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MSc THESIS

Comparative Techno-Economic Evaluation of LTE Fixed Wireless Access and FTTdp G.fast network deployment for providing 30Mbps broadband services in rural areas

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ABSTRACT

In rural areas in Europe, the deployment of High-Speed Broadband access networks lags behind in urban and suburban areas due to difficulties of deployment of fiber in the final meters. FTTdp networks using G.fast have been proposed as a cost-effective alternative to FTTH and FTTB [1] especially in rural areas [2] where FTTC and VDSL cannot always deliver service speeds of 30Mbps which is the minimum bandwidth defined in the European Digital Agenda as target to be met by 2020. However, fixed wireless access (FWA) networks based on LTE technology can be used as a "last mile" solution to provide high-speed broadband access to areas where fixed broadband is limited [3]–[5]. On the other hand, LTE technology offers high speed connections able to support internet browsing and IP services, while it can theoretically support up to 300 Mbps depending on network load and sharing. Thus, it can be considered as a true alternative to any fixed solution. In this paper, a techno-economic study is performed to assess the feasibility of a FWA network deployment based on LTE technology in comparison to FTTdp G.fast network rollout for delivering service speeds of 30Mbps in rural areas. We present cash flow results and standard financial indexes for the business cases discussed. The results are being appraised through a sensitivity and risk analysis to determine the most influential factors on the return on the investment. We also discuss the (non) profitability of both cases and the subsidization needed from structural funds. The results aim to contribute in the debate over network evolution scenarios among academia, industry, regulators, policy makers and governments.

SUBJECT AREA: Telecommunications

KEYWORDS: Techno-economic analysis, NPV, DCF, LTE, G.fast, VDSL, Fixed Wireless Access, FWA, FTTdp, FTTx, European Digital Agenda, subsidization, NGA, Broadband

ΠΕΡΙΛΗΨΗ

Στις αγροτικές περιοχές της Ευρώπης, η ανάπτυξη των δικτύων ευρυζωνικής πρόσβασης υψηλών ταχυτήτων υστερεί σε σχέση με τις αστικές και ημιαστικές περιοχές λόγω των δυσκολιών που υπάρχουν στην εγκατάσταση οπτικών ινών κοντά στα νοικοκυριά. Τα δίκτυα FTTdp βασισμένα στην τεχνολογία G.fast έχουν προταθεί ως μια οικονομικά αποδοτική εναλλακτική λύση έναντι των FTTH και FTTB [1], ιδίως στις αγροτικές περιοχές [2], όπου το FTTC και το VDSL δεν μπορούν πάντοτε να παρέχουν ταχύτητες 30Mbps, το οποίο είναι το ελάχιστο εύρος ζώνης που ορίζεται ως στόχος της European Digital Agenda που πρέπει να επιτευχθεί έως το 2020. Ωστόσο, τα δίκτυα fixed wireless access (FWA) που βασίζονται στην τεχνολογία LTE μπορούν να χρησιμοποιηθούν ως λύση «last mile» για την παροχή ευρυζωνικής πρόσβασης υψηλής ταχύτητας σε περιοχές όπου η πρόσβαση σε σταθερά ευρυζωνικά δίκτυα είναι περιορισμένη [3]-[5]. Από την άλλη πλευρά, η τεχνολογία LTE προσφέρει συνδέσεις υψηλής ταχύτητας ικανές να υποστηρίξουν υπηρεσίες διαδικτύου και υπηρεσίες IP, ενώ μπορούν θεωρητικά να υποστηρίξουν μέχρι και 300Mbps ανάλογα με το φόρτο του δικτύου. Έτσι, μπορεί να θεωρηθεί ως μια πραγματική εναλλακτική λύση έναντι των σταθερών δικτύων. Σε αυτή την εργασία πραγματοποιήθηκε μια τεχνοοικονομική μελέτη για την αξιολόγηση της ανάπτυξης δικτύου FWA βασισμένης στην τεχνολογία LTE σε σύγκριση με την ανάπτυξη του δικτύου FTTdp G.fast για την παροχή ταχύτητας 30Mbps σε αγροτικές περιοχές. Θα παρουσιαστούν τα αποτελέσματα των ταμειακών ροών και συνήθων οικονομικών δεικτών για τα αντίστοιχα επιχειρηματικά σενάρια. Τα αποτελέσματα αξιολογούνται μέσω ανάλυσης ευαισθησίας και κινδύνου για τον προσδιορισμό των σημαντικότερων παραγόντων που επηρεάζουν την βιωσιμότητα της επένδυσης. Συζητάμε επίσης την κερδοφορία ή μη κερδοφορία και των δύο περιπτώσεων και την επιδότηση που απαιτείται. Τα αποτελέσματα έχουν στόχο να συμβάλουν στη συζήτηση για την εξέλιξη των δικτύων πρόσβασης μεταξύ των ακαδημαϊκών κύκλων, της βιομηχανίας, των ρυθμιστικών αρχών, των υπευθύνων χάραξης πολιτικής και των κυβερνήσεων.

ΘΕΜΑΤΙΚΗ ΠΕΡΙΟΧΗ: Τηλεπικοινωνίες

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Τεχνοοικονομική Ανάλυση, NPV, DCF, LTE, G.fast, VDSL, Fixed Wireless Access, FWA, FTTdp, FTTx, European Digital Agenda, Δίκτυα Ασύρματης Σταθερής Πρόσβασης, Δίκτυα Πρόσβασης Επόμενης Γενιάς, Ευρυζωνικά Δίκτυα, Επιδοτήσεις

ΕΥΧΑΡΙΣΤΙΕΣ

Για τη διεκπεραίωση της παρούσας Διπλωματικής Εργασίας, θα ήθελα να ευχαριστήσω τους επιβλέποντες, αν. καθ. Δημήτριο Βαρουτά και τον ΕΔΙΠ Δημήτριο Κατσιάνη για τη συνεργασία και την πολύτιμη συμβολή τους στην ολοκλήρωση της.

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PREFACE

This study was conducted and submitted to the 29th International Telecommunications Society (ITS) Europe Conference 2018 in Trento, Italy. The submission was on the topics of “Investment strategies for very high capacity networks”, “Public-private interplay for high capacity networks” and “Fixed broadband access networks for rural areas”

1. INTRODUCTION

The European Commission's Digital Agenda for Europe (DAE) defined the broadband targets to be met by European member states by 2020. Some of the main DAE objectives are the following: a) all citizens should have access to broadband speeds of at least 30Mbps and b) 50% of households should have broadband subscriptions with speeds at least 100Mbps. The second objective is expected to be achieved through fixed Next Generation Access (NGA) networks which will be deployed mostly on urban and suburban areas. However, 100% population coverage of 30Mbps broadband is a challenging objective especially for rural areas of Europe where the deployment of NGA networks lags far behind the urban and suburban areas due to the low population density and the high cost of deployment of fiber networks. The European Commission reported [20] that in 2017 the average NGA coverage in rural areas of Europe was 46.9% compared to the 80.1% of overall NGA coverage mostly led by NGA network deployment in urban and suburban areas.

In the same report, it is stated that VDSL (Very-high-bit-rate Digital Subscriber Line) has the highest coverage growth and availability compared to other fixed broadband technologies in rural areas. However, as an upgrade of the existing ADSL network, VDSL cannot provide speeds of 30Mbps in rural areas where the average cable distance between the cabinet and the households is more than 1km nor does it offer a future upgrade path for such long distances. Fiber to the Distribution point (FTTdp) networks using G.fast have been proposed as a cost-effective alternative to FTTH and FTTB [1] especially in rural areas [2] in an attempt to reduce the copper cable length and provide higher broadband speeds compared to FTTC technologies. In addition, G.fast requires less power than VDSL technologies and the Reverse Power Feeding feature is expected to help reduce OPEX costs for distribution point installations.

Another important indicator mentioned in European Commission's reports is that 4G LTE coverage reached 89.9% in rural areas showing that fixed wireless access (FWA) networks based on LTE technology can be used as a "last mile" solution to provide high-speed broadband access to areas where fixed broadband is limited [3]–[5]. LTE technology offers high-speed connections able to support internet browsing and IP services, while it can theoretically support up to 300 Mbps depending on network load and sharing. Thus, it can be considered as a true alternative to any fixed solution especially when considering reuse of existing infrastructure.

The importance of 800MHz band to the deployment of high speed wireless internet services has also been recognized by European Commission since 2010 by proposing technical rules to ensure that radio communications equipment using the 800 MHz band, can be used efficiently for wireless broadband networks, such as LTE or WiMAX [19]. Also, in 2016 the European Council set the year 2020 as deadline for reassigning 700MHz band for wireless broadband services under harmonized technical conditions in order promote the take-up of 4G and the future roll-out of 5G networks [23]. The increased coverage offered by these lower frequency bands is a key factor when considering investments in scarcely populated areas.

