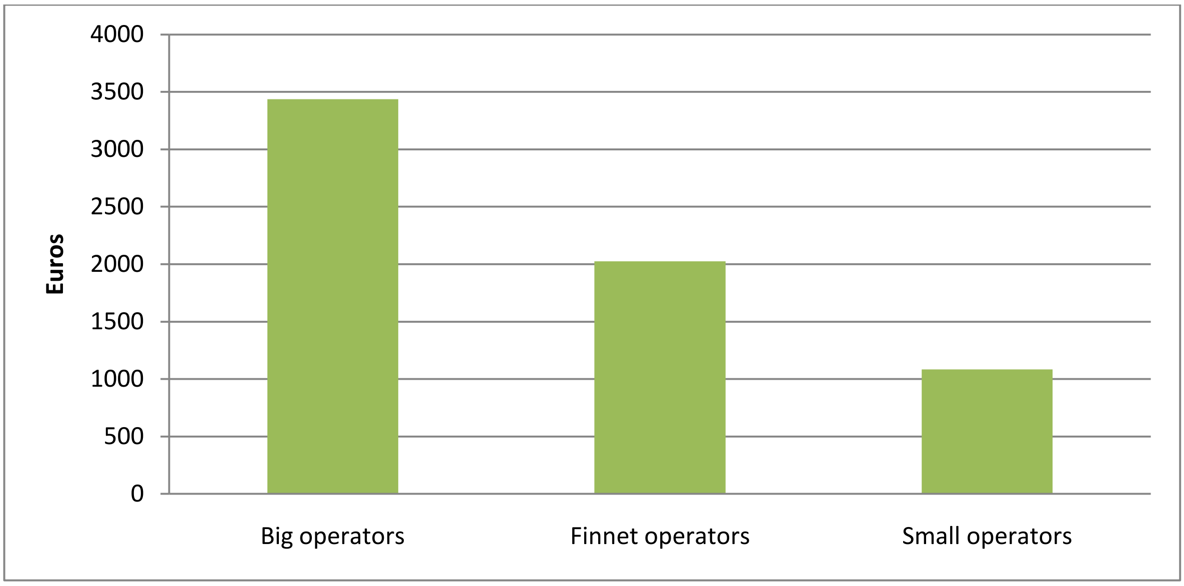

Figure 10. Average connection fee for a 300-meters-long subscriber line.

The cash flows, according to the estimations of the operator groups, are illustrated in the figures of the appendices 5, 6 and 7. The figures demonstrates the costs being significantly greater in the first, building, year; while the incomes spread evenly on the whole period with the exception of the public subsidy which is paid once. The costs of the first year were estimated over ten-times greater compared to the costs of the other years.

The economic target values of the operators are expected. The Table 1 shows the required rates of return and the payback times of the operator groups and demonstrates that the larger operators have higher targets compared with the targets of the smaller operators. The required rate of return effects are clearly seen in the NPVs and the Present Value of Cumulative Cash Flows (PVCC), such as in the Figure 11. The high rate decreases the benefits of the future cash flows, thus the increase of the PVCC declines fast with the high rate and the NPV stays in a low level. The target payback time defines the critical time period in which the PVCC of the investment should turn positive or neutral at least. The high economic target ratios are one significant reason for the high connection fees of the big operators and moreover the low activity of the big operators in the subsidized projects. The big operators should gain back the large costs during the short target payback time, thus the early incomes are in the important role, and thus the connection fees and other fees increase, and finally, the penetration decreases due to the high prices.

Table 1. Economic target ratios of the operator groups.

	Big operators	Finnet operators	Small operators
Required rate of return (%)	10	8,5	4
Target payback time (years)	Under 10	About 10	About 20

The Figure 11 illustrates the PVCCs of the operator groups calculated with the estimations of the operators during 20 years. The PVCCs of the small and Finnet operators are able to change positive during the observed period. The PVCC of the small operators reach the zero-limit in eleven years resulting much from the low required rate of return and subscriber line costs. The Finnet operators reach the positive PVCC in 17 years resulting significantly from the high penetration estimations. The NPV of the big operators stays clearly negative. The revenue of the fiber connections and the services through them are only observed in the calculation of the Figure 11, thus the revenue of other businesses, such as network leasing, are missing in the figure.

