Study for AB Stokab

The role of wholesale only models in future networks and applications

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0.1 Wholesale only networks and the Gigabit society

In September 2016, the European Commission set out its strategy on how to achieve a European Gigabit Society.[1] Core to the Commission's strategy is boosting high speed connectivity enabling Gigabit access, not only to homes, but also to support next generation (5G) mobile networks, as well as schools, hospitals and other drivers of socio-economic benefits.[2] The Commission has estimated that a further €155bln in investment, that already envisaged, will be needed to achieve these goals by 2025.[3]

Companies and public organisations that were not traditionally engaged in telecom provision have played a significant role in several member states in deploying the fibre connectivity needed to support these aims. Often, these players have deployed networks through a 'wholesale only' model in which the provider focuses on investing in infrastructure and providing wholesale services and does not offer broadband services directly to the public.

In this report for Stokab we examine (i) the role that wholesale only networks have played and are playing in boosting fibre deployment for public institutions, citizens and businesses across Europe; (ii) the views of infrastructure investors about the wholesale only business model; and (iii) the role wholesale only networks could play in the transition towards 5G, and its implications for future applications and services. A summary of the main findings follows.

0.2 Wholesale only networks – past present and future

Wholesale only initiatives have played a role in fibre deployment in Europe from an early stage. One of the earliest initiatives, Stokab in Sweden was established in 1994, based on a vision for connected public services and industry, that was well ahead of its time. Later, around 2007, mass-market wholesale only deployments by Stokab and other municipal providers in Sweden as well as initiatives by the City of Amsterdam and Reggefibre in the Netherlands brought fibre to consumers at a time when the average broadband speed offered across much of Europe was below 10Mbit/s.[4]

1 Commission Communication 2016: towards a European Gigabit Society https://ec.europa.eu/digital-single-market/en/news/communication-connectivity-competitive-digital-single-market-towards-european-gigabit-society
2 The Commission's Communication has outlined objectives by 2025 for all households to have 100Mbit/s access upgradable to Gigabit speeds, 5G coverage in major cities and highways and Gigabit access for 'socio-economic drivers'.
3 Estimations by the Commission drawing on the Study SMART 2015/0068. Staff working document accompanying the Communication "Towards a European Gigabit Society"
4 OECD https://www.oecd.org/sti/broadband/40629067.pdf

More recently, the wholesale only model has gained traction as a way to unlock investment in very high capacity networks in cases where traditional telecom operators have failed to upgrade their networks to full fibre or in rural areas where costs are high and the business case is difficult. Major initiatives starting from 2014/2015 include the extensive ongoing deployments by Enel Open Fiber in Italy and SIRO in Ireland. Other fibre initiatives, such as Dublin Docklands, have focused on serving innovation hubs and improving economic competitiveness, while supporting environmental objectives by limiting disruption from civil works and enabling e-working.

As shown in the map below, the model has been deployed in cities alongside legacy networks, as well as in rural areas, where only one high capacity network is viable, sometimes with the support of state aid. While many of the initiatives have been driven by local authorities and public utilities, private investors have also played an important role in some cases. Several of the initiatives are recent, illustrating how wholesale only is gaining traction amongst the investment community and public sector.

Figure 0-1: Wholesale only initiatives – past, present and future

Source: WIK-Consult.

The results from wholesale initiatives have been impressive, not only in stimulating deployment of very high capacity (fibre) infrastructure, but in supporting a level playing field for competition:

- **Sweden,** one of the pioneers of municipal networks, remains one of Europe's leaders in fibre deployment. Municipal networks in Sweden have since the early 1990's made significant investments in fibre infrastructure, which have in turn driven fibre investments by private actors such as the former incumbent. By 2016, more than 60% of Swedish households had access to fibre at home,[5] and take-up stood at 43% of all broadband lines, the second highest in Europe.[6] In Stockholm, there are more than 100 operators and service providers on Stokab's network, and the city ranks highly in usage of digital services and innovation.[7]

- Municipally backed wholesale only initiatives in **France** and **Austria** have brought high speed broadband to some rural areas for the first time. The variety of service providers in rural areas of France is in some cases considered to be greater than in urban areas where vertically integrated fibre deployments prevail.[8]

- The wholesale only initiatives in **Ireland** and **Italy** have led to major disruption in markets which were previously lagging behind in high capacity networks – and triggered a fibre investment response by incumbents. Fibre take-up in Italy is predicted to increase three-fold to reach more than 35% of households by 2021 (see graph below). Conversely, in the **Netherlands**, where the largest wholesale only operator Reggefiber was acquired by the incumbent in 2014, deployment of fibre has slowed.[9]

5 HS/VVA for the European Commission

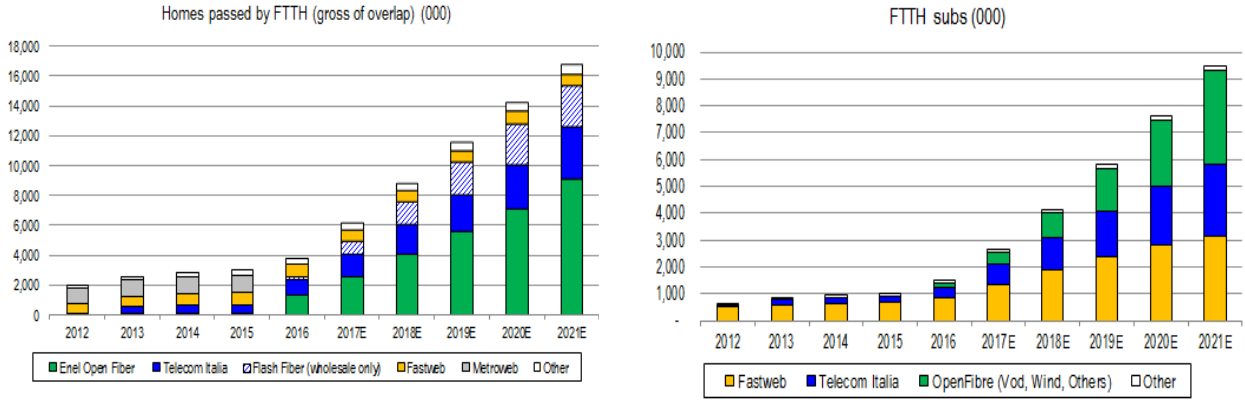
6 DATE for the FTTH Council – published Feb 2018 http://www.ftthcouncil.eu/documents/FTTH%20GR%2020180212_FINAL.2.pdf figures relate to FTTH/FTTB

7 WIK (2017) A tale of five cities: the implications of broadband business models on choice, price and quality https://www.stokab.se/Documents/Nyheter%20bilagor/A%20tale%20of%20five%20cities.pdf

8 See interview with Gabrielle Gauthey Caisse des Depots chapter 2

9 See case study in chapter 3. Although there is some deployment based on local rural initiatives, nationwide FTTP coverage in NL has plateaued at just above 30%.

Figure 0-2: FTTH homes passed and subscriber in Italy by operators, 2012 – 2021



Source: Credit Suisse (2017), Building the Gigabit Society, European Telecom Research.

These benefits have been acknowledged in proposals by the Commission to reform the electronic communications Code, which would allow lighter touch regulation of wholesale only players, unless competitive problems arise.[10]

0.3 The perspective of investors

In addition to achieving positive results for consumers, the public sector and business, wholesale only models have tapped into new sources of funding, attracting capital from long-term infrastructure funds, which would not otherwise invest in more risky telecom services businesses.

Caisse des Depots (CDD)[11] has been a major investor in FTTH in France, and a key proponent of the wholesale only model over the past two decades. CDD commits its partners to operate on the basis of open access, with a preference for wholesale only, and **stipulates in its contracts that the network cannot be sold to a vertically integrated operator**. Gabrielle Gauthey, Director of Investment and local development at the CDD, explains that *"**take-up on wholesale only networks is typically higher because the service is being marketed by multiple service providers***." This is a point echoed by other investors interviewed in the context of this study.

10 See article 77 of the draft EU electronic communications Code http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=comnat:COM_2016_0590_FIN

11 http://www.caissedesdepots.fr/en

Gauthey has also found that investing in fibre as an infrastructure has yielded positive returns, which are often higher than those for other infrastructures such as highways, railroads and energy. She also notes that there have been significant leverage effects from CDD's fibre investment. "CDD has made €4bln fibre investments possible because when CDD invests – there is a multiplier effect of 7 [mainly from private investors]."