In this paper, a techno-economic study is performed to assess the feasibility of a FWA network deployment based on LTE technology in comparison to FTTdp G.fast network rollout for delivering service speeds of 30Mbps in rural areas. The results are being appraised through a sensitivity and risk analysis to determine the most influential factors on the return on the investment. We also discuss the (non) profitability of both cases and the subsidization needed from structural funds. The results aim to contribute in the debate over network evolution scenarios among academia, industry, regulators, policy makers and governments.

2. BUSINESS CASE DEFINITION

2.1 Geographical Classification

The assessed areas include only rural areas according to Eurostat's definition of territorial typologies [15]. In this methodology, typologies of territory are based on clusters using 1km2 continuous grid cells with similarities in terms of population and density. Areas of local administrative units at level 2 (LAU level 2) can then be classified into three degrees of urbanization based on population share in different types of clusters. Areas where more than 50% of the population lives in rural grid cells are classified as rural areas. This classification is also defined at higher geographical scale like NUTS level 3 regions.

For the purpose of this study, three groups of European countries are considered with different population density in rural areas based on the Eurostat data for LAU level 2 share of population and land area. These groups were formed for low, medium and high population density and referred to countries with average rural population density of 30, 40 and 55 people per km2, respectively.

Furthermore, Eurostat's data on housing [16] and land use [17] in rural areas were taken into account for calculating the average number of households per km^2. The geotype parameters of the model which were defined by the aforementioned data are presented in Table 1.

Table 1. Geotype parameters.

Parameters	Values
Average population density Low / Medium / High	30 / 40 / 55 pop. per km^2
Average number people per household	2.1
Percentage of Single Dwelling Units	85%
Percentage of Multiple Dwelling Units	15%
Average share of non-residential area	70%

2.2 Technology driven scenarios

2.2.1 LTE Fixed Wireless Access

The LTE FWA network architecture consists of four (4) Aggregation Nodes (AN) linked through Aggregation Links (AL) which use only microwave links in a ring topology. The AN1 is the radio access network and is made up by four eNodeB. AN2 and AN3 constitute the transport network and consist of eight (8) Ethernet Switches and eight (8) Access Routers, respectively. Finally, the AN4 is made up by the core network elements of the LTE network which include the MME, PDN, etc. The dimensioning of AN1 is made by using hexagon-shaped cells while the dimensioning of the other ANs uses square-shaped areas. Finally, each household is connected to eNodeB using an outdoor directional antenna which is connected through cable to the indoor Customer Premises Equipment (CPE). This is a key factor for network planning because it increases the received signal quality in order to provide the necessary throughput for 30Mbps speeds over the longer distances in rural areas. An overview of the full network architecture is presented in Figure 1.

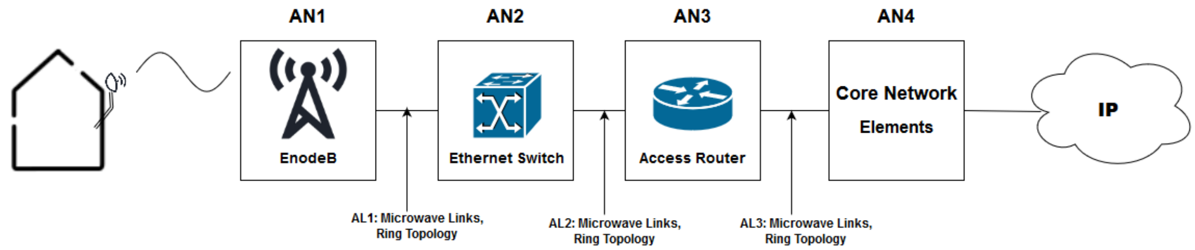

Figure 1. LTE FWA network architecture

The technical model starts with a link budget, followed by coverage dimensioning and finally capacity dimensioning. For the assessment, LTE 2 x 20MHz FDD carrier in 800MHz is considered. In other studies [4]-[5], 2 x 10MHz FDD carriers in the 800MHz has been used which is reasonable considering that the 800MHz band consists of 2 x 30MHz only. However, such low bandwidth greatly reduces the capacity capabilities of the network. As a result, a more dense radio access network is needed in order to provide 30Mbps speeds, increasing the overall cost of the whole investment. Thus, we consider

20MHz of carrier bandwidth should be available for the investment most probably through Carrier Aggregation (CA). Our technoeconomic evaluation results have shown that CA does not have any negative effect in the investment even when using higher frequency bands because capacity has much greater impact in network planning of the FWA network than coverage (capacity driven).

In addition, we assume deployment of 3-sector cell sites and single frequency reuse factor assigning all the available bandwidth for each sector. This is possible due to the advanced scheduling and interference management capabilities LTE technology. Furthermore, among other technical parameters (Table 2) a contention ratio of up to 10:1 was used, in line with existing cable networks. This contention ratio can assure an acceptable user experience taking into account that Cisco's estimate [14] of 140GB monthly average internet traffic per household in Western Europe in 2021 results in less that 3Mbps per household in busy hour.

Table 2. Technical input parameters.

Parameters	Values
Average Downlink throughput	30 Mbps
Average Uplink throughput (to downlink)	10%
Frequency Band	800MHz
Bandwidth	2x20MHz FDD
Number of sector per site	3
Frequency Reuse Factor	1
Propagation Model	Okumura-Hata
Contention Ratio	10:1
Control Channel Overhead	20%
BS transmitter power	46 dBm
BS antenna gain plus cable and connection losses	15 dBm
Outdoor CPE antenna gain plus cable and connection losses	8 dBm
Outdoor CPE antenna height	5 meters

2.2.2 G.fast FTTdp

For the FTTdp network architecture it is assumed that a Distribution Point Unit (DPU) cabinet will be used which will be installed in the street up to 250 meters close to the end user's premises between the distribution and the drop segment. FTTdp street is preferred over FTTdp building due to higher cost savings especially in rural areas [1]-[2]. The DPU cabinet contains a splitter, up to eight DPUs, one for each subscriber connected, and an internal main distribution frame (MDF). A Reverse Power Feeder (RPF) will be installed in each user's household supplying power to the DPU. While for the drop segment of the FTTdp street the existing copper infrastructure will be reused, for the fiber segments a Gigabit Passive Optical Network (GPON) architecture will be used. There will be two splitting levels – a 1:16 located in the street cabinet and a 1:4 located in the DPU cabinet (Figure 2).

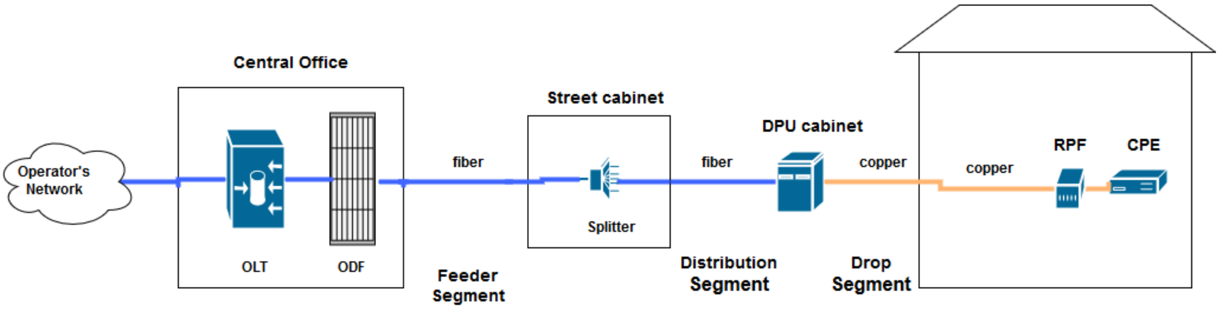

Figure 2. G.fast FTTdp street network architecture

Because of 10 Gigabit PON deployment, the G.fast FTTdp network is able to provide speeds up to 150Mbps much higher that the speeds that can be supported by the LTE FWA network. Nonetheless, we have not included services of higher internet speeds in the techno-economic methodology.