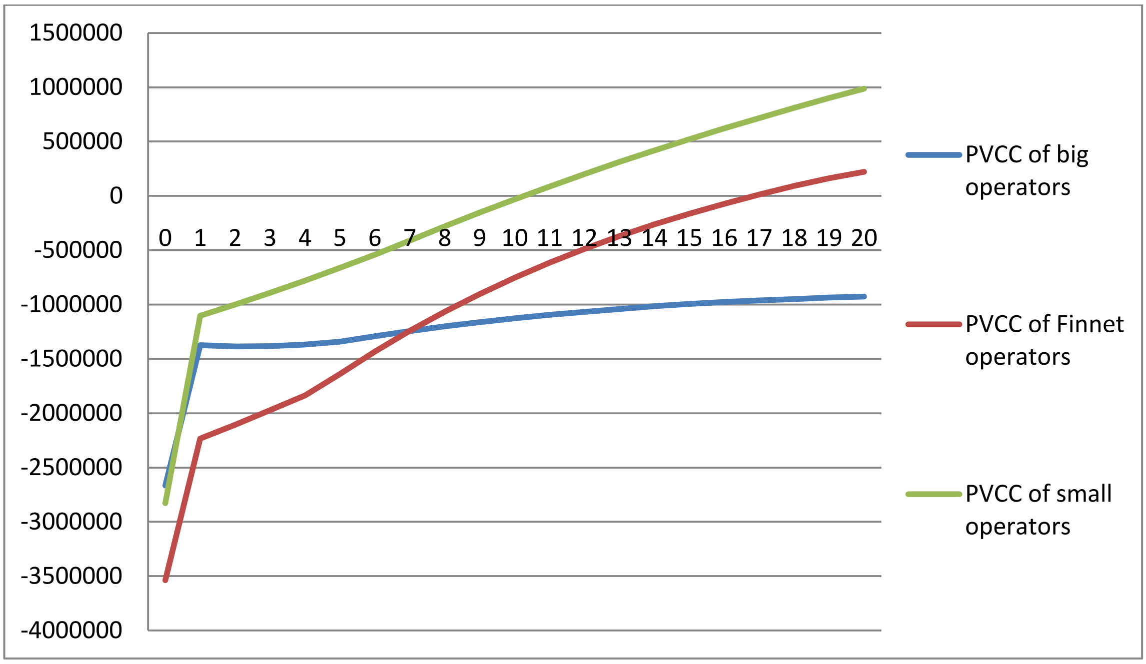

Figure 11. Present Value of Cumulative Cash Flows (PVCC) based on operators estimations in the case project during first 20 years. (Fiber connections and services through them are only observed.)

The Figure 12 illustrates the estimated cash flows and PVCCs of the Finnet operators with the probable and pessimistic penetration estimations. The most significant differences between the estimations can be found in the penetration of the permanent housing, which stays in 40 % instead of 70 %, and the penetration of the impermanent housing, which stays in the 20 % instead of 35 %. However, the pessimistic estimations of the Finnet operators equal with the optimistic estimations of the big operators. The pessimistic penetration forces the PVCC to stay clearly negative in the observed period. Thus, the sufficient penetration gaining is a key factor in the profitability of the rural area broadband investments.

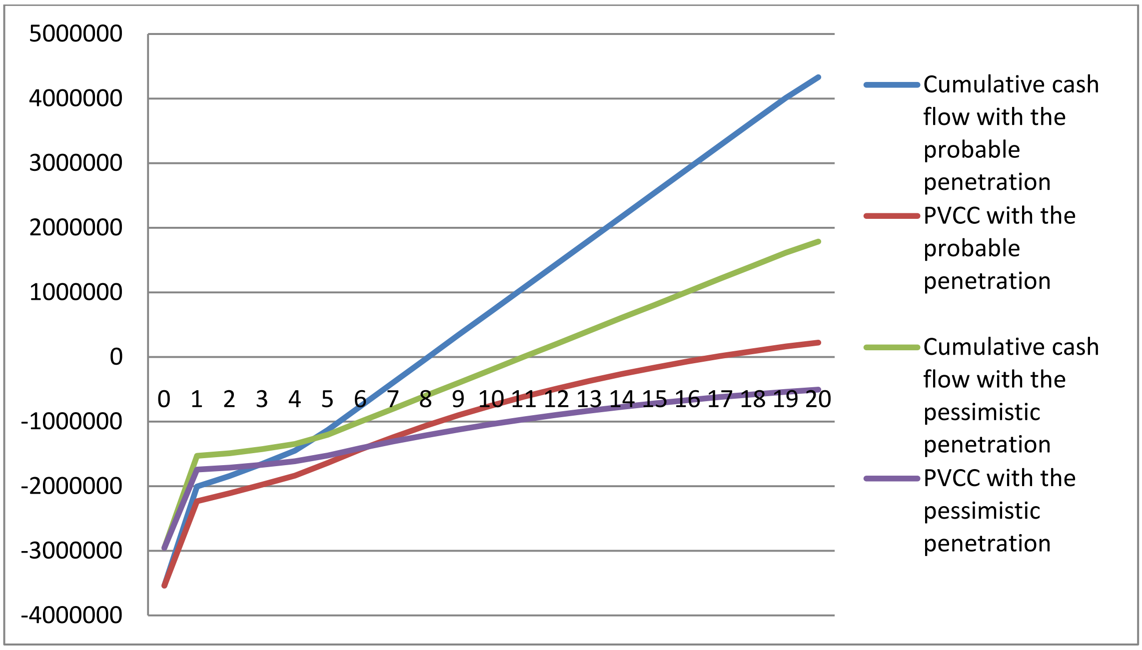

Figure 12. Effect of pessimistic penetration on the cumulative cash flow and the PVCC of the Finnet operators in the case project.

The 30 % increase of the revenue, as the result of the leasing estimation of some operators, significantly improves the payback time and NPV of the Finnet operators. The payback time of the Finnet operators shorten to 12 years with the network leasing which is close to the target payback time of the Finnet operators, about 10 years. The network leasing has been noticed from the fourth year due to the expected delay of the leasing benefits. The effect of the network leasing is illustrated in the Figure 13.