The experience of Randolf Nijsse, partner in Communication Infrastructure Partners[12] (and previously the Communications Infrastructure Fund (CIF)) shows how wholesale only models can also be effective in enabling underserved rural areas to be served without public investment or state aid. The business case works by setting higher prices to account for the higher connection costs, and by pre-signing customers. Nijsse notes that demand is so great, that they have achieved their target take-up for FTTH every time, with an average sign-up of more than 60%. Thus far the Dutch rural investment programme has delivered over 20 different projects and signed up 80,000 customers. Nijsse believes that an additional 200,000 customers could be served in this way.

The network is based on (passive) point to point FTTH network.[13] Nijsse says that ***"an important point in selecting the architecture was that it should be accessible to multiple service providers and should allow switching of service providers to prevent lock-in."***

Laurent Chatelin from the Investment fund Margueritte[14] has also found high demand for fibre deployments in rural areas, and notes that demand is not limited to fibre to provide households with broadband access. **There is demand for fibre (and towers) for mobile provision and Wifi as well.**

0.4 The road to 5G

As the focus shifts from fast fibre in the home to fast broadband everywhere, the role of wholesale only providers may expand further.

In a study conducted for Stokab in 2017,[15] WIK found that **wholesale only networks had played a significant role in enabling the swift deployment of 4G (LTE) networks by alternative operators in Stockholm, stimulating competition in mobile broadband**.

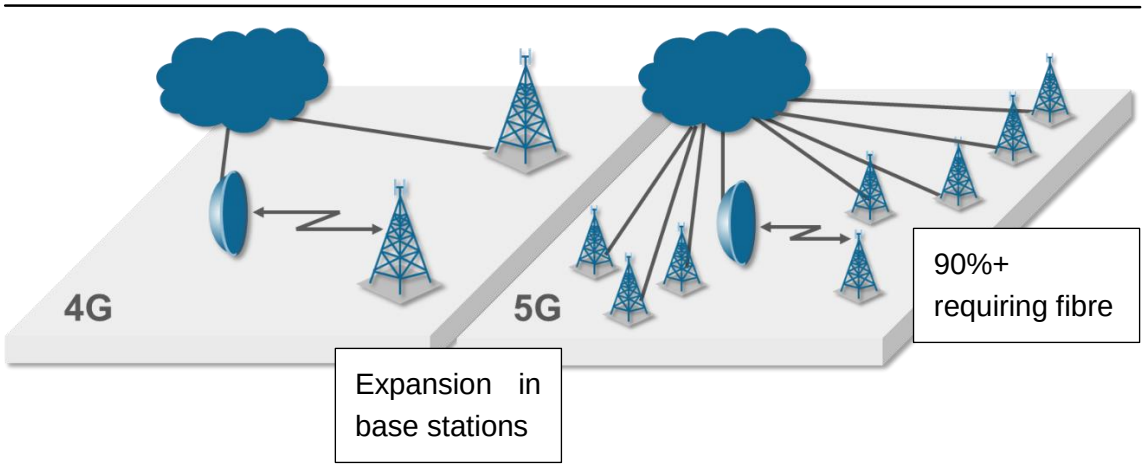
In an interview for this study, Peter Bryne, an independent consultant who was previously Head of Core and Transmission for Net4mobility, the joint venture between the mobile operators Telenor and Tele2 in Sweden, noted that "**A core benefit of the municipal networks is that they introduced competition in the market**. City

12 http://www.cominfrapartners.com/
13 FTTH GPON can also be deployed over this architecture
14 http://www.marguerite.com/
15 WIK-Consult (2017), A tale of five cities: The implications of broadband business models on choice, price and quality, a study for Stokab.

networks were also able to be more flexible in how and where they build and in their pricing. Importantly, city networks were also able to place value in wider social objectives and recoup investments over a longer period. In contrast commercial companies have a shorter term focus and have incentives to cherry-pick, deploying fibre selectively e.g. only to business premises. The resulting lack of widespread fibre coverage results in higher costs and prices for those premises for which fibre is installed."

The availability of dark fibre will become even more critical for mobile operators as they upgrade to 5G technologies which use higher frequencies with a lower range and therefore require build-out of additional base stations over time especially in densely populated areas. Interviews conducted by WIK with a number of mobile operators across Europe suggest that 5G is likely to require fibre to the vast majority of base stations (more than 90%), in comparison with today's networks, which still make use of microwave radio links for a significant proportion of connections.

Figure 0-3: Fibre requirements in a 5G environment



Source: WIK-Consult, based on operator interviews

As the economics of dense fibre networks are challenging, the role of neutral wholesale only providers is likely to be important in working with network operators to serve the required locations and enable quick deployment and competition. As Bryne notes: "***The availability of fibre city networks which have already been used to provide backhaul for 4G may enable a more rapid evolution towards 5G. Such networks will in particular provide an advantage for the second and third player in 5G compared with countries in which wholesale dark fibre is not available to the same degree.***" Co-investment could provide an alternative solution in countries and areas where this approach has been taken towards fibre deployment.

0.5 Implications for future applications

The fibre access that is made available by wholesale only initiatives offers the prospect not only of improved broadband in the home and for businesses, but also provides a **neutral platform on which service and application providers can develop their own innovative solutions for the public sector, businesses and society in general.** For example, ready access to wholesale access products, such as dark fibre, can enable innovation in other layers of the value chain within the fields of big data, the Internet of Things (IoT) and wireless remote technologies.

These innovations have been used in the healthcare system to improve the quality of patient care while reducing operational costs.[16] The publicly-owned[17] property company Sisab[18] provides another example, illustrating how dark fibre can support Smart Building technology to make building performance more efficient. Sisab is responsible for the maintenance, renovation and rebuilding of schools in Stockholm, and in doing so uses sensor-generated data to enhance the building user experience, reduce costs and support environmental goals.[19]

Investment by Sisab in climate sensors has generated savings of SEK 190 million in energy costs over 5 years and reduced energy consumption by about 26 % per square metre. Sisab's monitoring system also provides an overview of necessary maintenance, which creates opportunities to plan the work of building technicians in an efficient way.[20] IoT-enabled buildings can also enable real-time monitoring which alleviates security concerns for both owners and tenants.[21]

Monitoring of traffic to support safety and efficient traffic flows is another application that has been introduced in major Swedish cities, with the support of widely available dark fibre. Viscando Traffic Systems[22] has developed analytical methods to study the behavior of pedestrians and cyclists at a busy travel centre, where passengers can switch between different modes of public transport. Collecting detailed traffic data patterns several times per second, Viscando was able to identify areas where conflicts arose to support decision-making about the layout and operation of the centre.

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16 Stokab (2017), Focus on eHealth services: Healthcare providers and businesses describe the importance of dark fibre networks for meeting future health and social care needs

17 Sisab is wholly owned by Stockholm Stadshus AB, which in turn is owned to 100% by the City of Stockholm. Established in 1991, Sisab is one of the country's largest real estate companies with a broad and deep knowledge about educational environment. Sisab owns and manages 400 preschools and 200 primary and secondary schools in Stockholm and responsible for a total of 1.8 million square meters, with more than one hundred thousand people staying daily. In addition to the maintenance and management of the properties, Sisab works with extensive renovations and build-ups as well as some new construction projects.

18 Some of insights as regards to Sisab's operations are generated via the interview conducted with Niklas Dalgrip, head of the operations department at Sisab, on 25 January 2018.

19 Sisab (2015), Acclaimed fibre solution yields environmental gains in 600 schools.

20 Ibid.

21 Kejriwal, S. and S. Mahajan (2016), Smart buildings: How IoT technology aims to add value for real estate companies, Deloitte Center for Financial Services, Deloitte University Press.

22 http://www.viscando.com/

With dark fibre connectivity serving roads and highways, other, even more ambitious developments in intelligent transport could be realized. Autonomous driving is an important emerging technological development, which will require fibre deep in the network along highways and roads, alongside wireless connectivity and big data to enable communications between and amongst vehicles and the highway. Although MNOs could directly engage in the provision of such services, it is possible that, in areas where wholesale only fibre networks are available, specialist wholesale providers could emerge - supplying connectivity and other services to automobile vehicles on the roads, taking the burden of such costs from the mobile network operators (MNOs), and sharing any spare capacity with them.[23]

More generally, as seen in the WIK 2017 study[24] **wholesale only fibre networks seem to be associated with a more diverse range of service providers than competition models which rely on vertical integration. This diversity could help to drive innovation in IoT applications and services which have not yet been considered.**

0.6 Conclusions

The case studies and interviews we have conducted for this report lead us to draw the following conclusions:

- Wholesale only companies were amongst the first to deploy fibre in Europe. In recent years, wholesale only has played an increasing role in driving fibre deployment and competition in areas and countries where traditional telecom providers have been slow or failed to invest in upgrading their networks with fibre, as well as bringing fibre to rural areas in which only one high speed network is viable. Wholesale only initiatives are now present across multiple countries, both rural and urban areas and involving private as well as public investors.

