The efficiency and effectiveness of a mixed public-private broadband deployment

The case of New Zealand's Ultra Fast Broadband deployment

Marlies Van der Wee
Dept. of Information Technology
Ghent University – iMinds
Ghent, Belgium
marlies.vanderwee@intec.ugent.be

Fernando Beltrán
University of Auckland
Auckland, New Zealand
f.beltran@auckland.ac.nz

***Abstract* — Although it is widely accepted that the future telecommunications access infrastructure relies heavily on Fiber-to-the-Home (FTTH), its deployment is compromised because it requires substantial investment. As such, if the decision to go ahead with the investment is made, the partners involved should make sure the deployment and operations are performed as efficiently and effectively as possible, to ensure both economic and social viability. A deployment is efficient if achieved at minimum expense and is effective if it reaches the outlined goals. This paper analyses the impact of policy decisions affecting the efficiency and effectiveness of New Zealand's public-private partnership in charge of building up a nationwide FTTH network: the Ultra-Fast Broadband (UFB) network. The paper concludes that in the context of such type of partnership a trade-off exists between efficiency and effectiveness. Although both concepts are well suited for assessing the performance of large-scale projects such as FTTH rollouts, they are not necessarily always aligned.**

Keywords — Fiber-to-the-Home, broadband policy, efficiency, effectiveness, New Zealand

I. Introduction

Broadband access encompasses the deployment of a range of technologies with Fiber-to-the-Home (FTTH) being favored by several worldwide projects; the main goal is to bring higher speed and reliability to consumers. Although telecom operators in many countries (e.g. Western Europe) were privatized 20-30 years ago, the deployment of fiber-based access networks has seen a return to government intervention. One example is the Public-Private Partnership (PPP) [1]; which represents a mixture of public initiative and private entrepreneurship, while in other cases private operators undertake the construction of fiber networks at their own risk.

As access to a broadband connection has been deemed essential/fundamental to citizens of a country, some governments embark on improving and expanding the reach of current communications facilities by means of regional or nationwide broadband plans. Considering the public nature of such a broadband plan, a measurement of achievement is how well the deployment serves the households, both in terms of deployment time and geographical coverage.

Broadband upgrades frequently happen via high-speed FTTH technology. When the project attempts to cover a whole country, cost concerns can lead to a fraction of the connections not embodied in fiber but alternative technologies such as Very High Bit Rate Digital Subscriber Line (VDSL), Hybrid Fiber Coax (HFC), radio access or satellite links.

When a national or regional authority is – directly or indirectly – involved in the deployment of a broadband (FTTH) network, this public actor will in most cases not take up the full deployment and operations of networks and services. Instead, the public involvement will be limited to the infrastructure. In order to clarify this, the network responsibilities can be split up into three conceptual roles, as visualized in Figure 1 [2]. The Physical Infrastructure Provider (PIP) is responsible for the passive, dark fiber infrastructure (rights-of-way, trenches, ducts and fibers). The Network Provider (NP) lights up the passive network by installing active equipment at both the network side (central office) and the end user's side (Customer Premises Equipment – CPE). The Service Provider (SP), finally, uses the end-to-end connectivity offered by the NP to offer content and applications in dedicated services to the end user. Multiple NPs can share the PIP's infrastructure if the network is opened on fiber or wavelength layer, while multiple SPs can compete using the connectivity offered by one NP when opening on bitstream layer.

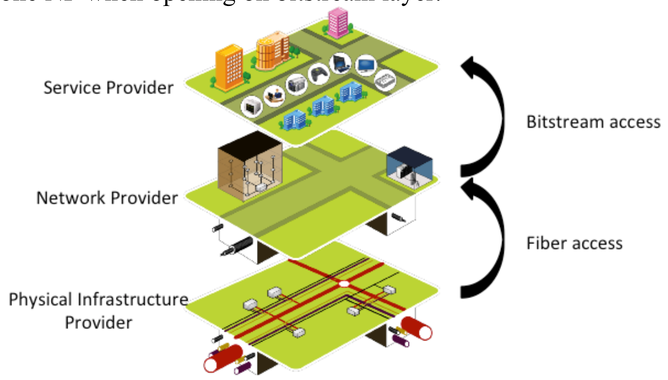

Figure 1: Overview of conceptual layers and access options

Public involvement in broadband deployment of course envisions the best use of taxpayers' money, and aims at reaching as many households as possible without giving in on the quality of the service. A deployment is efficient if achieved at minimum expense and is effective if it reaches the outlined goals. In essence, the goals are thus set as to maximize effectiveness (i.e. the goals) and efficiency (i.e. the way the goals are reached). Section II provides more details about how both concepts can be defined and indicates how both can be used for assessing a PPP broadband project.

In 2009, the New Zealand government created Crown Fibre Holdings (CFH), a company charged with managing a PPP with four Local Fibre Companies (LFCs) for the deployment of a FTTH network to 75% of the households in the country. This project, known as Ultra-Fast Broadband (UFB), is complemented by the Rural Broadband Initiative (RBI). This second infrastructure project covers a further 22.8% of households with alternative technologies (VDSL, fixed-wireless, satellite).