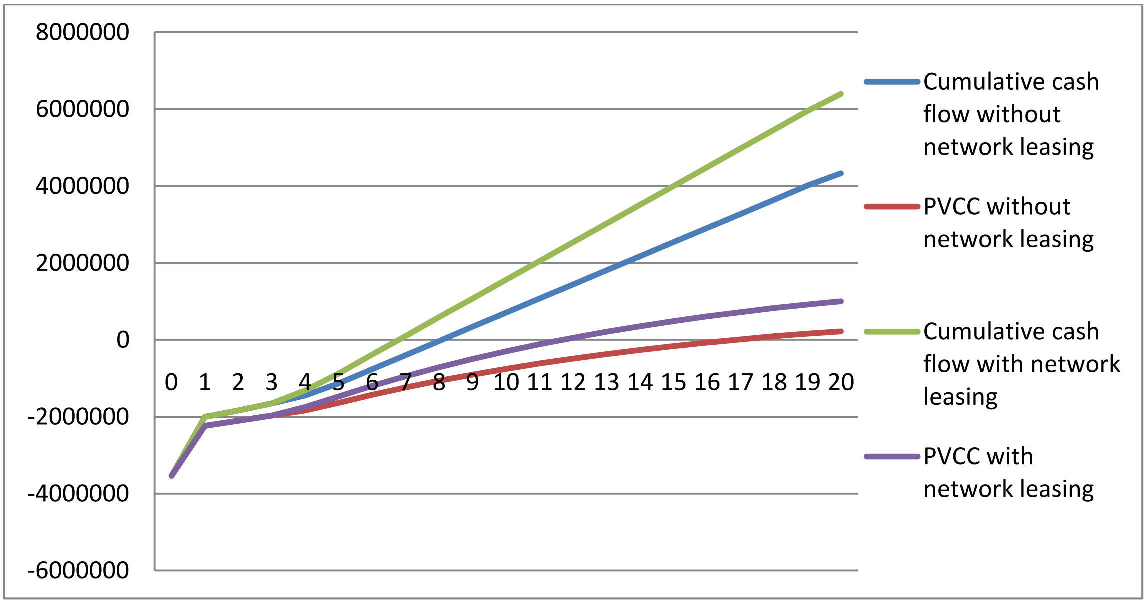

Figure 13. Effect of the network leasing in the cumulative cash flow and PVCC of the Finnet operators. (Network leasing increases the revenue with 30% after year 3.)

The results of the techno-economic model complement and support the results of the theme interviews. The quantitative estimation of techno-economic model and the qualitative answers of the interviews correlated in their common parts. The model confirms the differences between operator groups and points the significance of the profitability target values for the whole profitability estimation. In addition to the target values, the most significant revealed factors of the model were the low penetration estimates of the big operators, the high penetration estimation of the Finnet operators and the low subscriber line costs of the small operators. These operator specific factors mostly caused different profitability measurements in the case model. In addition, the network leasing seems to be important extra business which can improve the project profitability into the target level. However; according to the model, the key factor of the subsidized projects is clearly the penetration which differs between operators and projects and is hardly forecasted without a demand survey in rural area investments.

5. Conclusions

5.1. Results

The research revealed the three essential factors for operators in the rural area broadband investments:

- The rural area broadband investments must *co-ordinate with the overall strategy* of the operators. The co-ordination must emerge in all levels, such as geography, business, pricing, and future vision. Specifically, the co-ordination is needed in the profitability definition and the profitability targets of subsidized projects. The profitability potential of the projects was the main reason for the limited investments; even when the public subsidy was used. In fact, the differences in the operator activities can be partially explained by *the different profitability definitions of operators*. In practice; the profitability definitions, such as the expected payback time and the required rate of return, define the possibilities of operators for profitable investments. The projects have limited profit potential, thus the profitability definition of the operators must fit in these limits.
- *The penetration* must usually reach 50 percent in a profitable rural area broadband investment due to the sparse population of the areas. Thus, the penetration level is the second significant reason for the differences in operator activities in the rural area broadband investments. Different penetration levels were explained by the different price levels and the varying exploitation of the local connections in the subsidized projects. The challenge of the penetration has been also increased by uncertain advanced information about the demand.
- The rural area broadband investments need *the activity of municipalities and local inhabitants*. The lack of activity usually indicates poor penetration in rural area. All the operators agreed about the importance of local activity in the subsidized projects. Local activity is needed for successful investments in rural areas. For example, municipalities can promote investments by guarantying loans, making market surveys, supporting co-building and assisting in network planning.

In addition to the above three factors, the research provides a good tool for the segmentation of operators by dividing the operators into three groups based on their characteristics. Even though the segmentation was performed in the beginning of the research, the results confirm the reasonability of the segmentation. The subsidized projects, in which all operators wanted to participate in principal, revealed differences between the operators because of the project challenges.

5.2. Assessment of Results

The research, interviews and techno-economic model are strongly based on the experiences of the Broadband 2015 Project. However, the main results can be applied in all rural area broadband investments. Subsidies certainly bring some legal duties to operators; however, the main reasons and critical factors are important regardless of subsidies. Thus, the results can be used in any rural area fiber broadband investment.