- These initiatives have brought significant benefits to consumers through increased fibre deployment and competition. Competition has come both from incumbents, which have responded with fibre investments of their own, and from the multitude of service and application providers, which have been able to invest and innovate higher up the value chain, safe in the knowledge that their wholesale supplier will not compete with them for customers. The competitive advantages of the wholesale only model have been acknowledged in proposals by the Commission to reform the electronic communications Code.

- Wholesale only fibre business models have also unlocked additional capital as they can be attractive to long term infrastructure investors, who would not otherwise

23 LS telcom, VVA and Pliy Tracker (2016), Study on Spectrum Assignment in the European Union, a study carried out for the European Commission, p. 70.

24 In the WIK (2017) study “A tale of 5 cities”, it was noted that there were more than 100 service providers active in Stockholm on the Stokab network – compared with only around 5 in cities which were characterised by vertically integrated broadband providers

invest in integrated telecom companies. Such investors generally view the wholesale only network as an essential infrastructure. A key attraction of the model for these investors is to use multiple service providers to support demand. Wholesale only fibre investments have been found to deliver attractive returns for investors, compared with other essential infrastructures.

- Going forwards, fibre will be required not just to support broadband for homes and businesses, but also for the development of 5G networks, which require an increase in fibre-connected base stations and the Internet of Things. The role that fibre will play in supporting the wider needs of public institutions and industry as an 'infrastructure for society' is recognized in the Commission's Communication on Connectivity for a Gigabit Society.
- Neutral wholesale only suppliers could play an important role in meeting these needs, by providing an open platform for innovation across multiple industries and the public sector in the years to come.

1 Wholesale only models and the Gigabit Society

In September 2016, the European Commission set out its strategy on how to achieve a European Gigabit Society.[25] Core to the Commission's strategy is boosting high speed connectivity enabling Gigabit access, not only to homes, but also to support next generation (5G) mobile networks, as well as schools, hospitals and other drivers of socio-economic benefits.[26] The Commission has estimated that a further €155bln in investment, that already envisaged, will be needed to achieve these goals by 2025.[27]

Companies and public organisations that were not traditionally engaged in telecom provision have played a significant role in several countries in deploying the fibre connectivity needed to support these aims. Often, these players have deployed networks through a 'wholesale only' model.

WHAT ARE WHOLESALE ONLY INITIATIVES?

"Wholesale only" business models occur where the provider focuses on offering only wholesale services (often passive infrastructure such as dark fibre) and does not provide retail broadband services.

Operators pursuing wholesale only models are often not traditional telecommunication operators, but rather municipalities, public utilities and/or infrastructure investors.

An advantage of the model is that wholesale only operators do not have an inherent incentive to discriminate amongst different service providers. Those operated by public bodies may also have public interest objectives alongside commercial goals.

In this report for Stokab we examine (i) the role that wholesale only networks have played and are playing in boosting fibre deployment for public institutions, citizens and businesses across Europe; (ii) the views of infrastructure investors about the wholesale only business model; and (iii) the role of wholesale only networks could play in the transition towards 5G, and its implications for future applications and services.

25 Commission Communication 2016: towards a European Gigabit Society https://ec.europa.eu/digital-single-market/en/news/communication-connectivity-competitive-digital-single-market-towards-european-gigabit-society

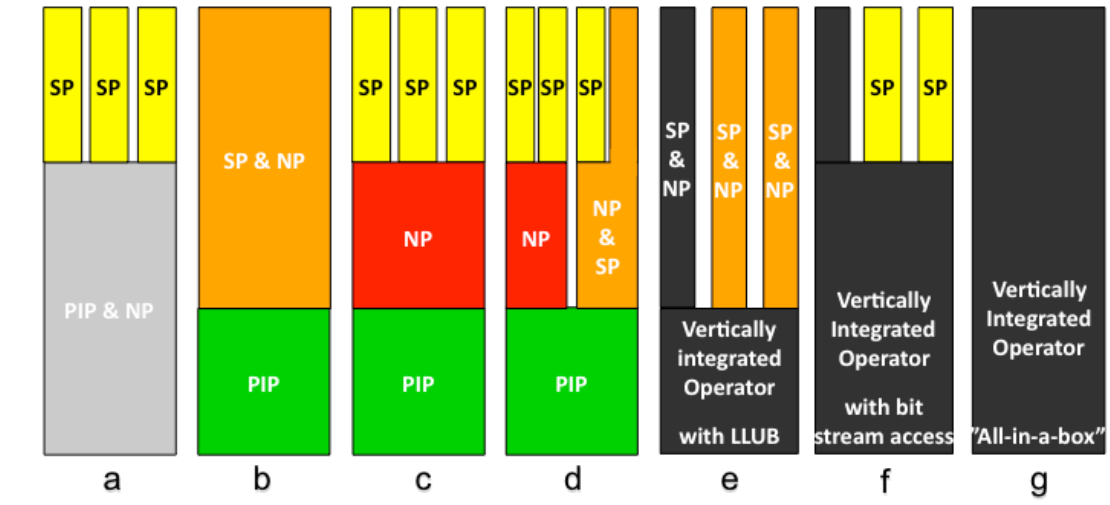
26 The Commission's Communication has outlined objectives by 2025 for all households to have 100Mbit/s access upgradable to Gigabit speeds, 5G coverage in major cities and highways and Gigabit access for 'socio-economic drivers'.

27 Estimations by the Commission drawing on the Study SMART 2015/0068. Staff working document accompanying the Communication "Towards a European Gigabit Society"

1.1 What is meant by wholesale only?

The following figure shows different business models for Next Generation Access deployment, distinguishing them by degrees of openness. Wholesale only typically corresponds to Options b-d (referred to here as a 'Passive Infrastructure Provider' model). The main feature is the separation of physical (passive) infrastructure from the downstream network operation and provision of retail broadband services to customers. However, in some of the case studies we describe, wholesale only providers have also (additionally to passive access) provided bitstream to meet market demand (option a).

Figure 1-1: NGA deployment models by degree of openness



Legend: LLUB – Local Loop Unbundling; NP – Network Provider; PIP - Passive Infrastructure Provider; SP – Service Provider.

Source: Forzati & Mattsson in Lemstra & Melody (2015) The dynamics of broadband markets in Europe – Realizing the 2020 Digital Agenda." Cambridge University Press.

Because wholesale only operators are not active at the retail level, they do not have an inherent incentive when offering wholesale access to discriminate against specific service providers, as can be the case with vertically integrated firms.

1.2 Who has invested in FTTH on a wholesale only basis?

Various business models for FTTH deployment exist in Europe today. The type of model usually reflects the background of the investor.

Network investors with a background in electronic communications services have typically pursued vertically integrated models, taking responsibility for the network investment, as well as the installation of active equipment and provision of retail

broadband services often coupled with other services such as telephony and TV. For these operators, installation of FTTH is pursued for commercial reasons. As telecom operators with legacy copper and cable infrastructure can make more incremental network upgrades at lower cost, they have typically had little incentive to make significant FTTH investments, unless faced with the threat of competitors investing in FTTH who would otherwise take market share.

Network investors without a background in electronic communication services have approached the business of investing in FTTH from a different perspective. For these investors, FTTH is viewed first and foremost as an essential infrastructure. Many of these operators operate on a wholesale only level, focusing on aggregating demand for connectivity – while leaving service providers to develop offers to meet the needs of different user groups.

There are some examples of commercial investors engaging in the deployment of wholesale only networks, for example in the Netherlands. We explore such cases in sections 2.2.2 and 3.2. However, in many cases, investment in FTTH as an infrastructure has been carried out by public authorities or publicly owned utilities (electricity companies), which may have public interest motives, alongside the motivation to make the project a commercial success.

2 The evolution of wholesale only models

Since the first examples of the 1990s, wholesale only initiatives have become more widespread across Europe. They now cover urban and rural areas (with and without state aid) across several countries, and have been pursued by both commercial and public sector investors. In this chapter we look at how wholesale only models have evolved, and what role they have played in driving fibre deployment and competition.

Key information about a selection of wholesale only initiatives (a subset of those active in Europe) is provided in the following table. It illustrates not only the variety of wholesale only models pursued (commercial and public, rural and urban), but also highlights the fact that **this business model is gaining traction, with several new initiatives in recent years.** Further details are provided in the following sections.

KEY FINDINGS

Wholesale only urban initiatives such as Stokab in Sweden, Amsterdam Citynet and Reggefiber in the Netherlands, were amongst the first to engage in widespread fibre deployment in Europe.