For the UFB, the contracts between CFH and the LFCs are quite detailed in terms of both economic and technological requirements. The contract terms can be summarized as follows [3]:

- LFCs are obliged to deploy a Gigabit Passive Optical Network (GPON) and offer bitstream access to all SPs on equal terms. LFCs thus act as a combined PIP-NP.
- The network should also be capable to offer Point-to-Point (P2P) access on request (albeit for a relatively high price).
- Unbundling on the fiber layer (on top of PIP) should be possible from 2020 onwards.
- Wholesale offers are fixed in terms of download and upload speed (30/10 and 100/50 Mbps), and price.
- The deployment should focus on priority users first (e.g. schools, hospitals, large businesses); residential homes are targeted in a second stage.

The RBI on the other hand aims to cover the less densely populated areas, where the cost for deploying FTTH would be too high. The main aspects of the deployment are [4]:

- Connecting 252,000 rural households by 2016 (about 90% of homes and businesses outside UFB areas),
- with speeds of at least 5Mbps through a mix of VDSL and fixed-wireless services,
- by two operators selected as RBI partners:
  - a fixed-line operator deploying fiber to cabinets and improved copper-based broadband (VDSL and ADSL),
  - and a wireless operator charged with the provision of fixed-wireless.

In early 2015 the UFB and RBI initiatives described above were renamed as Phase 1 to distinguish them from plans to extend their scope. Now, plans aim at increasing the FTTH coverage from 75% to least 80% of households, for which additional funding of up to $210 million (UFB extension) and $100 million (RBI) has been announced.

The contract terms and related obligations set by the New Zealand government, such as the open access obligation and the “priority users first” deployment sequence, of course impact the technological evolution of the network. Therefore, after a few years of continuous progress in UFB and RBI deployments, as well as following the recent announcement for extension, assessing the impact of the policy decisions on the PPP project, in terms of efficiency and effectiveness, can lead to useful insights.

The rest of this paper unfolds as follows: section II gives an overview of common definitions of both efficiency and effectiveness, and identifying suitable indicators for measurement. Section III gives an overview of the current status of the UFB deployment and progress. The combination of the analytical framework and the UFB data serve as input for section IV, in which policy decisions made in the New Zealand case are assessed. Finally, section V provides conclusions for this paper and gives directions for future work.

II. Efficiency and Effectiveness

As the goal of this paper is to draw conclusions about the efficiency and effectiveness of broadband deployments, a first step requires clearly defining both. This section will therefore introduce the concepts of efficiency and effectiveness and draw from that knowledge to identify characteristics to measure them. In short, effectiveness indicates to what extent the set goals are reached, while efficiency means the extent to which the minimum effort is incurred in reaching those goals. Typically, being efficient is adamant to minimizing the cost of reaching the goal. As such, effectiveness means doing the right thing, while efficiency is about doing the things right [5].

A. Efficiency

An accepted definition of efficiency implies “being productive without waste” [6]. Lemstra and Groenewegen describe five interpretations of the term efficiency [7] as follows:

- **Technical efficiency** refers to a firm using the minimum quantity of inputs required to produce a desired output.
- **Productive efficiency** denotes the firm’s efforts to incur minimum long-run average costs in its production process. It translates into finding the right balance between capital, upfront investment and recurring, operational expenditures.
- **Allocative efficiency**, also referred to as Pareto efficiency, deals with the allocation of resources in a way that the production is done at a level at which the marginal (last) unit cost equals the marginal benefit to consumers; it can also be stated as “not being able to make one consumer better off without disadvantaging another one”.
- **Adaptive efficiency** measures the flexibility and responsiveness of the firm to adapt to market changes both in consumer demand and technological capabilities.
- Finally, **dynamic efficiency** indicates the adaptation to long-term changes, i.e. to what extent the firm innovates with the goal of increasing its return on investment.

Fourie and Burger [8] furthermore argue that, in a properly functioning market, efficiency is driven by competition, risk and incentives for profit maximization. Private parties use the promise of personal financial gain to find a motive for producing at lowest cost, while the threat of a competitive offer stimulates efficiency to survive. Their research indicates that, in order to maximize efficiency, competition and private operator’s equity should be maximized, while uncertainties about demand estimation and the social importance of the product should be minimized.

There are incentives to being technically efficient; using the least amount of inputs to deliver on a goal translates also into reducing costs. Therefore technical efficiency can be also understood as a prerequisite to productive efficiency. In a high-speed broadband network deployment process a trade-off frequently is involved: a more reliable, but more expensive, network management system can reduce later operational and maintenance costs significantly, resulting in overall savings and hence desirable gains in productive efficiency.

Broadband deployments display some of the economic aspects that get in the way of allocative efficiency; for instance, when the network turn out to be a monopoly and its operation is riddled with externalities. When the deployment is a result of developing public policy, questions can be raised about the allocation of (public) resources to the construction of fiber connections. Allocative efficiency is considered an indispensable tool to measure how much markets and public policy improve or harm groups in a society. Its utilization may shed light on the kind of efficiency a broadband deployment generates [9].