The first critical factor, the co-ordination with the overall strategy, is needed in any investment not only in subsidized broadband projects. Especially, the profitability requirements of the investment must co-ordinate with a target profit in the rural area. The rural area always brings challenges in profitability, thus profitability target values are very important when the co-ordination of potential investments are evaluated. Moreover, the effect of these values is greater in broadband investments due to the long term nature of the investments.

The penetration is also a challenge for all rural area broadband investments, not just for subsidized projects. The low population density always forces operators to carefully estimate possible penetration on a case by case basis. Profitable penetration also requires co-operation and tailored marketing in rural areas in order to change all the demand of the sparse population to the subscriptions.

The local activity also becomes a critical factor in any rural area broadband investment where the profitability is a challenge. The local activity is needed for tailored inexpensive solution finding and penetration ensuring.

5.3. Exploitation of Results

The results can be widely exploited in the broadband investments of rural areas as described in the previous chapter. However, this chapter concentrates on how the results can be exploited in the Broadband 2015 Project due to its centrality in the research. Specifically, the results give tools for the government to understand and improve the subsidy system and for the municipalities to explore different possibilities for acquiring fast broadband. The research reveals the characteristics of different operators, and gives limits for operator expectations, which have been too high in some areas. A few practical exploitations of the results are presented next.

The big operators have rarely participated in the Broadband 2015 Project due to low profitability. The fundamental profitability factors of the areas, such as population density, cannot be easily changed, thus the indirect benefits are needed to increase interest of the big operators in the fiber broadband investments of rural areas. The big operators can be encouraged by improving the possibilities to connect the fiber and mobile broadband strategies. This change probably means the transformation of the Broadband 2015 Project strategy, as keeping the current strategy will likely limit the participation of the big operators in the future.

The risk and uncertainty over penetration rates and future demand could be diminished by advanced demand surveys, thus the network plan could be based on the real demand. All the interviewed operators described the surveys as too expensive and heavy to be performed by the operators. However, some municipalities have already performed the surveys themselves. Other municipalities could also invest in the surveys in order to provide a better base for operators to invest. The surveys function as a promotion for operators to invest in the area.

Municipalities can also perform the surveys in advance thus the demand is known in the planning phase of projects which enables the planning of demand based network structure. The reliability of the surveys can be improved by co-operation between local operators and municipalities in defining the realistic maximum price level of provided connections for the survey. The demand can be defined more accurately with the maximum prices, and even precontracts between an operator and a subscriber could be made during the survey. Due to known demand, the network could be planned based on real demand which would decrease the costs per subscriber. The advanced pricing would not be conclusive for the operators due to unknown demand in the pricing phase. The pricing would be used if the earlier estimated demand is found in the survey. This possibility could incentivize the operators into offering lower prices to gain higher penetration without the risk combination of the low penetration and low prices.

The demand based network planning could be supported by incentivizing earlier adopters and punishing late adopters. For example, the prices would be kept low in the beginning which would incentivize inhabitants into connecting in the early phases. While those adopting later would face significantly higher prices due to higher operator costs and the operator missing the possibility of a subsidy.

5.4. Future Research

As the Broadband 2015 Project progresses, new information about the subsidized projects is being gathered by the operators and other actors of the projects. Information from the first completed projects will define the real costs and demand for different operators. After this, the estimates for the Broadband 2015 Project could change significantly. Thus, additional research after the first round of the projects would give interesting results related to the projects and enable comparisons between the estimates and realized values. However, the factors underlying the operator decisions would probably stay relatively stable, even though the environment would change.

According to this research, municipalities play a key role in the subsidized projects and also in rural area broadband investments in general. Thus, further research should examine the subject from the perspective of municipalities. The co-operation between the municipalities and the operators is imperative for the success of the Broadband 2015 Project. Both views, the operator and the municipality, must be accounted for and understood.

Co-building was discussed only superficially in this research due to the limits of the work. Wider research would give a more specific picture of co-building and its challenges in Finland. Thus, a deeper analysis and recommendations could be given about co-building development.

The mobile broadband is not viewed as a real high-speed broadband option in the Broadband 2015 Project or in this research due to the high connection speed requirements. However, the potential of the mobile broadband is constantly increasing and it could be a viable substitute for fixed high-speed broadband in future. Research with more flexible connection speed requirements and future mobile technologies would likely reveal new options for the high-speed broadband strategy of rural areas.

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Appendix 1. Question Outline of Theme Interview

"G" before a question means that the answers were wanted from the perspective of broadband investments in general. "P" before a question means that the answers were wanted from the perspective of publicly subsidized broadband investments.