In recent years, the model has since gained traction across Europe as a means to kick-start fibre deployment where investment was lagging (e.g. Italy and Ireland), and to reach underserved rural areas (e.g. France, Austria and the Netherlands). The model has also been used as a means to connect innovation hubs and address environmental challenges (e.g. Ireland).

The results of many of the wholesale only initiatives have been impressive, driving investment not just by the wholesale only entrant, but by incumbent operators who have been forced to respond. For example, since the entry of Enel Open Fiber, fibre take-up in Italy is expected to grow three-fold to reach 35% by 2021.

In addition to boosting fibre availability and broadband speeds, wholesale only models have enabled investment and innovation by a diverse range of fixed and mobile operators and service providers using the networks – more than 100 operators and service providers are present on the Stokab network.

Table 2-1: Selected wholesale only initiatives in Europe

	Country	Urban/rural	Private/public/ PPP	Launch date	State aid?	No of FTTH premises planned	No of premises passed/connected (2017)	Total Investment
Stokab	Sweden	urban/ commercial	Public	1994	N		90% households, 100% enterprises connected*	€540 million from 1994 -2012
Reggefiber	Netherlands	urban/ suburban	Private	2005 (acquired 2014)	N		2 million homespassed, 677,000 activated (2014)	
Amsterdam CityNet	Netherlands	urban	PPP	2006	N	40,000 connected (first phase)	43,000 homes passed, 10,000 connected (2009)	€ 30 million
SIRO	Ireland	urban	PPP	2014	N	0.5m (by end 2018)	64,000 (2016)	€450m
Enel OpEn Fiber	Italy	urban/rural	PPP (via Enel, CDP)	2015	Y	9.5m (by 2021)	1.45 million homes connected (2016)	€3.7 billion
Nögig	Austria	rural	Public	2015	Y €40m	34,000 homes (first phase of deployment)		€100 m
Dublin Docklands Network	Ireland	Urban/ commercial	Public (contracted out)	2016	N			€8 m
CIP	Netherlands	rural	Private		N	280,000	80,000 (2017, 20 projects)	
Alsace	France	rural	PPP	2017	Y €164m	370,000 6 years		€480m

Source: WIK-Consult.

*Households connected in the context of Stokab imply multi-fibre connections through node in the basement

2.1 Early municipal deployments in Sweden

Swedish municipalities were amongst the first in Europe to highlight the importance of fast broadband for economic growth and regional development, and played an important role in triggering fibre network expansion in Sweden, at a time when few commercial operators were willing to take the perceived risk of long-term infrastructure projects.

Today, around 175 from 290 municipalities in Sweden have deployed fiber-optic networks in the past ten to fifteen years, representing more than 50 % of the local fiber coverage.[28] The municipal networks have played an important role when it comes to the roll out of fibre networks in Sweden and have also driven investments by the incumbent Telia, who switched their focus to FTTH/B investments rather than the FTTC technologies that prevail in some other countries.[29] This has accelerated to the extent that Telia is in the process of dismantling its copper network. The number of fixed broadband subscriptions over fibre now exceed the number of subscriptions over copper and cable.[30]

These fibre deployment activities were supported by the Swedish government's first broadband strategy, which financed the construction of a nationwide backbone in 2000, connecting the municipalities and providing access points for further development of regional and local networks.[31] The financial support of the Swedish government amounted to 2.5 billion SEK (or roughly €280 million) for a national operator-neutral backbone, 3.2 billion SEK (€360 million) for municipalities to develop access (in the form of tax breaks) and 2.6 billion SEK (€290 million) for regional networks and to create local infrastructure plans.[32]

The dominant business model among Swedish municipal fibre network operations is an open access network model, in which services are provided on a fair and non-discriminatory basis to network users based on a shared infrastructure. Open access is enabled by separating the roles of service provision and network provision to reflect the different technical and economic characteristics of the different layers of the network.

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28 WiK Consult (2016) based on Swedish Local Fibre Alliance (*Svenska Stadsnäts Föreningen)* http://www.ssnf.org/Global/Bilder/Rapporter%20och%20informationsmaterial/EU/Dokument/Local%20fibre%20networks%20in%20Sweden.pdf. Retrieved: 2016-01-06.

29 See for example https://www.telegeography.com/products/commsupdate/articles/2014/10/08/telia-investing-usd1-25bn-in-swedish-fibre-over-three-years/

30 PTS reported that as of June 2017, there were 3.7m broadband connections, of which 2.2m were supplied through fibre technology.

31 Gantumur, Ts. and B. Sörries (2018), Wholesale-only undertakings from a regulatory perspective, WIK Discussion Paper (in German), forthcoming.

32 WIK Consult (2016), p. 561, based on Swedish Local Fibre Alliance (*Svenska Stadsnäts Föreningen)* http://www.ssnf.org/Global/Bilder/Rapporter%20och%20informationsmaterial/EU/Dokument/Local%20fibre%20networks%20in%20Sweden.pdf. Retrieved: 2016-01-06.

Experience of fibre deployment in Sweden shows that, in general, companies that only provide passive infrastructure and contract out network management, tend to have a leaner organization, an easier business case, and a better medium and long-term financial situation.[33] However, at the same time, because of its regional focus, the layered model poses some challenges in attracting service providers wishing to target a nationwide footprint. In order to attract service providers and facilitate access, especially in the smaller and more remote municipalities, several municipality networks have recently formed regional associations to interconnect the different local networks. The resulting regional networks provide greater scale, visibility and a single-interface towards the service provider market.[34]

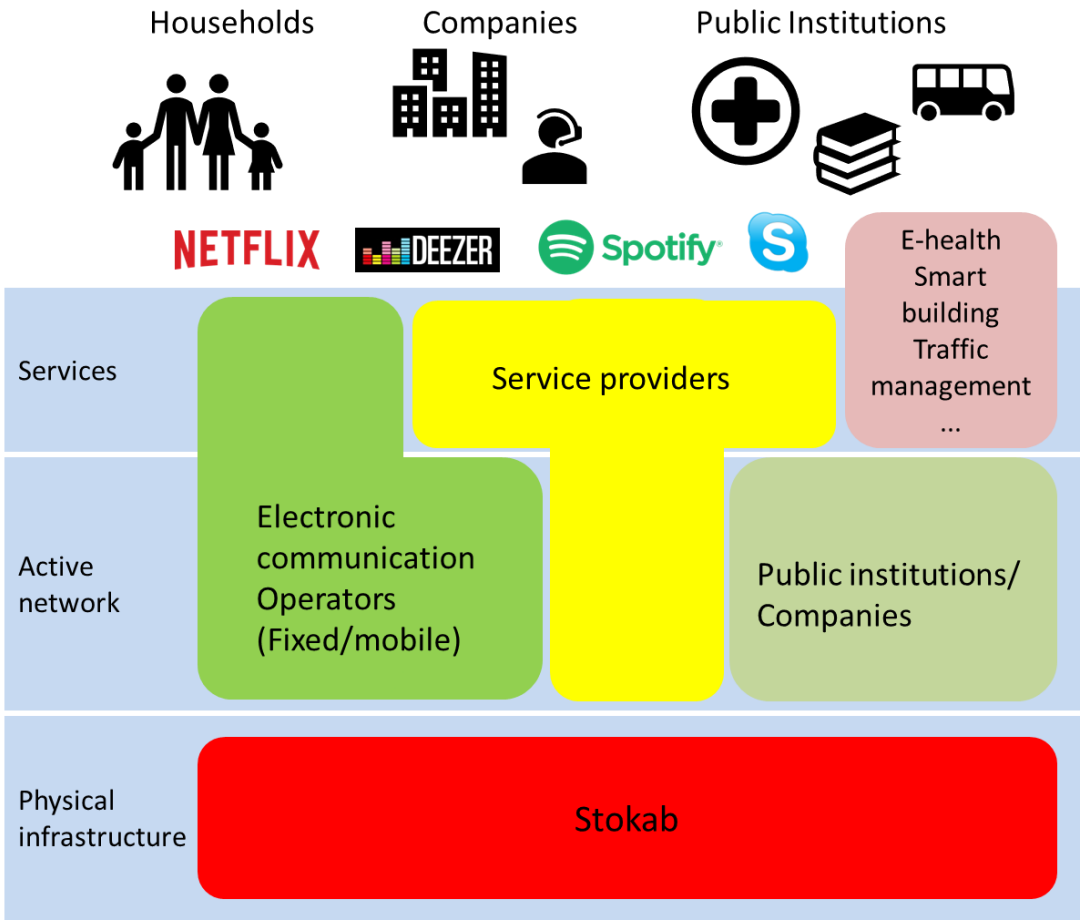
A prime example of Sweden's wholesale only municipal strategy is AB Stokab, which was set up in 1994 by the City of Stockholm to provide a passive fibre network to the highly knowledge-intensive[35] Stockholm region. The aim of the company was to build a competition-neutral infrastructure capable of meeting future communication needs, spur economic activity, diversity and freedom of choice.[36] The Stokab network was also designed to meet the needs of public administrations and wholly public owned enterprises as well the needs of public schools, childcare, leisure and culture.