Within the case of a FTTH deployment, the uptake is always uncertain and can only be estimated. The latter compromises the ability of the firm to be adaptively efficient. The capital investment should be such that the right balance between technical/productive efficiency and guaranteed return on investment must be found. On the other hand the deployment itself calls for a commitment to a given network technology and network architecture which, hopefully, should be chosen with the most flexible, state-of-the-art technology in mind. Once the decision is made and the network investment is sunk, adaptation to long-term evolution would need to happen in upper layers of the network hierarchy.

B. Effectiveness

Effectiveness, on the other hand, measures the extent to which both private and public goals are achieved [8]. It basically indicates the ratio of actual output to planned or expected output [5]. As for efficiency, different types of effectiveness can be identified but there should always be a clear indication of the goal. Cost-effectiveness for instance measures whether the product is produced under a certain cost threshold (and is as such different from efficiency, which is about minimizing the production cost).

OECD's approach to PPPs asserts that "faced with deciding between traditional procurement and PPP a government will then choose the most affordable option with the potential to deliver the highest value for money (VFM)" [1]. Building upon the OECD approach, [10] relates effectiveness to the concept of VFM, a criterion that involves risk transfer, performance measurements, incentives, and generation of additional revenue, arguing that a more effective project will lead to a higher VFM. Inquiring about effectiveness helps clear the way to determining the VFM a PPP or a procurement project is expected to deliver.

Linking the concept of effectiveness to FTTH deployments under a PPP approach demands for evaluation of both public and private goals, the public goal being the maximization of welfare (by efforts to maximize employment or GDP), while the private goal is the maximization of profit.

C. Efficient and effective FTTH deployments

In the context of an infrastructure project that aims at achieving social goals, effectiveness implies that these goals are *maximally* served, whereas efficiency measures whether consumer preferences are *optimally* served [8]. Although in an ideal world, project managers would like to reach high levels of both efficiency and effectiveness, reality seems to dictate they are frequently confronted in a way that suggests a trade-off between them. For example, in the case of broadband deployment, deploying FTTH to 100% of population (consequently meeting public goals and effectiveness) requires high investments in hard-to-reach rural areas and fails meeting deployment at lowest possible cost, and efficiency. Compromises involving fixed-wireless or satellite deployments to these rural areas try to meet both concepts as much as possible. As such, the decision of serving broadband by using both the UFB (full-FTTH deployment) and the RBI (DSL and fixed/wireless) can be seen as a first efficiency-effectiveness trade-off in New Zealand's public decisions.

This seeming trade-off is best addressed when ways of measuring both parameters can be identified. Table 1 displays a list of proposed indicators that qualitatively and quantitatively measure aspects of the two concepts and can serve to draw conclusions on the impact of policy decisions on broadband deployments.

A distinction is made between operator indicators and market indicators. Operator indicators measure efficiency and effectiveness by factors that an operator itself can control or, to a large extent, can influence. They include speed of deployment, availability and cost of deployment. Speed of deployment indicates how fast the network is being rolled out and can be taken as an indicator of reaching the set goals on time. Availability indicates the extent to which users can actually get connected to the network at a desired speed. It is related to coverage but unlike being concerned only with whether the network has already been passed by, it refers to available offers in terms of bandwidth, thus an effectiveness measure (mainly from a public point of view). Finally, cost of deployment denotes the money spent on building a broadband connection and bringing it up for offer, thus serves as an indicator for technical efficiency.

Table 1: Indicators for measuring efficiency and effectiveness

	Efficiency	**Effectiveness**
Operator indicators		
Speed of deployment	x	
Availability		x
Cost of deployment	x	
Market indicators		
Competition		x
Uptake		x
Uptake-coverage ratio	x	

The second part of the table identifies market indicators, which cannot be influenced by one party solely (either the government, the regulator or an operator), but depends on the structure and characteristics of the market, customer demand and service competition. Competition relates to both the number of providers on the market as well as the price setting.

It is an effectiveness indicator for the public partner, as it represents the dynamicity of the market. Uptake is a measure of how many customers have indeed decided to purchase a broadband connection and can thus be categorized as an effectiveness measure because maximizing the number of subscribers is both a public and a private target. The ratio of uptake to coverage, on the other hand, links to the business case efficiency of the deploying operator; i.e. does the operator obtain sufficient return for its sunk investment?

III. CURRENT STATE OF THE UFB DEPLOYMENT

The goal of this paper is to assess the efficiency and effectiveness of New Zealand's UFB project at this stage of deployment (five years into the project, but still almost four years to completion of stage 1). The authors collected data from a number of sources, from both the involved LFCs ([11]-[14]), the public partner company CFH ([3]), and commercially available data on SPs' websites (e.g. [15]-[19]).
The coverage details the percentage of homes passed per area until June 2015 [20]. The daily deployment rates (DDR) indicate the number of households passed per day, per area. Past DDR were calculated over the first 1431 days (from the project start through June 30 2015) whereas the remaining DDR were calculated over 1645 remaining days (from June 30 2015 through Dec 31 2019). The target rates indicate the number of homes that should be passed to reach to overall coverage goal by the end of 2019, reflecting the average DDR that is needed to reach the coverage targets set out by the government. The uptake indicates the number of households subscribed to the UFB, and is represented relatively to the total number of homes (uptake) and relatively to the number of homes that can subscribe (uptake to coverage ratio) [20]. The next column indicates the number of active residential SPs, while the final column shows the number of households per coverage area (i.e. the total potential market). The availability indicator can be assessed by taking the input from both columns on coverage and number of SPs.
The cost of a premise passed has been decreasing over time. Estimates for Chorus deployment of the UFB indicate that when the rollout started in 2012, the cost per premises passed was about NZD 3,500 (USD 2,760) compared to NZD 2,134 (USD 1,810) in 2014 [21]. Furthermore, the cost per premise connected, which amounts to the expense incurred in when connecting premises to the fiber passing the premises, was about NZD 1,233 (USD 1,050) in 2014 falling steadily since 2012 [21].