Broadband Strategy of Operators

- G/ How do you create a broadband strategy in your company? In which level, is the strategy created?
- P/ Do you have an own strategy for the publicly subsidized broadband investments?
- P/ Are there some essential differences between the publicly subsidized broadband investments and other broadband investments?
- GP/ Which kind of motives do you have for creating of (rural area/) broadband strategy and measuring of profitability? (Straight incomes, duty, sociological reasons, higher strategy) Is there indirect financial motives? How large effort have they compared with direct financial factors?
- P/ How does the public subsidy affect on the broadband strategy and profitability of broadband investments?
- P/ How does the leasing duty of publicly subsidized networks affect on the attractiveness of the broadband projects?
- P/ What kind of options do you have for fiber broadband investments in rural areas or immediate investing?
- P/ How do other broadband investments affect on profitability and attractiveness of the broadband projects?
- P/ Have you considered fiber network building with some other technology than FTTH?
- GP/ What kind of option is the mobile broadband for the fiber broadband? Do the strategy of the mobile broadband affect on the strategy of fiber broadband?

Risk of Broadband Investments

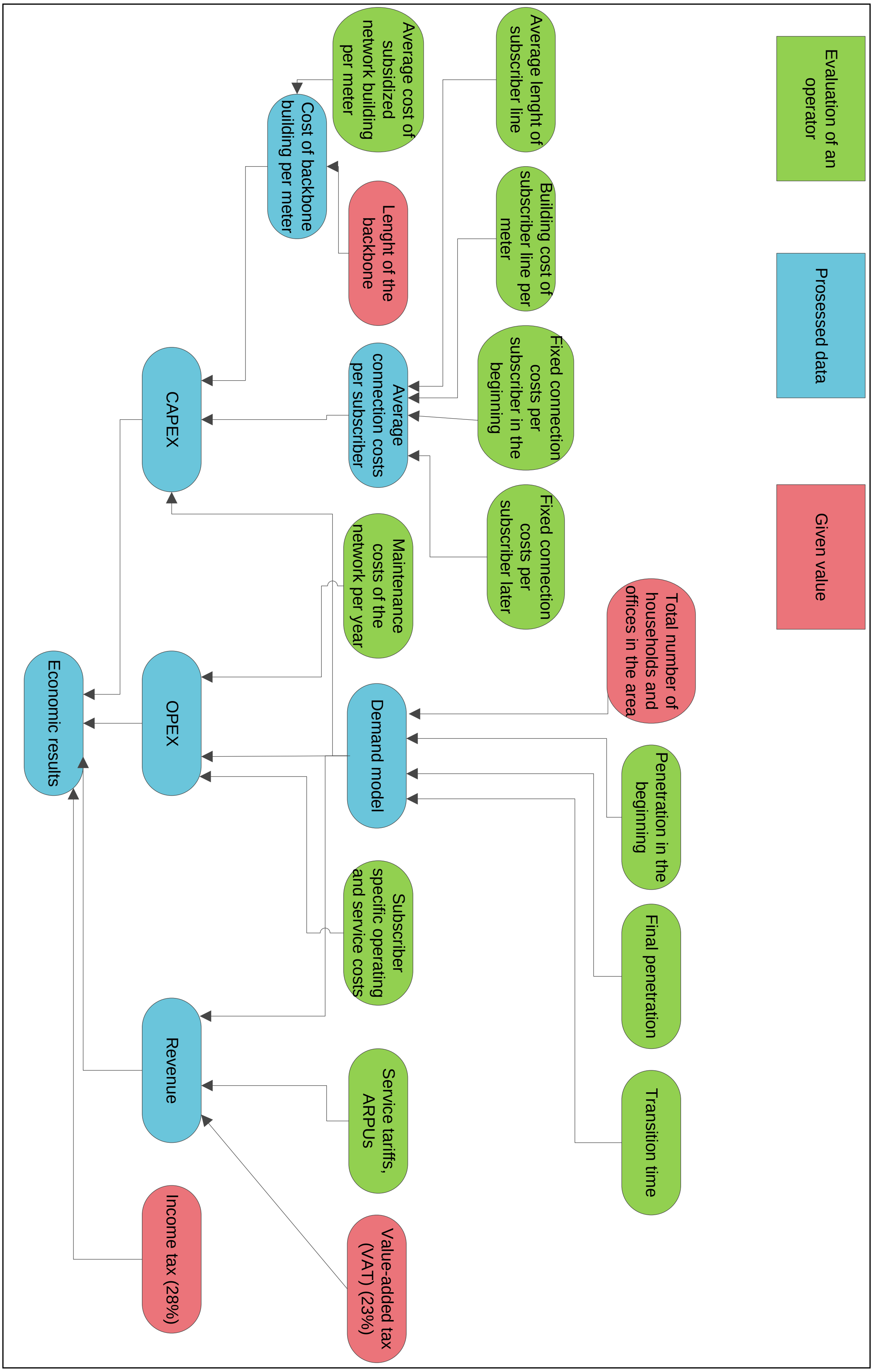
- G/ What kind of risks do broadband investments have?
- P/ Do the publicly subsidized broadband investments have some specific risks? (E.g. decreasing of population in the project area or uncertain paying time and size of a subsidy)
- GP/ How probable do you estimate the risks?
- GP/ Which of the risks are the most harmful if it comes true?

- GP/ What kind of risk analysis do you do for potential investments?
- GP/ What kind of limits do you have for risk parameters? (E.g. penetration or population)
- P/ Have the publicly subsidized investments different risk limits compared to other investments?
- GP/ How could essential risks be minimized? (E.g. Demand surveys) How large effect do these methods have?