For the dimensioning of the network, we use a geometric model according to which the NGA network consists of flexibility points (FP). These flexibility points are: FP1 the floor (in case of MDUs), FP2 the building, FP3 the street cabinet, FP4 a branching box, FP5 Local Exchange (LEx or Central Office). Each FP has a distribution rate based on the maximum connections from one FP to the next (Figure 3). These distribution rates are not constant and can change according to the input parameters for the capacity of each

FP (available space, ports, etc). Each FP is dimensioned based on a star-mesh topology in a rectangle area of L x L' size (m) which is divided equally among the units of the FP with each unit being placed at the center of each part while the next level FP is placed in the center of the whole area (Figure 4). However, in the case of FTTdp street, the DPU cabinets are placed (based on the maximum distance from the premises) in the FP2 layer after the calculation of ducts from the street cabinet to the buildings in order to reuse efficiently the already installed copper in the drop segment.

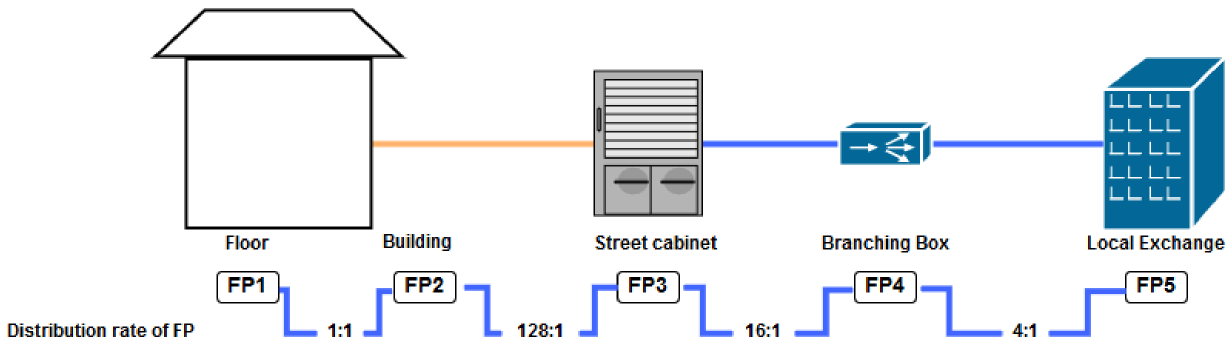

Figure 3. NGA network dimensioning model.

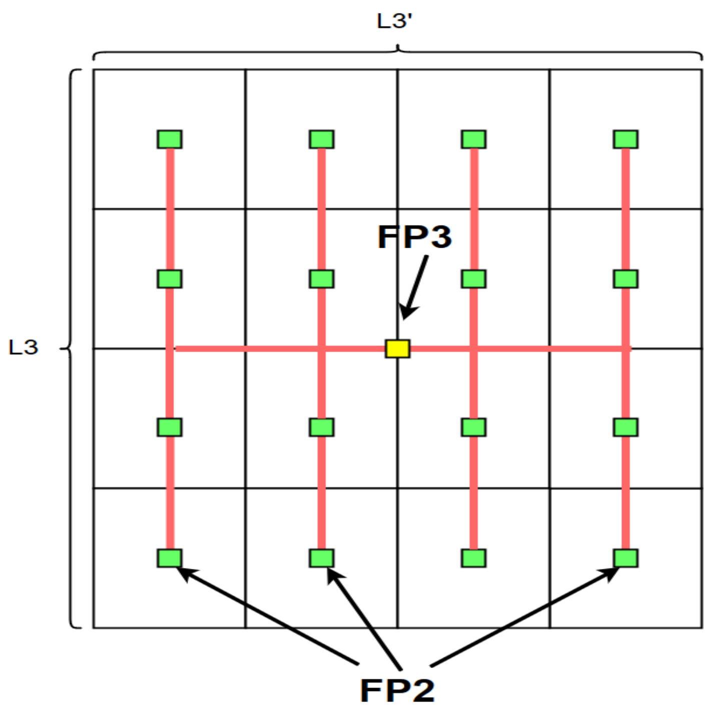

Figure 4. Example of Geometric model for FP3 (Layer 3).

3. TECHNO-ECONOMIC METHODOLOGY

The techno-economic methodology is based on a bottom-up analysis of discounted cash flows for network deployment, operation and maintenance. The techno-economic tool is based on the tool developed within a series of techno-economic projects, namely TONIC, ECOSYS, TITAN and it has been used in several related network evaluation studies for mobile [6], [7] and fixed networks [8]–[11]. We assume an eight-year study period, a reasonable period for fixed access network deployments, considering the time it usually takes to reach market maturity. The market penetration of broadband services and the tariffs for these services as well as their market share have to be defined. For the analysis, demand and price forecasts have been incorporated in order to calculate network components needed as well as revenues generated by network services. The methodology incorporates the geometric model described in the previous section for calculating lengths for cables and ducting for the FTTdp G.fast network case. As far as the LTE FWA network case is concerned, a radio propagation model is incorporated for dimensioning assuming the use of 800MHz frequency band. For both cases, the network is designed to provide at least 30 Mbps throughput per home. The result of the architecture scenario definition is the “shopping list” for each year of the study period that shows the volumes of all network cost elements and the distribution of these network components over different flexibility points and link levels. The costs of the network components are calculated using an integrated cost database. Architecture scenarios are used together with the cost database to calculate investments for each year (CAPEX and OPEX).

3.1 Demand and price forecasts

The demand is based on data of NGA coverage and subscriptions of households in rural areas for the years 2012 to 2017 in Europe [21]. Three diffusion models were employed for fitting, Logistic, Gompertz and Tonic [12]. Although the differences between Tonic and Gompertz were not significant (less than 0.5% on a yearly basis), Tonic model showed to fit the aforementioned data with lower error values compared to the other two diffusion models. The Tonic model was developed within the IST-TONIC project and provided reasonably accurate fitting over historical data related to high-technology products.

Three curves on demand were calculated, a pessimistic based on countries with low NGA demand, an optimistic based on countries with high NGA demand and a baseline of medium demand based on countries close to the EU average NGA demand in rural areas (Figure 5). The results presented in this paper will be based only in the medium demand case. The network penetration is expected reach 30% of population in 2027. Additionally, we assumed an annual churn rate of 2% and a tariff degression of 3%.

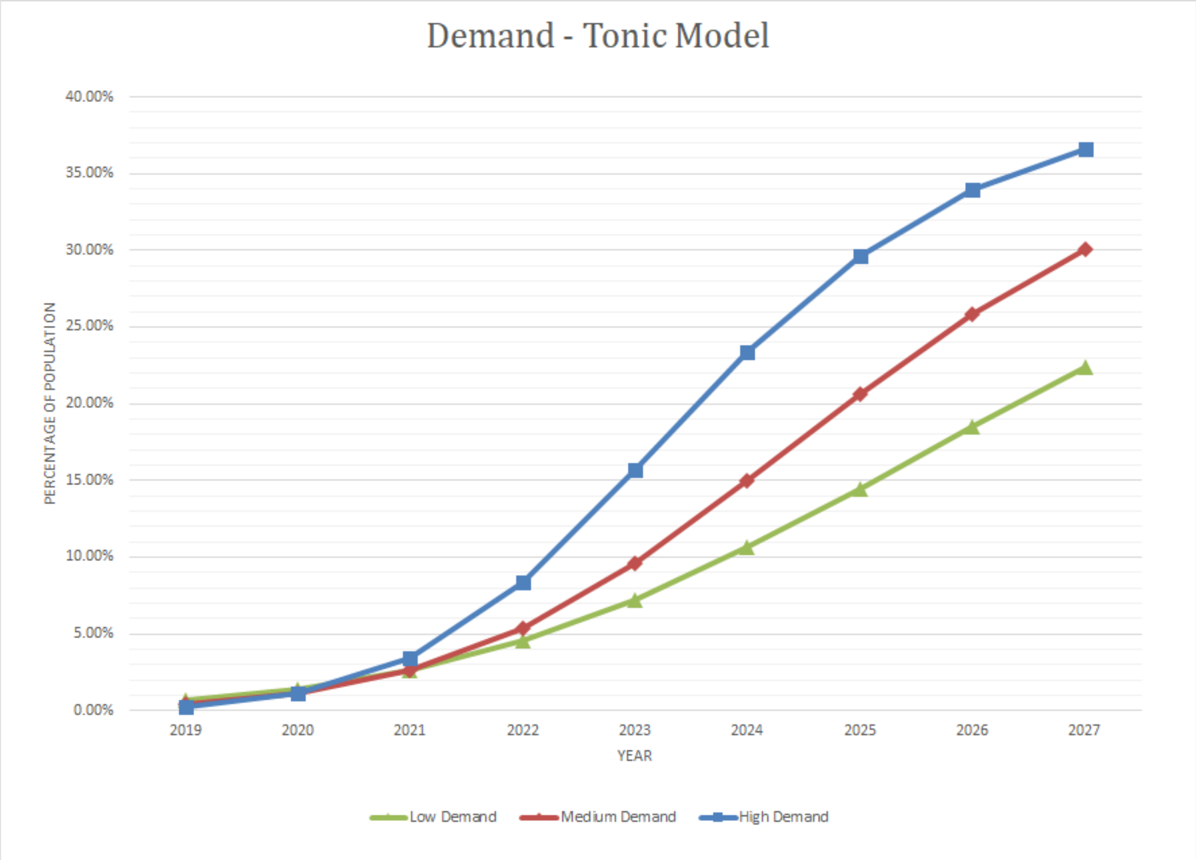

Figure 5. Demand forecast in rural areas using Tonic model.