Table 2: Overview of deployment parameters per area (June 2015)

Area	Coverage	Past DDR (#households)	Target DDR (#households)	Remaining DDR (#households)	UFB uptake	UFB uptake to coverage ratio	Number of residential SPs	Number of households
Northpower	100%	13.3	6.2	0.0	20.1%	20.1%	10	19,100
Whangarei	100%	13.3	6.2	0.0	20.1%	20.1%	10	19,100
UltraFast Fibre	89%	105.8	55.4	11.5	11.7%	13.2%	14	170,300
Hamilton	83%	38.7	21.7	6.9	11.3%	13.6%	20	66,800
Tauranga	90%	28.4	14.7	2.7	15.5%	17.2%	16	45,200
Tokoroa	100%	3.4	1.6	0.0	9.2%	9.2%	19	4,900
New Plymouth	85%	12.2	6.7	1.9	9.4%	11.0%	11	20,600
Hawera	100%	11.5	5.3	0.0	8.1%	8.1%	8	16,400
Wanganui	100%	11.5	5.3	0.0	9.1%	9.1%	8	16,400
Enable	47%	47.3	46.8	46.4	7.5%	16.0%	10	144,100
Christchurch& Rangiora	47%	47.3	46.8	46.4	7.5%	16.0%	10	144,100
Chorus	47%	259.5	255.9	252.7	7.0%	14.9%	9	787,100
Auckland	39%	101.4	120.9	137.9	6.6%	16.9%	18	372,000
Rotorua	90%	13.1	6.8	1.3	12.7%	14.1%	11	20,900
Taupo	100%	6.9	3.2	0.0	6.1%	6.1%	6	9,900
Whakatane	61%	2.3	1.8	1.3	4.6%	7.5%	7	5,500
Gisborne	36%	3.1	4.0	4.8	2.2%	6.0%	5	12,300
Napier/Hastings	45%	12.9	13.3	13.7	6.6%	14.6%	11	40,900
Palmerston North	62%	12.1	9.1	6.4	10.4%	16.8%	11	27,900
Feilding	32%	1.3	1.8	2.3	1.9%	5.9%	11	5,600
Masterton	89%	5.3	2.8	0.6	9.7%	10.9%	6	8,500
Kapiti	30%	3.4	5.3	7.0	0.8%	2.8%	4	16,400
Wellington	35%	30.9	41.0	49.9	5.0%	14.4%	17	126,200
Levin	33%	1.6	2.3	2.9	1.6%	4.9%	6	7,100
Nelson	56%	9.2	7.6	6.3	6.4%	11.4%	9	23,500
Blenheim	100%	7.8	3.6	0.0	18.9%	18.9%	8	11,100
Greymouth	83%	2.0	1.1	0.4	4.0%	4.8%	2	3,500
Ashburton	100%	5.7	2.6	0.0	14.2%	14.2%	6	8,100
Timaru	100%	8.9	4.2	0.0	16.3%	16.3%	8	12,800
Oamaru	100%	4.1	1.9	0.0	11.4%	11.4%	6	5,800
Queenstown	82%	2.8	1.6	0.5	7.7%	9.4%	8	4,900
Dunedin	53%	16.5	14.5	12.7	8.4%	15.8%	15	44,500
Invercargill	60%	8.3	6.4	4.8	7.2%	12.0%	9	19,700

IV. THE IMPACT OF POLICY DECISIONS

As mentioned above, the technological partner does not solely take the decisions to deploy high-speed broadband networks in an efficient and effective manner. When public funds or another type of government support is involved, all funding parties want to reach their own goals and as such impose certain obligations onto the network, which directly affect its technical specifications and may later have a sizable impact on key market determinants as the network becomes operational. As this paper focuses solely on the UFB deployment in New Zealand, assessing the relative efficiency and effectiveness of the entire project is not possible, as no comparisons are made to other deployments (this is beyond the scope of this paper, but interested readers can be referred to [22]-[24]). An absolute assessment of efficiency and effectiveness is the aim of this paper, and more precisely evaluating the impact of certain specific policy decisions on both performance parameters.

A. Bitstream open access to everyone

In New Zealand, the government decided that the UFB network should be a GPON (Point-to-Multipoint, P2MP), on which any LFC would offer connectivity to any interested service provider on non-discriminatory conditions (the LFC thus assuming the role of PIP and NP, see Figure 1). This connectivity is offered through setting up a virtual tunnel (bitstream), and should be done in an open access way, implying that the LFCs cannot act as SPs themselves, as they are only allowed to provide wholesale services.