Own Profitability Measurements and Criteria of Operators

- GP/ How do you measure the profitability of broadband investments compared with other investments? Are broadband investments just an investment like the others?
- GP/ How do you measure potential broadband investments? What kind of elements is used in the measuring? (E.g. Strategy, some specific indicators or variables.)
- GP/ Are the measures and indicators equal compared to other investments?
- GP/ What kind of values and limits do you use in the indicators? (Time period, is an aspired ROI about 10% like usually in ICT sector?)
- P/ Do you measure publicly subsidized broadband investments in different than others?
- GP/ How do you describe a profitable broadband investment from a perspective of an operator? (Penetration and so on)

Appendix 2. Structure of Techno-Economic Model Case Table



Appendix 3. Comparison Table of Operator Groups

	Big operators	Finnet operators	Small operators
Strategy	The subsidized projects are the part of the overall strategy. The projects are mainly concentrated on the own area or next to it.	All the projects of own area and next to it aim to be participated.	The business usually bases on the subsidized projects and concentrates on the rural areas. The small operators do not want to compete with larger operators in the commercial areas.
Profitability factors	The broadband connections and services through them are the main source of the revenue. In addition, the overall strategy supporting factors, such as base station backbones renewing, are aspired to use; however, their importance is usually relatively small in the profitability of the projects.	The financial profitability is mainly gained by the fiber connections; however, the network leasing will also become important business for some operators with about 30 % revenue increasing. The importance of the interest group benefits differs between operators from significant to minor.	The financial profitability is mainly gained by fiber connections. Some small operators also notice network leasing in their profitability measuring. The indirect benefits for interest groups, such as municipalities, are in the significant role.
Profitability measuring	The subsidized projects are measured equally with other investments and the projects contend for investing budget with the other investments. The first projects have had special position in the profitability.	The subsidized projects are generally measured equally with other investments of the own area.	The specific limit, such as penetration, is set for the profitability of a project. If the limit is qualified, the project is participated. Municipalities usually participate on the measuring process.
Target payback time	Under 10 years.	About 10 years.	20 years or even more.
Required rate of return	About 10 %.	Differs between the values of the small and big operators.	About 5 %. Related to the interest rate of an investing loan.
Risks	The low penetration is the significant risk for the big operators which do not have strong and wide local connections and information. In addition, some of the subsidy duties are uncertainties in the long-term investments.	The low penetration is the most significant risk, which is decreased by the locality. The limited capital is becoming a challenge in the fast project schedule.	The low penetration is a significant risk; however, it is smaller compared to the larger operators due to local information and engagements. The development of the loan interests is risk with the long payback times.

Mobile vs. fixed broadband	The mobile and fixed broadband are usually supplementary technologies; however, they could also be alternative in some cases, such as in rural areas. The mobile broadband should be supported equally with the fixed one in the subsidized projects. The high targets of the 3G extension increase the willingness of the big operators to use the subsidy in the mobile broadband.	The fiber broadband is assessed as the only solution for the communication services of the future. The mobile broadband is not a relevant alternation for the fiber broadband. However, the mobile communication base stations of the big operators are noticed in the network planning from the perspective of a network leasing.	The fiber broadband is the only long-term solution for ensuring of the developed services. The mobile broadband is not a relevant alternation for the fiber broadband. However, the mobile communication base stations of the big operators are noticed in the network planning from the perspective of a network leasing.
Important factors in the interesting high-speed broadband investment	The development of the population structure and business activity must be positive in a project area, and the local activity must be found. In addition, the project must co-ordinate with the overall strategy of the operator.	The role and activity of the local municipalities are significant in the subsidized projects. The project must be also the natural part of the already existing network.	The operation of the small operators requires the activity of the local municipalities and inhabitants. The municipalities are also usually guarantors for the investing loans of the small operators.
Evaluation of the current situation in the Broadband 2015 Project	The subsidized projects do not mainly profit in the current subsidy system. Moreover, the special requirements of the projects diminish the attractiveness of the projects. The projects should be more demand based.	The locality and reasserting of the local presence have strongly affected on the active participation in the subsidized projects. The limited capital and tighter project evaluation, while the competition is missing, could decrease the activity of the Finnet operators in the future projects.	The small operators can benefit their locality in the projects. This fact and the low profitability targets enable profitable investing for the small operators in the projects which would be unprofitable for the other operators. The operation of the small operators requires significant local activity, and it is also requirement for the creation of new small operators.

Appendix 4. Table of Techno-Economic Case Model

(grey)	= Given information which is the base of the further modeling.
(orange)	= Filled with an operator
(yellow)	= Description of asked values

What would be the used default technology in the last two kilometers?

Tax rate (%)	28 %
Lenght of new backbone (km)	220
Total number of permanent housing	600
Total number of impermanent housing	1000
Total number of offices	100

In **demand modeling**, a operator assumes which could be a demand in this kind of a project.
The operator can assume that he/she has same extra information than usually making investing decision.
Permanent housing is divided in two groups: Customer A and Customer B.
Customer A is a basic user who don't use much services.
Customer B is an average advanced user who also uses services.
Penetration in the beginning is the penetration which is assumed to gain at the same time with backbone building.
Total penetration is the penetration which is assumed to gain after all in the area.
Transition period is the time which is assumed to go to transition from the beginning to the total penetration.
Min/Max are assumed minimum and maximum values or in some cases they can be interpreted as optimal and pessimistic values.
Mean is the most probable value.