3.2 Model Assumptions

For the purpose of this paper, the internet service of 30Mbps is considered without data caps or limits. No others services were included in the current study. Furthermore, a fixed 50% market share is used for network coverage up to 90% of rural areas within the first two years (2019-2020) of the investment. 2019 is considered to be the initial year of investment while the network is expected to be completed within 2020. The network deployment will be conducted in a greenfield scenario and network sharing is not included in the assessment. Some important economic and demand input parameters of the model are presented in Table 3.

For LTE FWA, the spectrum price is set to the average price in European countries and is measured in euros per MHz per population. The data is based on the GSMA's effective spectrum pricing report [13]. It is important to note that only the share of population of rural areas is used in the calculation in the total cost of spectrum. This share could also be omitted in a subsidization approach from the regulator.

Power Consumption for each active element of the network is included in the OPEX of the investment. The average electricity price in European countries was used according to the available data [18]. In addition, a straight line depreciation was used based on the lifetime of assets.

The minimum monthly Average Revenue Per User (ARPU) is calculated for the NPV to become zero in 2027 (last year of study). The subsidization of CAPEX for the two first years is calculated as the ARPU is reduced close to the average minimum EU prices (purchase power parity corrected) of subscriptions with speeds at least 30Mbps [22].

Table 3. Economic and demand input parameters.

Parameters	Values
WACC	13%
Tax Rate	20%
Annual Tariff Degression	3%
Churn Rate	2%
Network Take-up	30%
Market Share	50%
Network Coverage	90%

4. RESULTS AND DISCUSSION

4.1 CAPEX, OPEX and Cash Balance

The results presented in this paper will focus mainly on Net Present Value (NPV) and Cash Balance. The Net Present Value (NPV) describes today's value of the sum of resultant discounted cash flows (annual investments, running costs, revenues, etc), or equivalently the volume of money, which is expected over a given period of time. If the NPV is positive, the project is acceptable and it is a good indication for the profitability of an investment project, taking into account the time value or opportunity cost of money, which is expressed by the discount rate. The Cash Balance (accumulated discounted Cash Flow) curve generally goes negative in the early part of the investment project because of initial capital expenditures. Once revenues are generated, the cash flow turns positive and the Cash Balance curve starts to rise. The lowest point in the Cash Balance curve gives the maximum amount of funding required for the project. The point in time when the Cash Balance turns positive represents the Payback Period for the project.

Figure 6, shows the share of accumulated CAPEX and OPEX in the costs of investment during the study period for a medium population density country. The results are almost the same (within 1% to 2%) for the low and high population density scenarios. For the LTE network, eNodeB site acquisition and spectrum fees are the biggest part of CAPEX costs having a share of 34.7% and 23.5% of total accumulated CAPEX. Additionally, eNodeB site rent is 57.1% of total accumulated OPEX. In the case of G.fast network, the cost of ducts is 72% of total accumulated CAPEX.

For both technologies in the three population density scenarios, we calculated the minimum monthly ARPU required for NPV to be equal to zero at the end of the study period (Figure 7). These results can be used as an indicator of the cost of service for each subscriber.

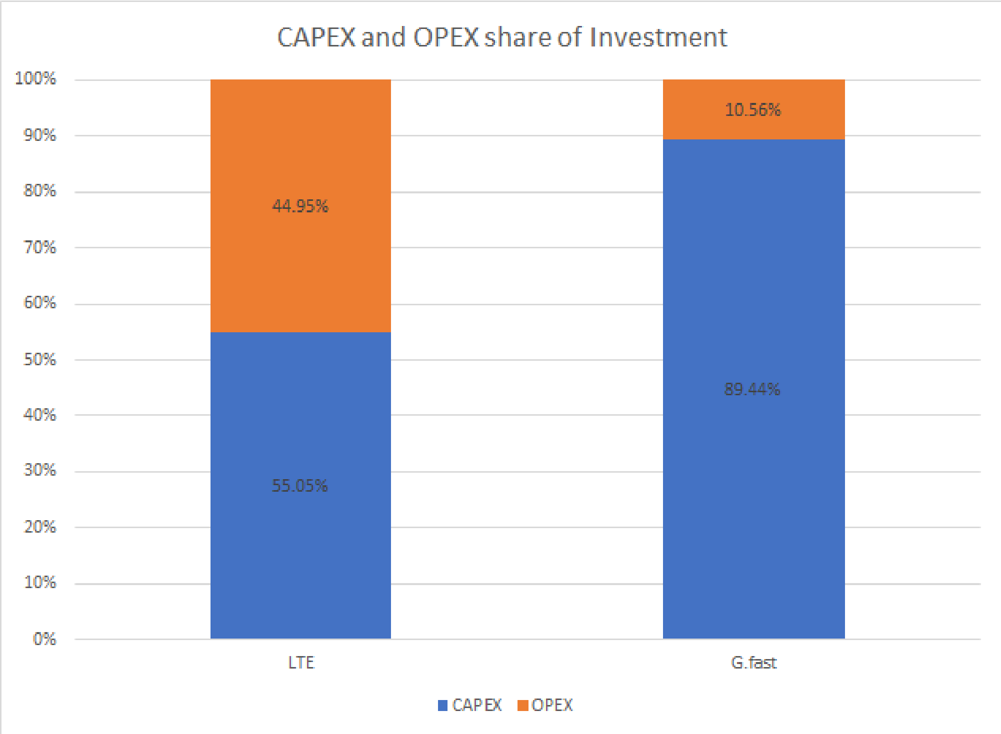

Figure 6. Percentage of CAPEX and OPEX in total investments.

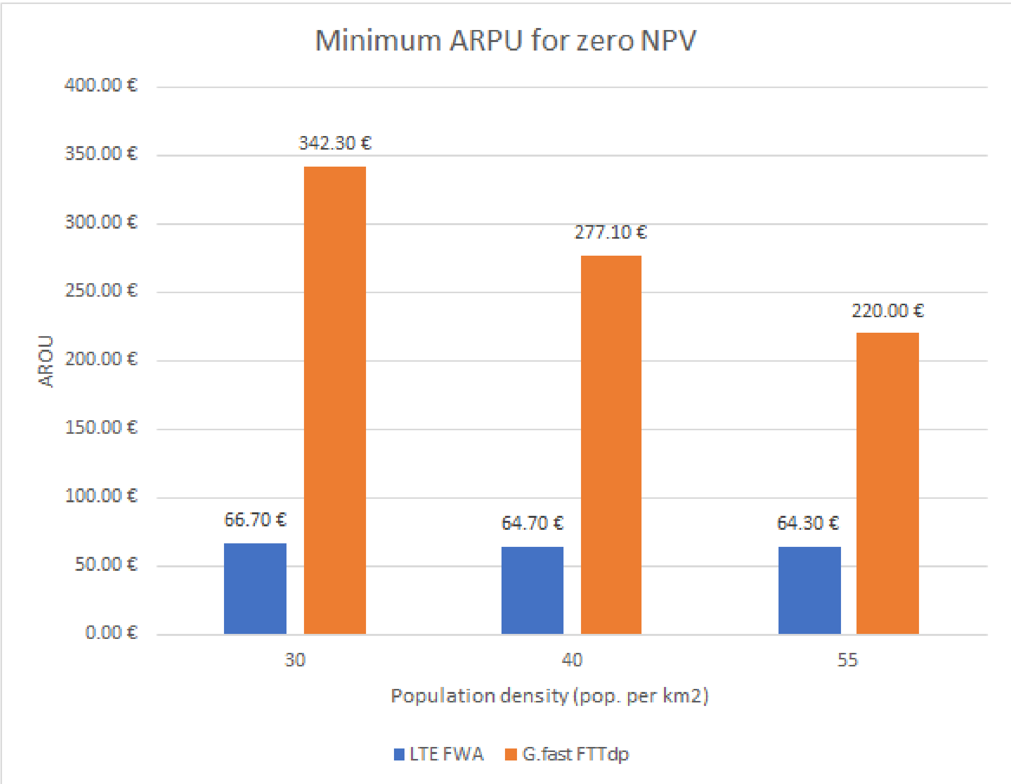

Figure 7. ARPU required for zero NPV.