The bitstream open access obligation has multiple consequences. On the one hand, bitstream access allows for multiple service providers to use one underlying network, hence promoting competition between service providers without needing to duplicate the infrastructure. As of Q1 2015, 87 service providers (both residential and business) were offering services on the UFB network countrywide. As seen in Table 2, some areas are served by up to 20 residential SPs. Such a number is a significant increase in comparison to the copper-based market where Spark (formerly Telecom) is the dominant player (50%), leading Vodafone (32%) and a fringe of smaller providers [25]. It enhances the ability of a customer to get the best match between her expectations and what the market offers, so making a positive contribution to improve competition, one indicator of effectiveness. Furthermore, although absolute prices for broadband access have remained stable, customers now receive faster connections (both in download and upload speed) with higher or unlimited data caps for the same price (e.g. [15]-[19]).

On the other hand, the open access part of the obligation has both positive and negative effects. Non-discriminatory open access stimulates competition, which increases customer choice, but also has the downside of lacking a direct link between the LFC and the end customers. This therefore raises an interesting issue: if the LFCs are not allowed to interact directly with customers, how can they stimulate customers' subscriptions and hence reach higher uptake? This issue is reflected in the relatively low uptake to coverage ratios (absolute uptake hence being even lower) as shown in Table 2. Recent data for selected areas [20] however show a significant increase in uptake (a number of areas reaching 15-20%), but this uptake might have been higher had the LFCs themselves been allowed to subscribe end customers.

B. Fiber unbundling on request

Apart from bitstream access, the LFCs are also obliged to offer Point-to-Point (P2P) dark fiber on request. Dark fiber unbundling translates into allowing other providers to use the passive infrastructure – leasing out access to PIP level (see Figure 1) – in order to operate services that will then compete with those of the LFCs; in doing so, such providers will turn themselves into wholesalers, thus becoming competitors of the LFCs at the NP level with the LFCs continue to hold a monopoly at the PIP level.

These requests for P2P and dark fiber access of course have a significant impact on the network (Figure 2), as they require physical fiber to be leased instead of virtual tunnels. In order to cope with the expected variety of (future) requests, the LFCs decided to over-dimension their FTTH networks. The main features of such decisions are:

- Multiple feeder fibers drawn in between the central office and the street cabinet (in this part of the network multiple end users share fibers), or extra empty ducts deployed in the existing feeder trenches, which can be filled with air-blown fiber as soon as needed for new users that join the network.
- Reserved space needed in the street cabinets for installation of extra splitters in order to allow for a multi-NP scenario.
- Every household connected to the street cabinet using two fibers in the distribution section (from street cabinet to customer's house), which means that a customer can, in the future, be connected to at most two NPs at the same time.

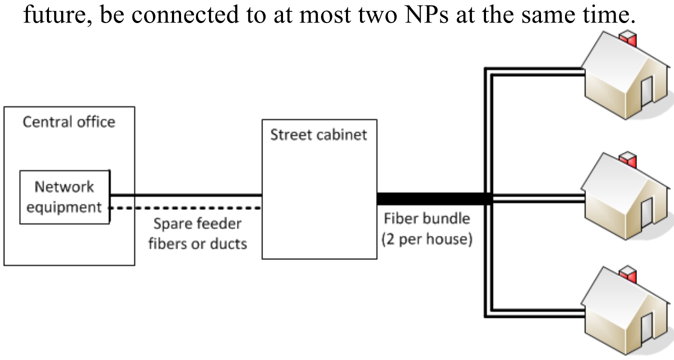

Figure 2: Overview of the impact of fibre unbundling on the network deployment cost

Though over-dimensioning of the network makes it future-proof, the extra investment is not directly countered by extra revenues, as fiber unbundling is not included in the standard wholesale offer. We can thus conclude that, although this over-dimensioning entails a decrease in efficiency (in terms of cost of deployment), it might lead to higher - public - effectiveness (more competition) and possibly lower prices (as wholesale competition might push the price towards marginal cost). This statement can unfortunately not be backed up by quantitative data, as there is no area-specific cost data available and the demand for dark fiber unbundling remains uncertain.

C. The tender process and the funding scheme

The selection of the LFCs was based on a number of tender processes, one for each reference area (Figure 3, for an overview of the areas see Table 2). Three new companies (Northpower, Ultra-Fast Fibre and Enable) were chosen for 9 areas, while Chorus, a company divested from the former incumbent Telecom, serves the remaining areas [27].

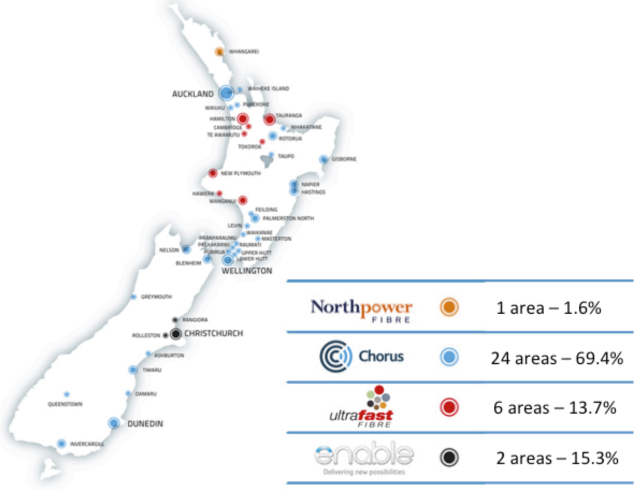

Figure 3: Geographical allocation of the reference areas following the tender process [10].