Demand modeling

	Total number	Penetration in the beginning			Total penetration (%)			Transition period (year)		
		min	mean	max	min	mean	max	min	mean	max
Permanent housing	600									
number out of total parmanent housing penetration	0									
number out of total parmanent housing penetration	0									
Impermanent housing	1000									
Offices	100									

General financial factors

Depreciation time of network investment (year)		<- The time, that is used in accounting, affects on taxation.
Required rate of return		<- The rate is used to discounting of future cash flows.

Cost modeling

CAPEX

	min	mean	max	
Planning costs (which are not included in the subsidy).				<- All costs which are generated before subsidized the part of the project.
Average cost of backbone building per meter				

Subscriber-specific connection costs in the biginning are average costs which are generated by connecting one subcriber during the backbone building.
Subscriber-specific connection costs later are average costs which are generated by connecting one subcriber after the backbone building.
In this project, it is assumed that an operator doesn't need to invest in new device rooms.
The connection costs include all costs which are related to the connecting.

	Fixed part of cos	Per meter costs		
		min	mean	max
Subscriber-specific connection costs in the beginning				
Subscriber-specific connection costs later				

Average lenght of a subscriber line

OPEX tries to model running costs of the project network and a part of the service costs which can be allocated to the subscribers of the area.

OPEX

	min	mean	max
Service costs per subscriber per a month			
General operational costs/ project/ year			

Revenue modeling

Flat rate fee is the average value of money which is payed by a subscriber group.

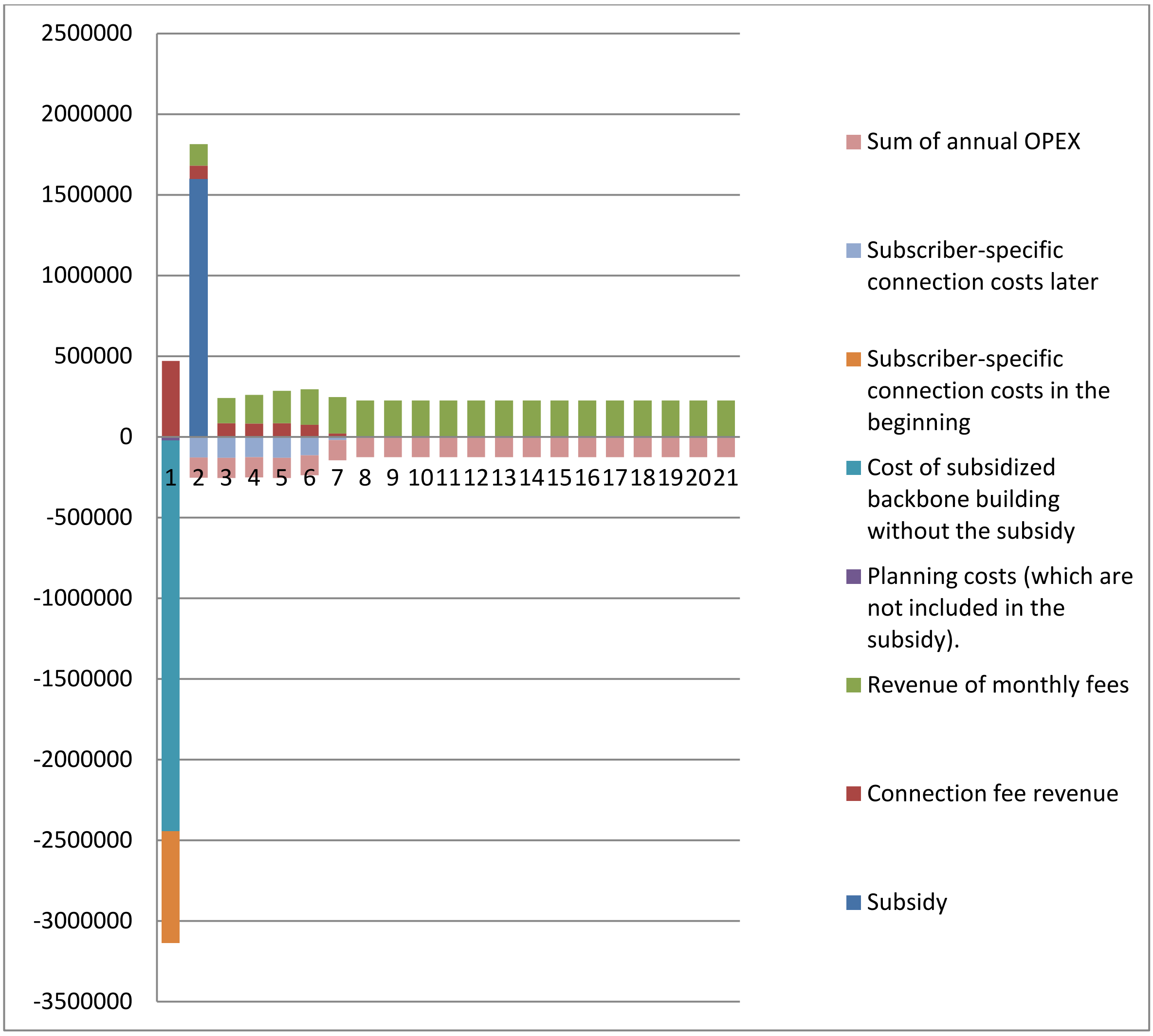
	Connection fees	Flat rate fee/ a month			Average service revenue/ a month		
		min	mean	max	min	mean	max
Permanent housing							
Customer A							
Customer B							
Impermanent housing							
Offices							