Figure 8 illustrates the revenues, investments and cash balance of all scenarios assuming ARPU equal to 40 euros which is close to the average pricing of NGA services in Europe. In all cases, the gradient of the cash balance curves at the end of the study period indicate the future earning potential. The case of high population density country has much more potential revenues than the other two cases of LTE due to the greater potential of market size.

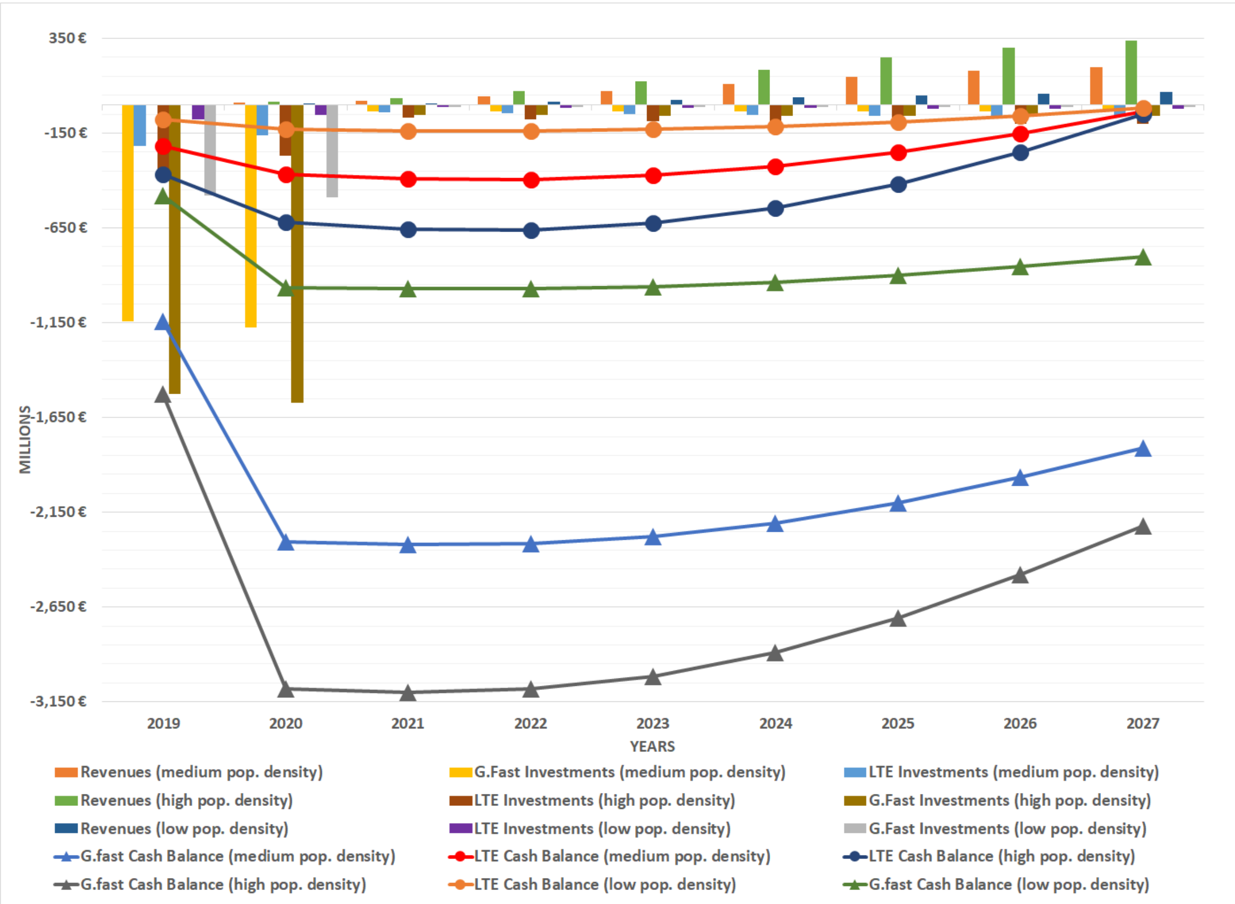

Figure 8. Revenues, investments and cash balance for ARPU equal to 40 euro.

The lowest point of the cash balance indicates the amount of investment funding required from the operator. Significant investments are needed during the first two years of the project in order to deploy the FWA and FTTdp networks in rural areas. In addition, the investments and operational costs show crucial differences between the two technologies. The maximum need for funding is quite significant, especially for FTTdp where we see negative cash balance for all cases compared to FWA in which the discounted cash balance turns to steady growth after 9 years. Finally, large subsidization schemes are needed due to the negative cash balance in the beginning of all cases.

4.2 Sensitivity Analysis

Sensitivity analysis has been carried out in order to rank a number of selected uncertainty assumption variables according to their impact on the NPV (Figure 9 and Figure 10). In a “traditional” approach, each of the selected parameters is changed on a one-by-one basis by the same percentage up and down. This is basically wrong, as some variables are inherently more uncertain than others. Instead, 5% and 95% percentiles have been chosen as lower and upper limits respectively for each variable and probability density functions have been applied to all parameters. For the majority of demand and economic parameters these limits are based on the available data of Eurostat for the European countries.

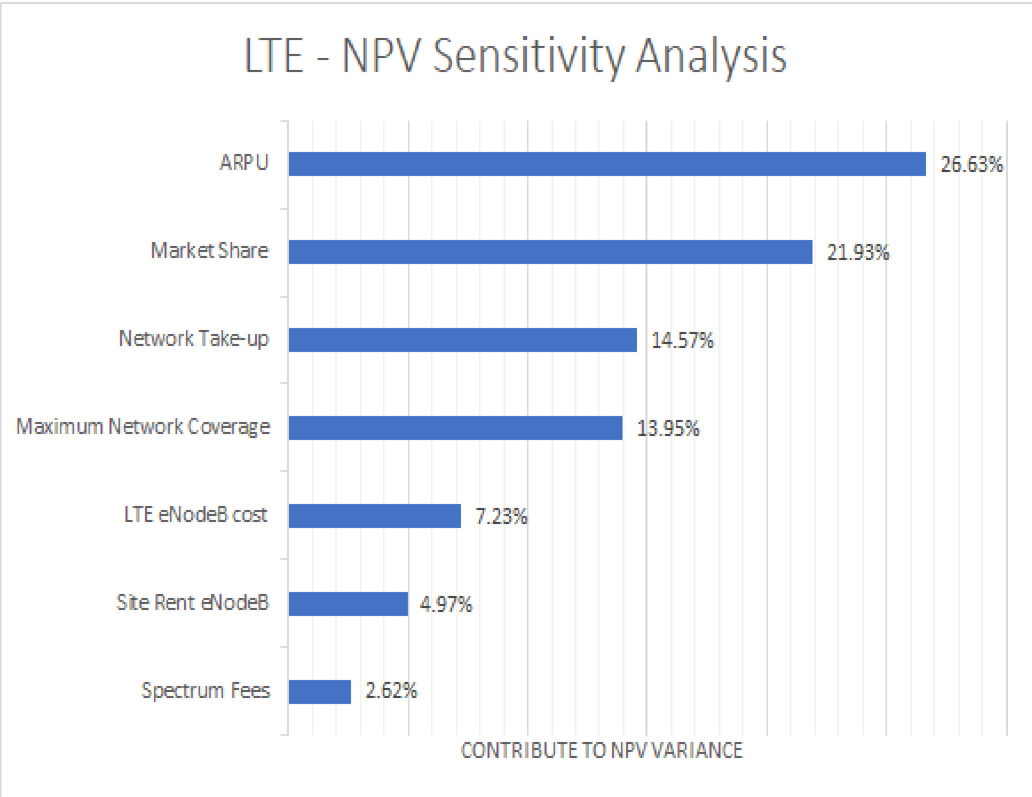

Figure 9. Sensitivity analysis results for LTE FWA

As was expected, both models are sensitive to changes of ARPU and demand related variables like market share and take-up. Also costs which make up the biggest part of CAPEX (spectrum fees, eNodeB cost, duct cost) and OPEX (site rent) have a serious impact in the feasibility of the investment.