The new partner companies follow a so-called “funds-recycling” mode, a funding scheme in which the government funds the fiber passing (the fiber in the streets, the public domain), while the partner funds the drop section (from the street to the customer’s premises), as seen in Figure 4. When a customer subscribes, the LFC pays back a representative part of the network investment to CFH and connects the customer by deploying the drop. As this drop section is only installed at the moment a customer decides to subscribe to the UFB, the LFC is ensured of revenues at the moment it has to invest its own funds [27].

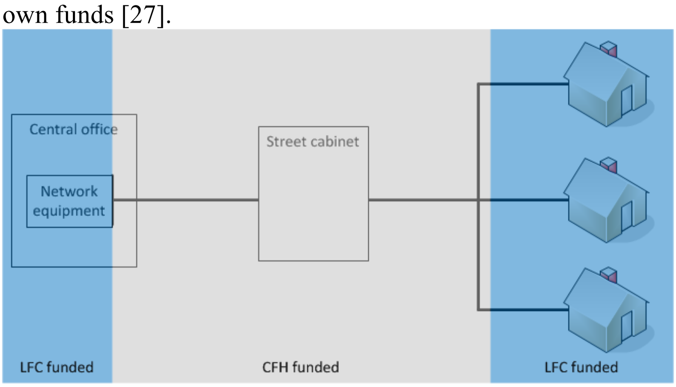

Figure 4: Graphical representation of funds-recycling scheme

Chorus, on the other hand, uses the “investment model”, according to which the government injects funds directly into the company. Chorus autonomously decides how to use them while having to comply with agreed coverage and uptake targets. Chorus is also responsible for the operations and maintenance of the copper-based DSL network, which runs in parallel to the UFB network.

With 724,000 homes passed as of June 30 2015, completion rates in the UFB areas range from 30% to 100%, with an overall average achieved coverage of 72% (an increase of 20% when compared to June 2014). The daily deployment rate is 425 homes passed per day, which is higher than the target rate of around 365 households per day. Table 2 displays both rates for each LFC. These figures help providing a quantitative support to analyze the efficiency and effectiveness of the UFB deployment from an operator’s perspective by using the speed of deployment and the availability indicators.

The LFCs that signed the funds-recycling scheme, have achieved completion rates of 100% (Northpower), 89% (UltraFast Fibre) and 47% (Enable). Apart from Enable, whose lower DDR can be explained by the delays caused by the earthquake of February 2011 [28], the local LFCs prove to be more efficient in delivering on their targets than their larger counterpart. Their targets have been either met or are on the right pathway towards completion on time. The completion rate of Chorus stands at 47%, with the additional complication that among its least developed areas are the two main urban areas of the country. The two cities (Auckland and Wellington) comprise 40% of the country’s population but up until June 2015, only 30-40% of their households have a fiber connection available. The latter seems to suggest that the funds-recycling scheme is providing a higher incentive for fast deployment than the combination of the investment model with the foreseen technology replacement of Chorus’ own DSL services. As customers are not likely to be subscribed to both FTTH and DSL, the FTTH uptake will bring down DSL consumption, hence leading to a cannibalization of Chorus’ DSL offer. In favor of the funds recycling scheme, one could argue that the option of reclaiming ownership of the network by purchasing parts of the network when assured of revenues provides a clear incentive to complete the deployment faster than in case of the investment model, which leads to a (at least partially) third party ownership.

Apart from speed of deployment and coverage, one could also investigate if there is a link between the LFC (smaller local company or large former incumbent) and consumer uptake, as there seems to be no direct incentive for the LFCs under the funding recycling scheme to attract new customers. A new subscriber causes the LFC to incur a double expense: the investment in the connection (drop section and connection in the central office, see Figure 4) as well as a reimbursement to CFH, while only getting a limited security on the revenue side, usually a contract for a maximum of 24 months. Most recent data at the area level (see Table 2) indicates that as of Q2 2015 the highest uptake figures were split among areas covered by three new LFCs with the largest two cities – Auckland and Wellington, both served by Chorus - hovering around the 15% mark. Rather than a clear effect of the funding model on uptake the figures seem to suggest the usual decisions by service providers to focus on the more densely populated areas.

D. Pricing and competition on different networks

A deal between CFH and the LFCs fixed the prices for the wholesale offers, 30/10 and 100/50 (Mbps down/up), at NZD 37.50 and NZD 55.00, respectively. LFCs can bring other offers to the market but the two offers mentioned above must be made available at least until 2020. These prices are comparable to the current wholesale charges on the legacy DSL network (current proposal stands at NZD 38.39 [29]), while the lowest bandwidth offer (30/10) is not significantly faster than speeds already offered in certain parts of the country on Chorus' DSL network. The current debate on the price of copper is being fuelled by recent challenges to the Commerce Commission's decision to reduce the rental price of copper lines, a decision aimed to benefit users of DSL connections; however reducing the price of copper may not be in the best interest of the needed growth in UFB uptake as users may not see the benefits of subscribing to a more expensive service. When the new product does not exhibit an obvious, superior characteristic than the old one it becomes hard for service providers to convince customers to switch to the UFB network, hence impacting the uptake-to-coverage ratio as well as the business case for the operators.