The fibre deployment began in the commercial areas of the Stockholm's inner city and the major industrial areas around Stockholm City. Today, Stokab's fibre network comprises 1.4 million fibre kilometers, 5,500 cable-kilometers and 600 cross-connections.[37] The fibre network extends from Norrtälje to Nynäshamn with its focus on the municipality of Stockholm. It covers large parts of the city of Stockholm as well as a large number of offices and business centers in the region. Almost every residential unit in multiple dwellings in Stockholm is connected to the fibre network.

The business model of Stokab's fibre network is based on offering point-to-point dark fibre, on a non-discriminatory basis to any customer which has a need for it. This includes operators specialising in providing wholesale active (bitstream and wholesale leased line) services to service providers as well as fixed and mobile vertically integrated operators, which may add their own business and residential services as well as enabling customers to access the full range of 'over-the-top' offerings. . Stokab also offers dark fibre directly to businesses, public institutions and housing associations, which can develop their own services, sometimes in conjunction with specialist providers.

33 Lemstra, W. and W. H. Melody (Eds). The dynamics of broadband markets in Europe: Realizing the 2020 Digital Agenda. Cambridge: Cambridge University Press. p. 145.
34 Ibid.
35 Almost 60 % of Sweden's IT employees are located within the Stockholm region.
36 http://www.stokab.se.
37 Ibid.

Figure 2-1: Business model of Stokab's fibre network



Source: WIK-Consult

Stokab's wholesale prices are set on a commercial (unregulated) basis. Discounts are available based on the volume and the duration of a contract.[38] Customers may also choose to lease point to point fibre at a price reflecting the distance between two addresses or pay a fixed price for access connections within a certain area (fibre unbundling). Stokab offers three service level agreements (SLAs), depending on the needs of customers. For high security applications, Stokab also offers redundant connections.[39]

Today, more than 100 operators and service providers are present on Stokab's fibre network. These include "traditional" electronic communication operators (fixed and mobile) that are vertically integrated above the infrastructural level, i.e. have both active network and services. In addition, service providers can choose to either lease dark

38 Stokab (2017), Stokab – The foundation for IT in Stockholm.
39 Ibid.

fibre from Stokab directly or rent the active network from operators or other service providers. The service providers on Stokab's network offer services ranging from connectivity services to e.g. data storage, back-up, firewalls, databases, operating systems and general applications for data. Specialized services for different sectors and services for e.g. streaming film and music can in turn be provided on top of that layer or as part of the offering of the service provider.

Moreover, companies and public institutions that require efficient and secure data communication with high data capacity can rent their own fibre connections from Stokab. There are now around 800 non-telecoms companies, such as banks, media and security companies and housing companies, but also public institutions (e.g. schools, hospitals and traffic management) renting point-to-point fibre directly from Stokab.[40] They can either operate the active network by themselves,(e.g. S:t Erik Kommunikation, which is responsible for the management and development of the City of Stockholm internal communications network) and or procure the operation of the active level from an operator/service provider. On that active platform, they can then procure different services in full competition on the market. The ability to rent dark fibre directly from Stokab consequently enables these customers to implement individual data services and IT solutions, rather than potentially needing to procure such services as part of a bundle offered with the connection.

Since 2002, real estate and housing companies in Stockholm have also played an important role in the deployment of fibre connections in multi-dwelling-units.[41] They take charge of in-house wiring, and decide whether to connect their properties to a particular network provider and make agreements for the provisioning of services to the tenants. In order to enable competitive supply, the real estate and housing companies usually mandate a network provider as an intermediary between the fiber network and multiple service providers. By connecting the property with fibre, the apartments and business premises gain more market value and attractiveness. In addition, a range of real estate services, such as heat regulation, electricity and water metering, electronic locking and monitoring – can be supported.

The coverage of fibre connections in Stockholm has grown from around 58% of the population in 2010 to 93% in 2016.[42] Stokab's fibre network alone is connected[43] to buildings serving around 90 % of households and almost 100 % of enterprises.[44]

Furthermore, the ability to rent the basic network elements including antenna sites and to connect mobile masts to Stokab's fibre network has enabled mobile operators to

40 Stokab (2017), Stokab – The foundation for IT in Stockholm.
41 Mölleryd, B. (2015), Development of High-speed Networks and the Role of Municipal Networks, OECD Science, Technology and Industry Policy Papers, No. 26, OECD Publishing, Paris.
42 WIK (2017) "Tale of 5 cities" based on http://www.statistik.pts.se/bredband
43 Connected houses refers in this context to multi-fibre deployed to a node in the building
44 http://www.statistik.pts.se/bredband; WIK-Consult (2016), Regulatory, in particular access, regimes for network investment models in Europe, final report, prepared for the EU-Commission, p. 565.

quickly establish themselves on the market. This is particularly evident in the expansion of mobile 4G / LTE networks in the Stockholm region. By agreeing long-term contracts with Stokab, Net4Mobility (Telenor and Tele2 joint venture) expanded 4G / LTE networks in Stockholm, which were in direct competition with the incumbent's world's first 4G / LTE network. Today, four large 4G / LTE networks are represented in Stockholm, providing a competitive platform for almost 13 mobile operators. The explosion in mobile data usage has triggered in turn the expansion of the Stokab's fibre network. In Stockholm, full coverage of mobile broadband services via LTE technology was reached within three years (2011 – 2013).[45]

Stokab has invested an average of more than 250 million SEK (approx. €25 million) per year, to total of 5.4 billion SEK (€540 million) up to 2012.[46] The first phase of the network deployment was funded using loans, but soon customer revenues provided the funds necessary to expand the network. Stokab started generated positive cash flows in 1998 until 2003, overextension in network deployment combined with a contraction in demand resulted in a first loss. Following a write-off of €50 million, positive cash flows returned after 2003 and profits in 2008. In 2017 the turnover was SEK 784 million (approx. €77 million) and profits amounted to SEK 234 million (€23 million), the best ever.[47]

2.2 Wholesale only pioneers in the Netherlands

2.2.1 The case of Amsterdam Citynet

The case of Amsterdam Citynet (Glasvezelnet Amsterdam (GNA)) in the Netherlands provides another example in which municipalities played a leading role in the early deployment of fibre.

However, a key difference from the Swedish cases is that the initiative was formed as a public-private partnership (PPP), with the incumbent KPN later acquiring a controlling stake.

In 2001, the Amsterdam authorities were concerned about a possible 'digital divide' emerging in the city and recognized the importance of high-speed connectivity for the economic well-being of the city. Following advice from Dutch and European regulators in 2004, Amsterdam municipality decided to create a public-private partnership (PPP) to invest in the passive fibre infrastructure.

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45 http://www.statistik.pts.se/bredband.

46 WIK Consult (2016), Regulatory, in particular access, regimes for network investment models in Europe, final report, prepared for the EU-Commission, p. 565.

47 Stokab, Annual report 2017,https://www.stokab.se/Documents/%c3%85rsredovisning/AB%20Stokabs%20%c3%85rs-%20och%20h%c3%a5llbarhetsredovisning%202017.pdf Retrieved on 2018-03-21.

In 2005, the city of Amsterdam together with five housing corporations and two financial investors (ING and Reggefiber) agreed to invest in a FTTH network. The municipality of Amsterdam invested € 6 million, ING and Reggefiber each invested € 3 million, three social housing corporations invested each € 1.5 million and two housing corporations each invested € 750,000. The total equity investment amounted to € 18 million. Another €12 million in funding was provided as debt financing. The total budget of € 30 million enabled the first phase of implementation, 40,000 connections, to start in 2006.[48]

The EU-Commission initially questioned whether the investment of the municipality of Amsterdam fulfilled the market economy investor test (MEIP). However, the investment was ultimately cleared with several remedies. In particular, the network should be operated using the 'open network' concept, meaning that the wholesale specifies that all service providers must be able to purchase transport capacity on non-discriminatory conditions.[49]

The passive infrastructure of GNA was operated by BBned, which was selected through a tender procedure. BBned leases fibre from GNA and had the right to provide wholesale transport and related services to retail operators at its own risk. It paid a fee per household connected to GNA for the use of the passive network.