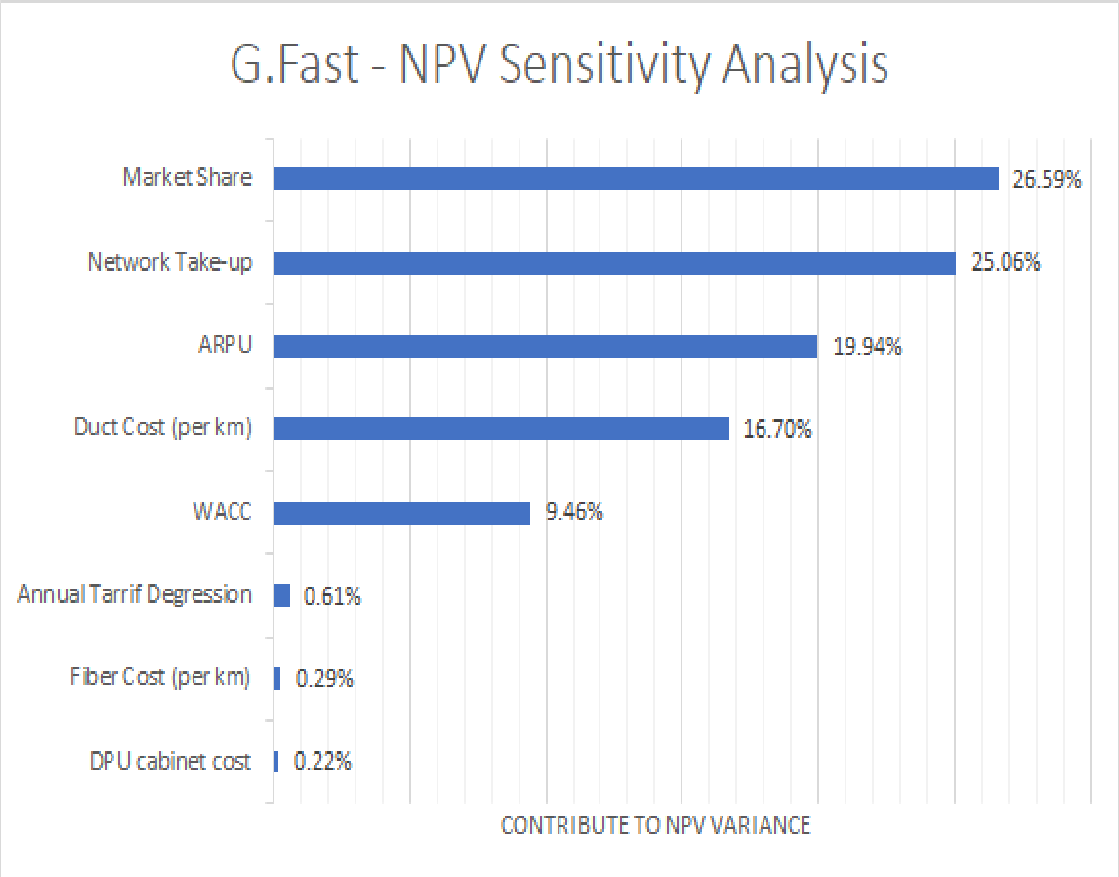

Figure 10. Sensitivity analysis results for G.fast FTTdp.

4.3 Subsidization

Finally, because demand is expected to be very sensitive to the price of the service, it is important to specify a desirable tariff but also the subsidization required to reduce the risks and ensure the profitability of the investment. Thus, an extensive risk assessment has been performed on the different tariff scenarios and subsidization values. The result is the minimum subsidization required (as perc. of CAPEX) for the first two years of investment given an ARPU/tariff value in order to ensure (with certainty greater than 90%) a positive NPV at the end of the study period. The results show (Figure 11) that in all scenarios, the FTTdp network requires huge subsidization to ensure profitability compared to the FWA network.

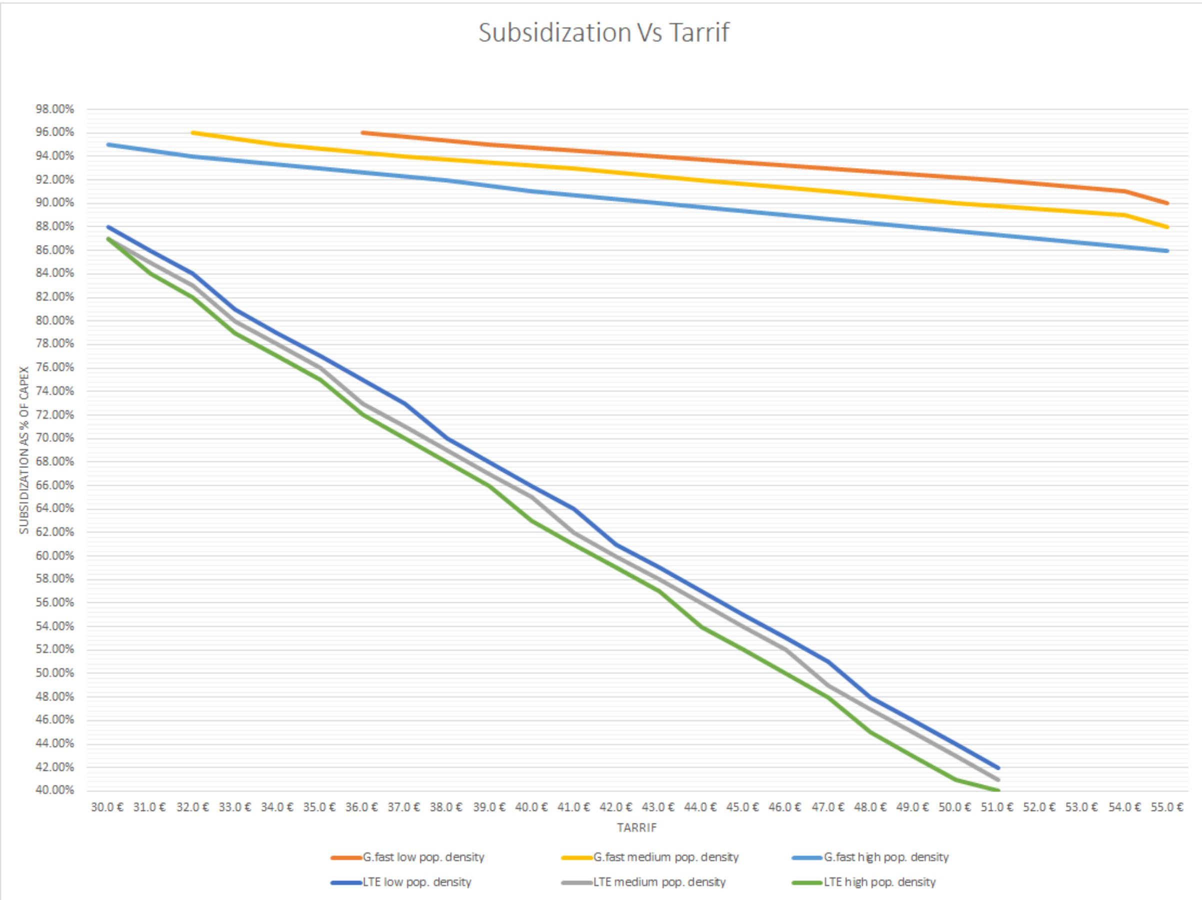

Figure 11. Subsidization required for given tariff value for NPV>0 with 90% certainty.

4.4 FTTdp with aerial cables

In some countries there is a wide use of aerial cables in the distribution segment of access network in rural areas. Using aerial cables and DPUs on available poles can greatly reduce the CAPEX for G.fast FTTdp deployments due to reduced duct costs which consist the higher portion of CAPEX of the investment. In the figures below we present the minimum monthly ARPU required for NPV to be equal to zero at the end of the study period (Figure 12) and the revenues, investments and cash balance of all scenarios assuming ARPU equal to 40 euros (Figure 13). Although there is a great improvement when using aerial cables, the G.fast network is still not as cost effective as the LTE FWA network.