Incentives to reach allocative efficiency in the deployment of this PPP-based FTTH broadband network tend to be obscured by the way the contractual terms are set up; the future network should be operated as a monopoly with open access obligations while construction must proceed under, usually, tight budget. With wholesale prices negotiations happening way before the first connection is lit, it is hard to know or even estimate the price mark up over marginal cost.

On the other hand, as already shown in section IV.A, this geographical infrastructure monopoly has led to a significant increase in competition on the higher network layers. When comparing the achieved uptake with the number of active residential SPs in the area, Table 2 shows a clear positive link with both uptake and uptake-to-coverage ratio: areas with an uptake of over 13% have a choice of at least 10 providers (with two exceptions: Tokoroa and Feilding, reaching only 9.2% and 5.9%, respectively). Furthermore, the network now allows for start-ups to arise and gain market on a local scale, taking the examples of local service providers such as Gisborne.net (Gisborne area), Earthlight (Dunedin) and the Uber group (Whangarei).

E. Priority users

A group of designated "priority users" occupy a special place in the broadband expansion project. The contracts the LFCs signed with the government request that these priority users, such as schools and rural hospitals, be connected first. To date the numbers of schools connected to fiber service of 100 Mbps are 1,403 and 1,020 by UFB and RBI, respectively (as of June 2015 [30]). The RBI further serves 52 more schools, which are located in remote areas are receiving point-to-point wireless connections with peak speeds of at least 10 Mbps.

Non-surprisingly the contract conditions reveal a tension between an understandable government's policy goal and the LFC's commercial goals. One could argue that while such obligations, when met, constitute a certain contribution to the effectiveness of the deployment of broadband services, such a "priority-users first" deployment is unable to follow the most economic route, thereby affecting the speed and cost of deployment [31]. While this latter conclusion may well fit reality, quantitative underpinning is not possible because no data on the actual deployment routes and area-specific costs is available.

V. CONCLUSIONS AND FUTURE WORK

The Ultra-Fast Broadband deployment in New Zealand was conceived as a Public-Private partnership which, halfway through its expected duration, is already delivering important benefits to those who have opted for connecting. The short-term objective of the government was to put the country back on the higher notches of the OECD's digital ranking by providing a renewed, more powerful communication infrastructure to businesses and households.

As a way to provide an assessment framework to an unfinished project such as the UFB network, this paper proposed a set of indicators that capture different expressions of efficiency and effectiveness; the indicators pertain aspects of a deployment that stakeholders may be most interested in or more acquainted with. Six indicators were defined in two categories: operator indicators and market indicators. Operator indicators, which can be influenced by one single partner, are availability and speed and cost of deployment. Market indicators on the other hand depend on the adoption, market structure and evolution: competition, uptake and uptake-to-coverage ratio. Using publicly available data the paper aimed to quantify the assessment by using the indicators to analyze the efficiency and effectiveness of the deployment.

The evaluation revolved around assessing the impact of five distinct policy decisions: the open access requirement, the fiber unbundling obligation, the tender process and financial funding scheme, pricing and competition, and special dispense given to priority users.

The first policy decision, the open access requirement on bitstream level, opens up the network for increased competition and customer fiber uptake - hence improving public effectiveness. However, it prohibits the LFCs, which can only provide wholesale services, to directly influence the uptake on their networks, thus impacting the efficiency of their business case. The network flexibility introduced by the fiber unbundling obligation increases the opportunities for competition, but on the other hand negatively impacts the operators' efficiency in terms of cost of deployment.

The dual funding structure represented by the funds-recycling and the investment models does not seem to have a significant impact on the uptake, especially when taking into account the potential effect of cannibalization of the DSL network for Chorus.

Wholesale price levels for DSL services impact the uptake as users, frequently not fully aware of fiber benefits, may prefer cheaper services. Finally, the "priority users"- first decision shows (at least qualitatively) a clear trade-off between public and private goals.

The previous observations point at one revealing aspect of the relationship between efficiency and effectiveness in the context of a PPP. While both concepts help partners evaluate the success of the project, the two are not necessarily aligned. Such 'misalignment' suggests a trade-off may exist between efficiency and effectiveness by which trying to increase one may come at the expense of the other.

Future work of course includes updating the results as deployment progress continues and uptake increases. Secondly, the analysis could be enhanced if more detailed data were available. Uptake should be more explicitly measured, both in terms of FTTH specifically and broadband (FTTH, DSL, DOCSIS, fixed-wireless) in general, as well as in terms of service offerings (download speed, upload speed, data cap). Furthermore, although sufficient data for reliable statistical analysis (e.g. regression methods) might not be available yet, future studies should also evaluate the effects of the UFB project on the welfare and economic prosperity of the country (measured e.g. in terms of employment rates or GDP), as the latter might better reflect the actual goals of the public partner in such a large infrastructure project.