By 2009, 43,000 homes in Amsterdam had been passed (approx. 11% of the total of 380,000) and 10,000 connected. By 2014 the number of homes passed had reached 67,000.[50] Afterwards, the participation of the municipality and housing corporations was absorbed over time by Reggefiber and ultimately by the incumbent KPN. First, ING sold its shares to Reggefiber, while the city and the social housing corporations sold half of their shares, which made Reggefiber the majority owner (70%).[51] KPN's acquisition of Reggefiber then brought Amsterdam Citynet under its control. The remaining 30% is still owned by the municipality of Amsterdam.

2.2.2 The case of Reggefiber

While initiatives such as Amsterdam Citynet played a significant role in initiating fibre deployment in the Netherlands, the largest scale deployment of fibre in the Netherlands was driven by Reggefiber, a subsidiary of the private investment company Reggeborgh, founded in 2005.

48 EU-Commission (2007), C (2007) 6072 final, Decision of 11.XII.2007 on THE STATE AID case C 53/2006 (ex N 262/2005, ex CP 127/2004).

49 Ibid.

50 Lemstra, W. (2016), Broadband developments in Europe: A retrospective review of the determinants of supply and demand, IBEI Working Paper, p. 19.

50 Lemstra, W. (2016), Broadband developments in Europe: A retrospective review of the determinants of supply and demand, IBEI Working Paper, p. 19.

51 Mölleryd, B. (2015), Development of high speed networks and the role of municipal networks, p. 39 – 40.

Reggefiber, a new entrant in the Dutch telecom market, was set up by a construction company in Rotterdam in order to start deploying fibre to the houses it owned, intending to make its real estate more attractive through fibre connections.[52] Reggefiber took a long-term perspective on fibre deployment, applying a real estate model based on the principle of a passive infrastructure with open access. The Reggefiber network was financed through shareholder equity as well as debt from third parties including the European Investment Bank (EIB).[53]

At first, Reggefiber co-operated with smaller service providers. However, when it found that they had trouble establishing competitive offers for television, Reggefiber organised a television offer through Glashart Media for all service providers active on its network, leveraging the combined subscriber numbers in negotiations with content providers. The model of aggregating demand pursued by Reggefiber was replicated by others, and resulted in some successful local co-operative fibre networks, which often used the same technology as Reggefiber networks, and with service providers that are also active on Reggefiber's network.[54]

In 2006, Reggefiber was involved as an investor in municipal networks such as Glasvezelnet Amsterdam and OnsNet Nuenen. After acquiring the backbone provider Eurofiber in 2006, Reggefiber connected the various isolated municipal initiatives[55], but take-up had been slow.[56]

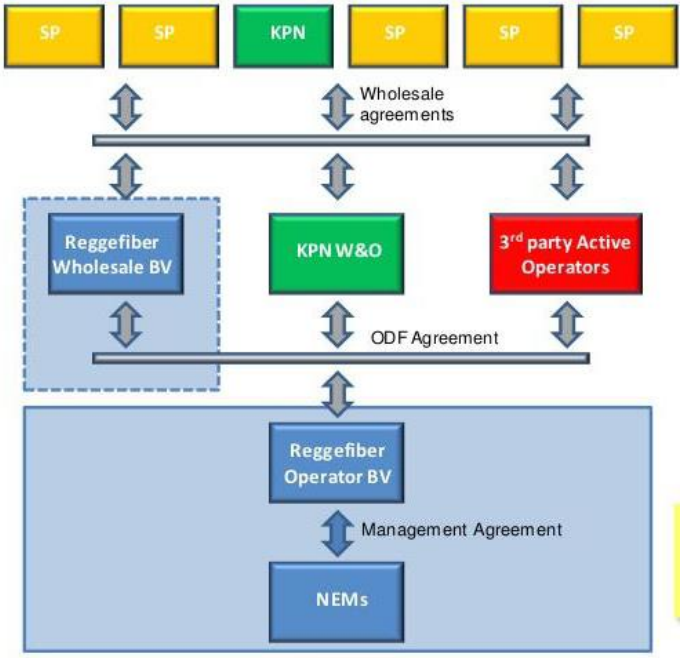
The emergence of Reggefiber as a new infrastructure player changed the competitive dynamics, compelling the incumbent KPN to develop an FTTH strategy in response. KPN opted for an acquisition strategy and in 2008, KPN entered into a joint-venture with Reggeborgh, whereby KPN acquired a minority interest of 41% of Reggefiber's shares while Reggeborgh kept the remaining 59%. The transaction was notified to the Dutch competition authority (NMa) and Telecom Authority (OPTA)[57]), and approved with remedies. The main concern of NMa was that a merger would result in the removal of Reggefiber as a potential competitor to KPN, thereby decreasing competition and reducing incentives to provide access to the network to downstream service providers. Therefore, as a condition for the joint-venture agreement, Reggefiber's fibre network was required to grant access to third parties on non-discriminatory terms. Further expansion of KPN's share in Reggefiber depended on specific thresholds concerning numbers of homes passed or dates which allowed for the execution of call options by

52 Lemstra, W. (2016), Broadband developments in Europe: A retrospective review of the determinants of supply and demand, IBEI Working Paper, p. 28.
53 Schrijver, T. (2015), Off-Balance Financing of the fiber network at Reggefiber: a case study, p. 3.
54 Mölleryd, B. (2015), Development of high speed networks and the role of municipal networks, p. 41.
55 Domingo, Al., Oliver. M., der Wee, M.V. and S. Verbrugge (2015), Deployment strategies for FTTH networks, Broadband Communities, p. 18.
56 Hesseling, D. and T.Vermeulen (2011), Access to networks through competition law: the case of KPN-Reggefiber, Network Industries Querterly, 13(1), p.14-16.
57 These authorities were subsequently consolidated into ACM

KPN or put options by Reggeborgh.[58] KPN ultimately increased its ownership of Reggefiber to 100% in 2014.

Reggefiber's Business Model was based on the layered open-access approach (Figure 2-2). As a passive infrastructure provider Reggefiber exploits and maintains the dark fiber network. Each fibre deployment project in a certain municipality is legally separated in a 'Netwerk Exploitatie Maatschappij' (NEM). The NEM's are the economic and legal owners of the network and are split by municipalities.[59] The NEM's have a management agreement with Reggefiber Operator BV and pay a management fee for maintenance and exploitation. The unbundling obligation of Reggefiber at the Optical Distribution Framework (ODF) is subject to a monthly tariff, which depends on the capital expenditure. Monthly revenue of Reggefiber includes rents from POP and backhaul in addition to the ODF tariff.[60]

Figure 2-2: Business Model of Reggefiber's fibre network



Source: Schrijver, T. (2015), p. 4.

The network operators install active equipment on Reggefiber's passive fibre network and deliver wholesale fibre services to service providers. Service providers deliver

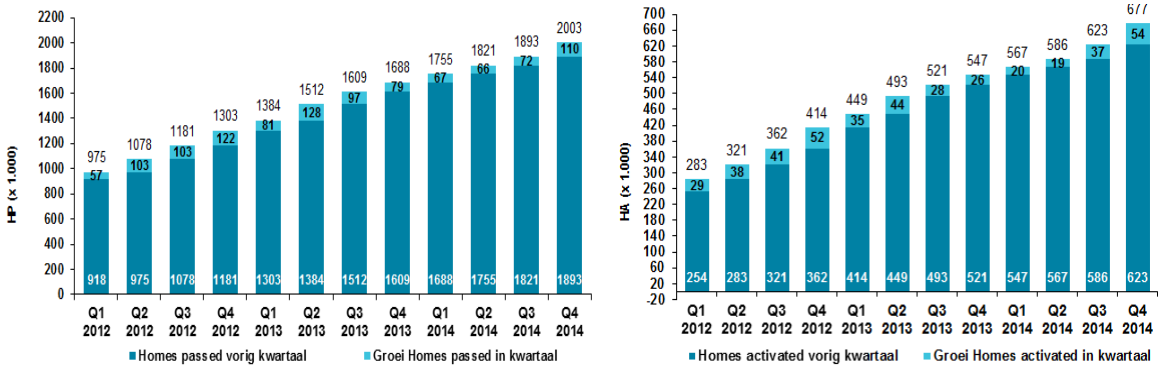
58 Schrijver, T. (2015), Off-Balance Financing of the fiber network at Reggefiber: a case study, p. 3 – 4.
59 Ibid.
60 Ibid.

services to end users and pay a monthly fee to the network operator which is defined in the wholesale broadband access tariff (WBA).[61]

In order to ensure sufficient revenues from the start of each fibre deployment, Reggefiber used a demand aggregation strategy, based on a presubscription level of 30 – 40 % of households.[62]

In 2014, Reggefiber's fibre network covered 2 million homes passed and 677,000 homes activated, which corresponded to a growth of 105% and 139% compared to 2012 respectively (Figure 2-3).