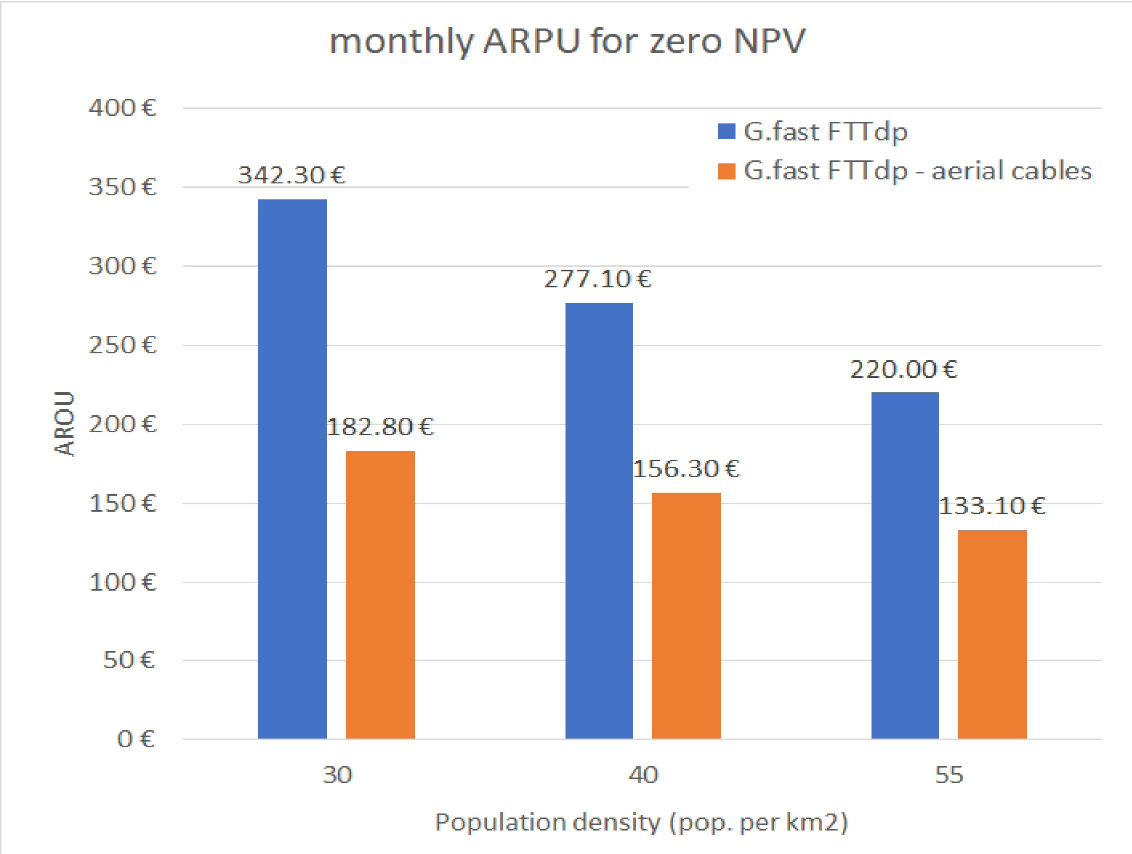

Figure 12. ARPU required for zero NPV for FTTdp G.fast using aerial cables.

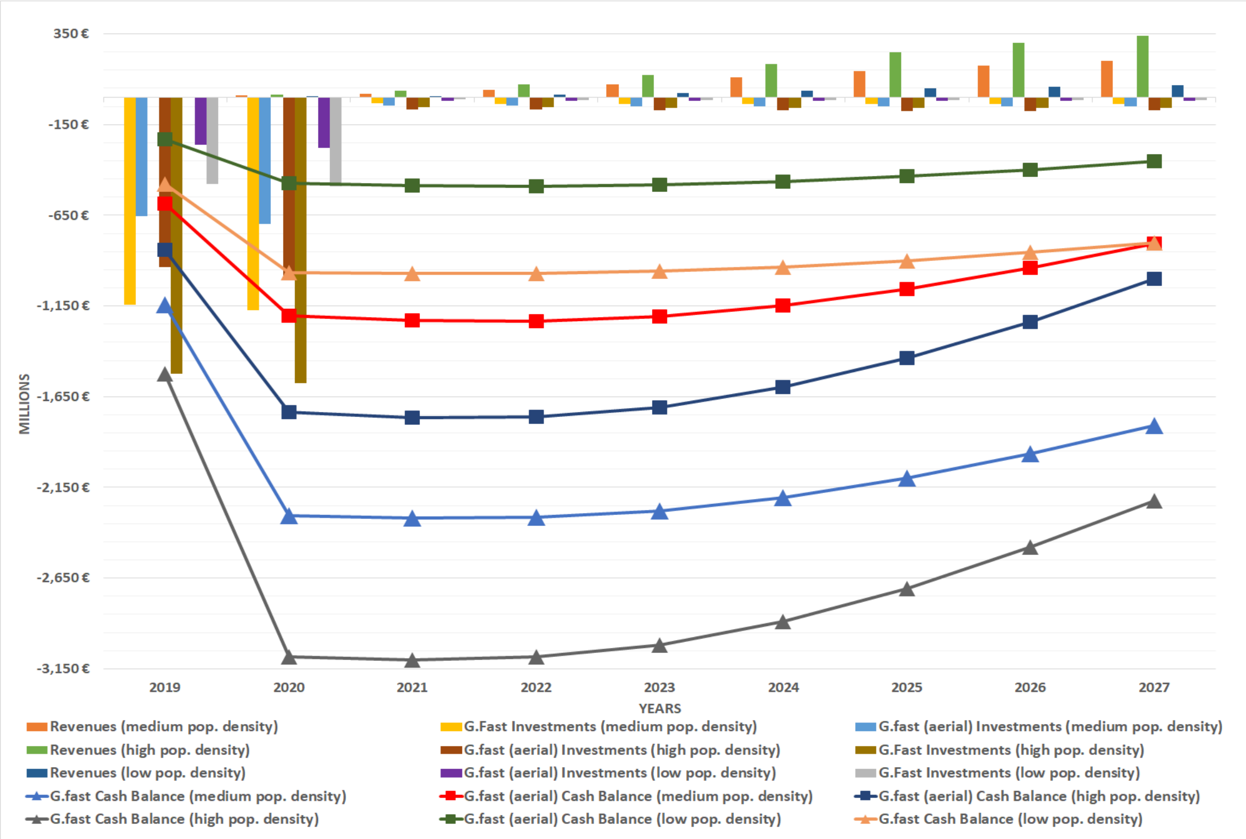

Figure 13. Revenues, investments and cash balance for ARPU equal to 40 euro for FTTdp G.fast using aerial cables.

4.5 FWA with spectrum subsidization and passive site sharing

The high LTE radio access network (RAN) coverage, the percentage of site acquisition costs and spectrum licenses cost in investment CAPEX, show that considerable cost savings can be expected from RAN sharing and spectrum subsidization. Two scenarios were considered, one with zero spectrum costs and one with passive site sharing. The results of the above scenarios are presented in Figure 14, Figure 15 and Figure 16. In both cases, we see considerable improvements for ARPU (17% to 25%) and cash balance.