VI. ACKNOWLEDGEMENT

The authors of this paper would like to thank the contact persons within CFH and the LFCs for their contributions and interesting discussions. The first author received funding from the Agency for Innovation by Science and Technology in Flanders, Belgium. We would also like to thank the reviewers of the paper for their valuable comments that helped improve the final version of this paper.

VII. REFERENCES

[1] OECD (2008). Public-Private Partnerships - In pursuit of risk sharing and value for money. OECD Publishing, Paris.

[2] Van der Wee, M. Supporting Strategic Decisions in Fiber-to-the-Home Deployments: Techno-Economic Modeling in a Multi-Actor Setting, PhD Thesis, Ghent University, February 2015.

[3] Crown Fibre Holdings. (2015) http://www.crownfibre.govt.nz/

[4] New Zealand's Ministry of Business, Innovation and Employment (2015) The Rural Broadband Initiative and getting connected. http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband/rural-broadband-initiative

[5] Larbi-Apau, J. A. and Moseley, J. L. (2010), Performance-based measurement: Action for organizations and HPT accountability. Perf. Improv., 49: 7–17. doi: 10.1002/pfi.20116

[6] Woolf (Ed.), H. B. (1977). Webster's new collegiate dictionary. Springfield, MA: Merriam Company.

[7] Lemstra, W. & Groenewegen, J.P.M. (2010). Efficiency concepts. Working Paper, Department Technology, Policy and Management, TUDelft.

[8] Fourie, F. and Burger, P. (2000) An economic analysis and assessment of public-private partnerships (PPPs). The South African Journal of Economics, 68(4).

[9] Boundless. "Allocative Efficiency." Boundless Economics. Boundless, 14 Nov. 2014. Retrieved 14 May. 2015 from https://www.boundless.com/economics/textbooks/boundless-economics-textbook/competitive-markets-10/long-run-outcomes-68/allocative-efficiency-258-12355/

[10] Beltrán, F. (2013) Effectiveness and Efficiency in the Build-Up of High-Speed Broadband Platforms in Australia and New Zealand. Communications and Strategies, 91 (3).

[11] Chorus (2015). Annual Report 2015. https://www.chorus.co.nz/file/65885/5.4-3348-CHO-Annual-Report-2015_WEB.pdf

[12] Northpower Fibre (2015) Our partners. http://www.northpowerfibre.co.nz/index.php/partners

[13] Enable (2015) How to connect? http://www.enable.net.nz/how/residential.html

[14] UltraFast Fibre (2015) Ultra-Fast Broadband (UFB) has landed! http://www.ultrafastfibre.co.nz/get-ultrafast

[15] MyRepublic (2015) Plans and Pricing. https://myrepublic.co.nz/pricing/

[16] Spark (2015) Plans and pricing. http://www.spark.co.nz/shop/internet/plans-and-pricing/

[17] Vodafone (2015) Build your ultimate Red Home package. http://www.vodafone.co.nz/internet/package-builder/?data=unlimited&speed=fastestUFB100&phone=no&tv=notv&onaccount=yes

[18] Uber Group (2015) The best broadband in Northland - available only from Uber! http://ubergroup.co.nz/broadband.uber

[19] Compass (2015) Ultra Fast Fibre Broadband. http://www.compass.net.nz/at-home/ultra-fast-fibre.html

[20] MBIE (2015) Broadband Deployment Update, June 2015. http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/fast-broadband/documents-image-library/regional-broadband-factsheet-june-2015.pdf

[21] Gregory, M. (2015). How much do FTTP NBN connections really cost? http://www.businessspectator.com.au/article/2015/9/18/technology/how-much-do-fttp-nbn-connections-really-cost

[22] Van der Wee, M. et al. (2011) Making a success of FTTH. Learning for case studies in Europe. Journal of the Institute of Telecommunications Professionals (ITP), 5(4), 22-31.

[23] Van der Wee, M., Beltrán, F. and Verbrugge, S. (2014) Evaluating the impact of financing structure decisions on FTTH deployment. A comparison between New Zealand and Europe. TPRC, September 2014, Arlington, USA.

[24] Domingo, A., Van der Wee, M., Verbrugge, S. and Oliver, M. (2014) Deployment strategies for FTTH networks and their impact on the business case: a comparison of case studies. ITS World, December 2014, Rio De Janeiro, Brazil.

[25] Commerce Commission of New Zealand. (2015) Annual Telecommunications Report 2014.

[26] Chorus (2015) Blenheim leads NZ in Ultra-Fast Broadband uptake. Press release 26/05/2015. https://www.chorus.co.nz/blenheim-leads-nz-in-ultra-fast-broadband-uptake

[27] Crown Fibre Holdings (2015) Crown partners. http://www.crownfibre.govt.nz/crown-partners/

[28] New Zealand History (2011) Christchurch earthquake kills 185. http://www.nzhistory.net.nz/page/christchurch-earthquake-kills-185

[29] Commerce Commission (2015) Further draft pricing review determination for Chorus' unbundled copper local loop service. Public version. ISSN 1178-2560. July 2nd, 2015.

[30] MBIE (2015) Broadband deployment update, June 2015.

[31] Van Ooteghem, J. et al. (2012). Municipal driven fiber access network rollout. Biannual ITS conference, Bangkok, Thailand.