Figure 2-3: Reggefiber's homes passed and homes activated, 2012 – 2014



Source: Schrijver, T. (2015), p. 5.

However, while many telecom operators in Western Europe are increasingly embracing FTTH, KPN slowed down the expansion of its FTTH footprint. In 2016, the number of homes passed in the Netherlands grew by 137,000, a sharp decrease compared to the 200,000 new fibre lines in 2015.[63] KPN announced that it would scale down its investment in new fibre lines and instead focus on vectoring technology, which could reduce costs as it requires only partial fibre installation.[64, 65]

61 Ibid.
62 Domingo, Al., Oliver. M., der Wee, M.V. and S. Verbrugge (2015), Deployment strategies for FTTH networks, Broadband Communities, p. 19.
63 https://www.telecompaper.com/nieuws/ruim-3-miljoen-ftth-aansluitingen-in-nederland-in-2021-2--1201165, retrieved on 2018-1-18.
64 https://www.telecompaper.com/nieuws/ruim-3-miljoen-ftth-aansluitingen-in-nederland-in-2021-2--1201165, retrieved on 2018-1-18.
65 Mölleryd, B. (2015), Development of high speed networks and the role of municipal networks, p. 41.

2.3 The re(entry) of utilities

As discussed in the previous sections, early initiatives by municipalities in Sweden and the Netherlands were driven by the belief that high speed infrastructure was essential for local competitiveness and social welfare. These initiatives helped to propel the local communities they served to the top of broadband league tables at a time when most broadband services were based on much lower speed ADSL broadband, and can thus be seen as ahead of their time, as least in comparison to what were the prevailing (2005) objectives in Europe, which focused on increased competition – mainly in copper-based broadband services.[66]

Drawing inspiration from countries such as these as well as international experience from Japan and South Korea, in 2010 the European Commission stepped up its broadband ambition, advocating the deployment of 'next generation networks' through its EU2020 targets (of achieving full availability of broadband at 30Mbit/s and 50% take-up of 100 Mbit/s by 2020)[67] and the 'Digital Agenda for Europe'.[68]

Seeing that commercial deployments alone were not achieving these targets and were focused on more incremental upgrades at the expense of longer term investments and open networks, Governments in Italy and Ireland directly and indirectly fostered the (re)entry of public utilities as drivers of FTTH investment).

Utilities benefit from the ability to re-use existing infrastructure such as ducts, poles, transmission towers, overhead cables, and substations for colocation of fiber equipment. It is estimated that the use of power infrastructure in rural areas can reduce fibre deployment costs by up to 45%.[69]

Although utilities in some countries which have deployed broadband networks e.g. in Germany and Denmark, have operated their own retail services (in some cases due to a lack of available and interested service providers), a recent study[70] suggests that a wholesale-only model, a joint venture or combination of both provides the best chance of success overall. In this section we focus on the fibre deployments of the wholesale-only operator OpEn Fiber in Italy and the Irish joint venture SIRO. Even though these initiatives are recent, the effects on FTTH coverage in these countries (in both denser and less dense areas) have already been significant, both directly and as a result of the responses from legacy telecom operators to the competitive challenge.

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66 In 2005, the European Commission announced the i2010 initiative http://europa.eu/rapid/press-release_MEMO-05-184_en.htm?locale=en. The main objectives concerning broadband were to stimulate competition by enforcing access regulation in the context of the EU Framework for electronic communications i.e. the promotion of local loop unbundling

67 https://ec.europa.eu/digital-single-market/en/broadband-strategy-policy

68 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52010DC0245R(01)

69 Analysis Mason and Huawei (2017), Market Research: Power companies deploying fibre networks.

70 Ibid.

2.3.1 Enel OpEn Fiber (Italy)

A notable example on the contribution of utilities to driving fibre deployment is the wholesale-only infrastructure operator Enel OpEn Fiber (EOF) in Italy.

Enel Group, founded in 1962, is an Italian multinational manufacturer and distributor of electricity and gas. While the national energy and gas incumbents were privatised in the late 1990s, the Italian government still holds a majority stake either directly or through Cassa Depositi e Prestiti (CDP)[71]. Enel first engaged in telecom markets in the early liberalization period, when between 1997 – 1999, together with France Télécom and Deutsche Telekom, it founded the telecommunication company Wind. Enel subsequently sold Wind and focused on expanding its core energy business internationally.

However, in December 2015, Enel Group returned to the telecom business with the creation of Enel OpEn Fiber S.p.A (EOF). The aim of the initiative is to create a national high-speed fibre network leveraging the knowledge of the Group as well as its existing infrastructure. In 2016, EOF initially announced a plan to roll out FTTH networks in 224 cities, as part of its project to install smart meters across Italy,[72] Although the two plans were separated following the energy regulator's concerns about cross-subsidization.[73] OEF estimated that leveraging its own infrastructure as well as that of other utilities could reduce build costs by as much as 25%. (see Figure 2-4).[74]

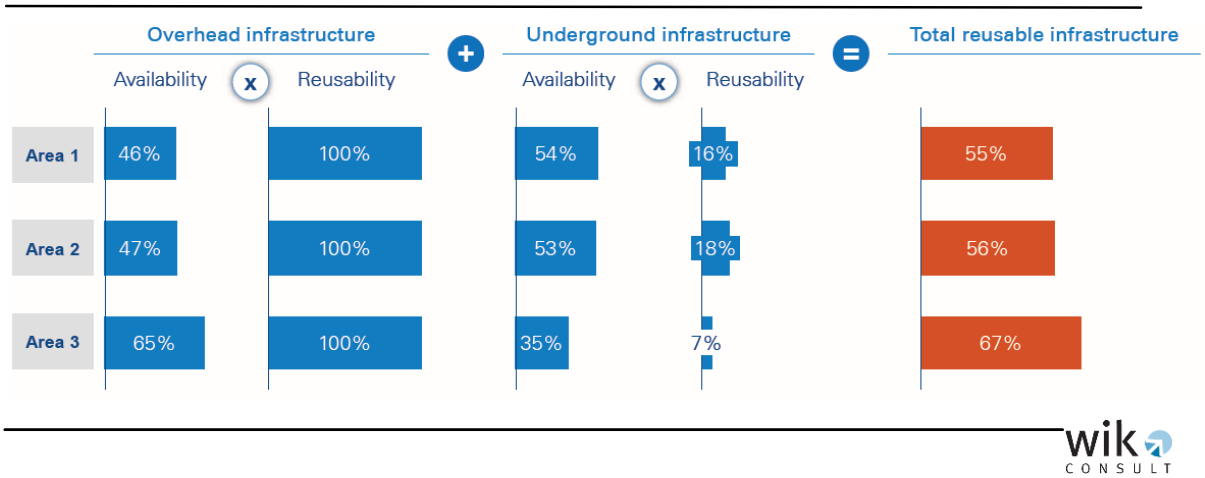
71 Cassa Depositi e Prestiti is a company under the control of the Italian government active in the acquisition and management of shareholdings in Italian companies.

72 Enel (2016), Enel open fibre strategic plan presented to Enel Board of Directors, Press release from March 23rd 2016, https://www.enel.com/content/dam/enel-com/pressrelease/porting_pressrelease/1665521-1_PDF-1.pdf.

73 Gerli, P., Van der Wee, M., Verbrugge, S. and J. Whalley (2017),The involvement of utilities in the development of broadband infrastructure: A comparison of EU case studies, p. 7.

74 Arthur D Little (2017), Utilities' contribution to national fibre development, p. 8

Figure 2-4: Synergies by reusing electrical network announced by Enel (Italy)



Source: Gerli et al. (2017) based on Enel's presentation to the Italian Senate of the Republic.

In December 2016, Enel OpEn Fiber and Metroweb Italia merged, creating a structure in which the company was equally held by Enel and the publicly controlled investment vehicle Cassa Depositi e Prestit (CDP).[75] EOF then updated its strategic plan in June 2016, expanding the scope of its cabling operations up to 250 cities, all of which are located in market success areas and include the largest Italian cities. The EOF's updated 2016 - 2030 strategic plan aims at providing:[76]

- coverage with high-speed fibre optics of about 9.5 million homes (compared with 7.5 million homes in the previous plan in 2016) in the period from 2016 to 2021;
- progressive increase in investment from around € 2.5 billion to € 3.7 billion, of which about 85% in 2016 - 2021.

Enel Open Fiber has played a key role in bridging the urban rural digital divide.