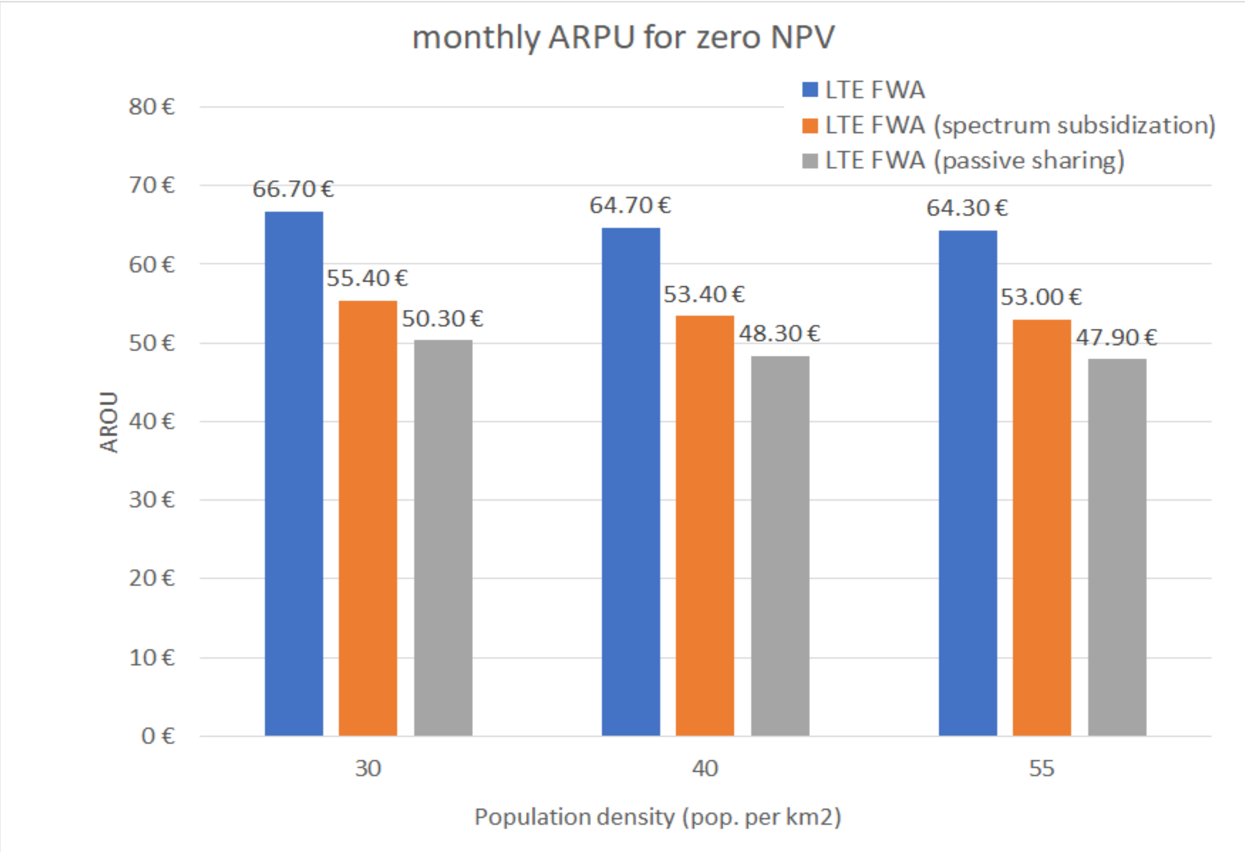

Figure 14. ARPU required for zero NPV for LTE FWA in the case of spectrum subsidization and passive site sharing

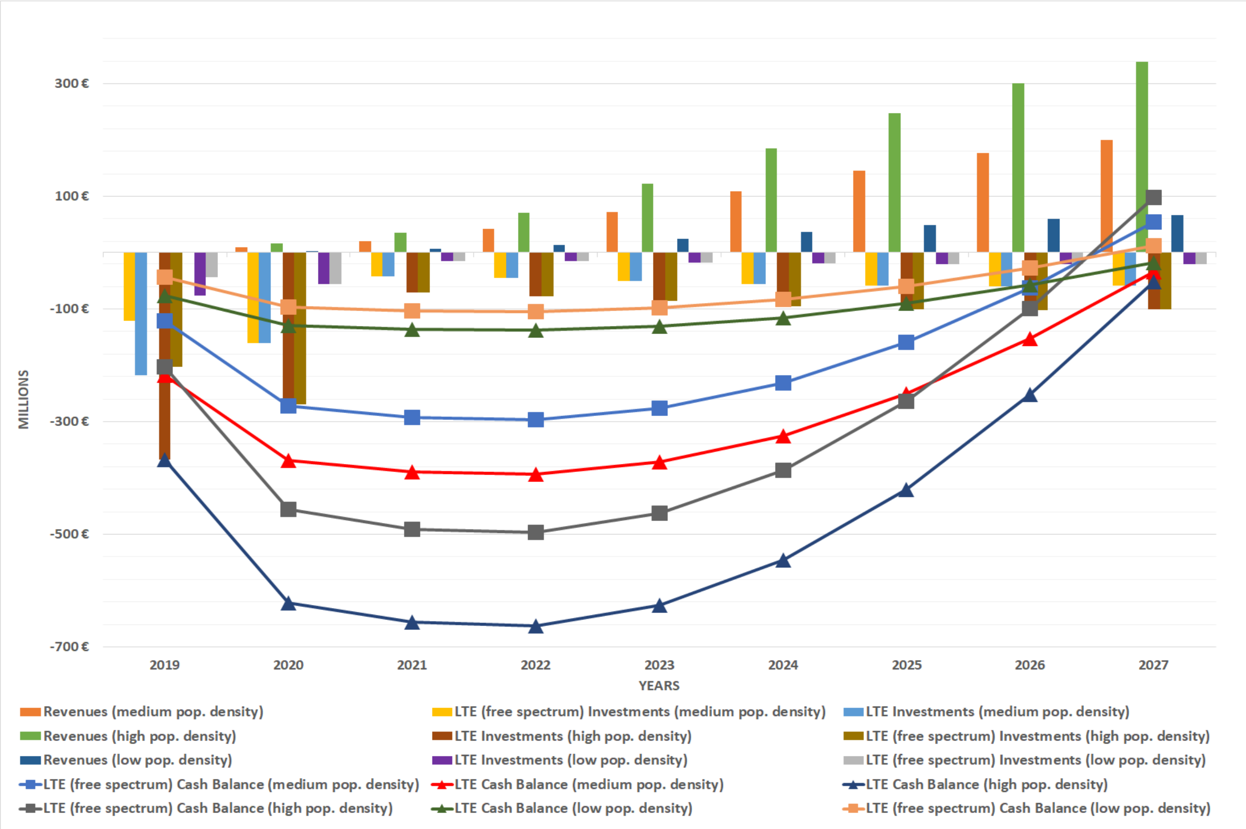

Figure 15. Revenues, investments and cash balance for ARPU equal to 40 euro for LTE FWA in the case of spectrum subsidization.

Figure 16. Revenues, investments and cash balance for ARPU equal to 40 euro passive site sharing.

5. CONCLUSIONS

In this paper, the feasibility of providing 30Mbps internet services in rural areas of Europe through LTE FWA or G.fast FTTdp is assessed. FTTdp G.fast is a promising technology that, in theory, can deliver up to gigabits of throughput per subscriber with less cost than FTTH. FTTdp architecture enables an easy bandwidth upgrade and therefore it can be considered a futureproof solution in the case of large subsidization. However, the cost of FTTdp network roll-out is too high for rural areas where population density is low and demand is not high enough to ensure the profitability of the investment even with subsidization. In case of fixed broadband network, other solutions like FTTdp VDSL or hybrid G.fast, VDSL networks should be considered in order to provide a future upgrade path to 100Mbps or higher internet speeds in rural areas. Also, other methods of reusing the existing copper infrastructure like aerial cables could be used to reduce the duct costs which consist the higher portion of CAPEX of the investment.

The results showed that LTE Fixed Wireless Access networks can be a viable, cost-efficient solution for delivering 30Mbps internet services in scarcely populated areas even in greenfield scenarios. Thus, considering the already high LTE RAN coverage and the percentage of site acquisition costs in investment CAPEX, considerable cost savings can be expected from passive and active RAN sharing. Furthermore, since spectrum is another large part of investment CAPEX, new spectrum policies should be discussed like spectrum sharing and deep network sharing of equipment should be encouraged especially in sparsely populated areas.

Finally, new mobile network technologies like 5G networks could be a solution for upgrading LTE fixed wireless networks in the future. More studies should be done to evaluate the cost of such investments in order to determine whether fixed wireless networks can be a futureproof solution to provide speeds comparable to fixed NGA networks.

TABLE OF TERMINOLOGY

Ξενόγλωσσος όρος	**Ελληνικός Όρος**
Broadband	Ευρυζωνικής
Net Present Value	Καθαρή Παρούσα Αξία
Subsidization	Επιδότηση
Broadband Access Networks	Δίκτυα Ευρυζωνικής Πρόσβασης
Techno-Economic	Τεχνοοικονομική

ABBREVIATIONS - ACRONYMS

FTTC	Fiber To The Cabinet
FTTH	Fiber To The Home
FTTB	Fiber To The Building
FTTdp	Fiber To The distribution point
ADSL	Asymmetric digital subscriber line
VDSL	Very-high-bit-rate Digital Subscriber Line
G.fast	G series fast access to subscriber terminals
LTE	Long-Term Evolution
FWA	Fixed Wireless Access
NGA	Next Generation Access
IP	Internet Protocol
DAE	Digital Agenda for Europe
RPF	Reverse Power Feeder
4G	4^{th} Generation
5G	5^{th} Generation
WiMAX	Worldwide Interoperability for Microwave Access
CAPEX	Capital expenditure
OPEX	Operational expenditure
LAU	Local Administrative Units
NUTS	Nomenclature of Territorial Units for Statistics
SDU	Single Dwelling Units
MDU	Multi Dwelling Units
AL	Aggregation Links
AN	Aggregation Nodes
eNodeB	E-UTRAN Node B
MME	Mobility Management Entity
PDN	Packet Data Network
CPE	Customer Premises Equipmen
FDD	Frequency division duplex
CA	Carrier Aggregation

BS	Base Station
DPU	Distribution Point Unit
MDF	Main Distribution Frame
GPON	Gigabit Passive Optical Network
FP	Flexibility Point
LEx	Local Exchange
EU	European Union
GSMA	Global System for Mobile Communications Association
ARPU	Average Revenue Per User
NPV	Net Present Value
WACC	Weighted average cost of capital
RAN	Radio Access Network

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