Cost of different specific works

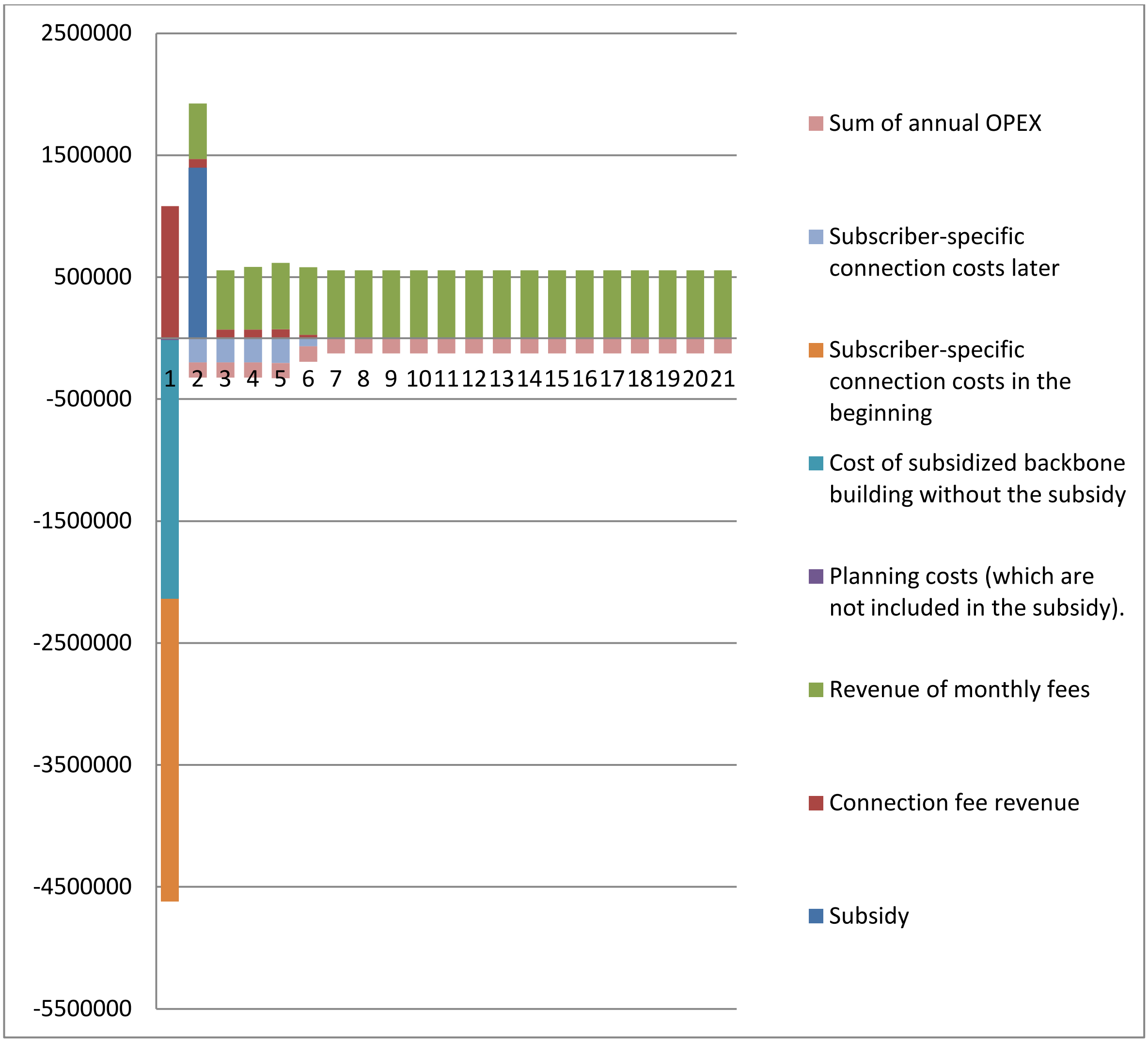
	min	mean	max
Digging per meter			
Plowing per meter			

	Dividing of average backbone building costs (%)
Digging and plowing	
Fibers	
x	
x	
x	
x	
SUM	100 %

Appendix 5. Estimation of Big Operators about Cash Flow in Case-Project during 20 Years



Appendix 6. Estimation of Finnet Operators about Cash Flow in Case-Project during 20 Years



Appendix 7. Estimation of Small Operators about Cash Flow in Case-Project during 20 Years