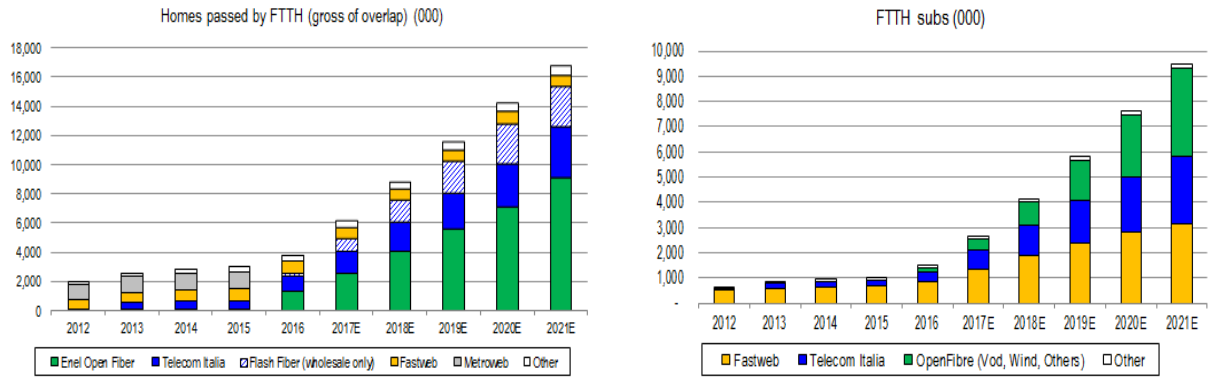
As a neutral wholesale-only infrastructure provider, EOF offers dark fibre to network operators and service providers. At the End of 2016, nearly 1.45 million FTTH home-passed were covered by the OEF-Network (including the fibre network initially deployed by Metroweb).[77] In 2017, the company extended its operation to the following Italian big cities: Bari, Cagliari, Catania, Firenze, Genova, Napoli, Padova, Palermo e Venezia.

75 Enel (2016), Enel signs agreement for the acquisition of Metroweb", Press release from October 10 2016, https://www.enel.com/media/press/d/2016/10/enel-signs-agreement-for-the-acquisition-of-metroweb.
76 Ibid.
77 Credit Suisse (2017), Building the Gigabit Society, European Telecom Research, p. 108.

In addition to planning service to more densely populated areas, for which the economics of fibre deployment are more attractive, EOF has also played a key role in bridging the urban rural digital divide. Recently, EOF and Infratel Italia signed the concession contract for twenty years for the design, construction and management of the fibre access network in white areas, e.g. “market failure” areas, in the regions Abruzzo, Molise, Emilia Romagna, Lombardy, Tuscany and Veneto.[78] This is the second Infratel tender under the Ultra-Broadband Plan, which aims to cover 3,700 municipalities by providing fibre connections to approximately 4.7 million homes. EOF has obtained the award of all six lots, committing to connect 3.5 million homes at the maximum speed with FTTH technology able to guarantee speeds up to 1 Gbps, while the remaining share of homes will be covered with wireless radio technology.[79]

An important implication of the EOF deployment was that the incumbent Telecom Italia, which had previously, together with Fastweb, committed to only a more modest investment in FTTC/VDSL, expanded their ambitions, reaching agreement in mid 2016 to build an FTTH network through a joint venture Flash Fibre. The fibre network built by the joint venture provides ultra-broadband access services on a wholesale-basis, but is not wholesale only. The goal of TI and Fastweb is to connect 3 million homes in 29 major Italian cities already covered by FTTC by 2020 for a total investment of €1.2 billion, financed part in equity and part in debt.[80] At the end of 2016, Flash Fiber had reached almost 200,000 households.[81]

Figure 2-5: FTTH homes passed and subscriber in Italy by operators, 2012 – 2021



Source: Credit Suisse (2017), Building the Gigabit Society, European Telecom Research.

78 Banda ultralarga - Enel Open Fiber firma contratto su seconda gara Infratel, Press release from December 27 2018, https://www.corrierecomunicazioni.it/telco/banda-ultralarga/banda-ultralarga-a-open-fiber-la-seconda-gara-infratel/; http://openfiber.it/fibra-ottica/area-infratel.

79 Ibid.

80 https://advanced-television.com/2016/07/28/fastweb-telecom-italia-partner-on-ftth-network/.

81 https://advanced-television.com/2017/02/10/antitrust-probe-for-telecom-italia-and-fastweb/.

As a result of this competition, Credit Suisse forecasts that 17 million homes will be passed by FTTH in Italy by 2021, with an expected 25% overlap between the fibre networks of EOF and Telecom Italia (Figure 3-5). While it is anticipated that EOF will cover about 9 million homes by 2021, Telecom Italia could reach about 6.2 million homes.

2.3.2 SIRO (Ireland)

SIRO is another example of co-operation between utility, telecom operators and government, in order to accelerate fiber deployment at a national level.

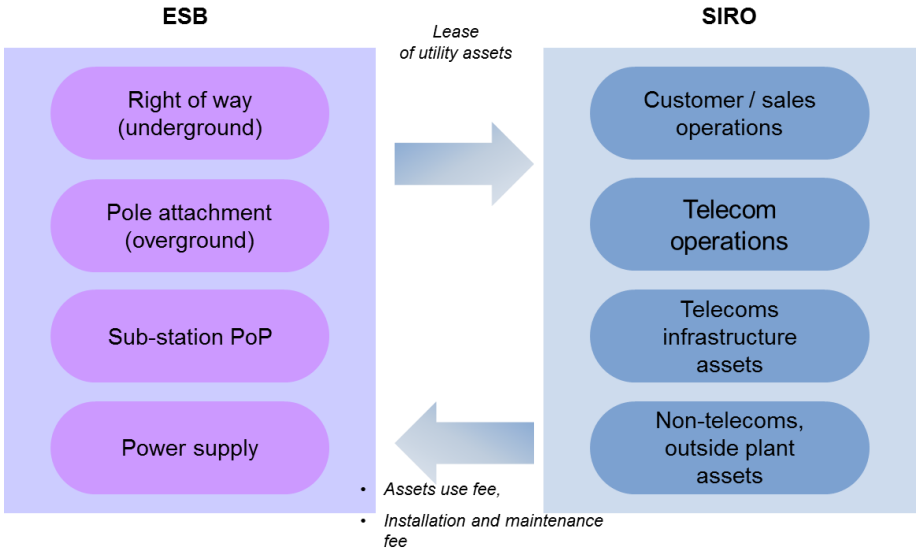
ESB is an electrical utility in Ireland, principally active in the transmission, distribution, generation and supply of electricity. ESB is 95% owned by the Irish State, while the remaining 5% of the issued capital stock of ESB are held by an Employee Share Ownership Trust. ESB owns a long-distance fibre network across its high-voltage electrical footprint which is established over 15 years and used for internal use as well as for external services. Its subsidiary ESB Telecoms Limited sold trunk fibre services to other communications operators and retail end-to-end business connectivity services.[82] It also leased space, mainly on towers, to mobile communications operators. However, these activities were concentrated in major cities like Dublin.[83]

In order to expand its deployment of fibre network in regional and rural areas of Ireland, ESB initiated in 2012 an open procurement process to select a joint venture partner. Following that, ESB set up in 2014 a 50/50 joint venture with Vodafone which is active in several wholesale and retail markets for mobile and non-mobile telecommunications.

The primary activity of the new company SIRO is the provision of wholesale local network infrastructure access services, with a focus on fibre. As regards the relationship between ESB and SIRO, SIRO pays ESB an annual fee for the right to use ESB's distribution network for FTTB, while ESB expects that access-right fees from SIRO can be used to reduce tariffs for its power customers (Figure 2-6).[84] Moreover, SIRO subcontracts from ESB services such as fibre network design, building and maintenance.

82 European Commission (2014), Case COMP/M.7307 – Electricity supply board / Vodafone Ireland / JV, 24.10.2014, C(2014) 8058 final.
83 Arthur D Little (2017), Utilities' contribution to national fibre development, p. 14.
84 Analysis Mason and Huawei (2017), Market Research: Power companies deploying fibre networks, p. 35.

Figure 2-6: Relationship between ESB and SIRO



Source: Analysis Mason and Huawei (2017).

For the first phase of the deployment of FTTB network, which is expected to offer speeds from 200 Mbps to 1 000 Mbsp, about 450,000 premises in 50 towns of moderate size are expected to be covered during the first five years.[85]

SIRO offers wholesale access to the FTTB network on a commercial, open and non-discriminatory basis. While the majority of the JV's retail sales are expected to be made to Vodafone, the FTTB network of the JV is likely to have sufficient extra capacity to serve both Vodafone and third parties.[86] It is expected that the deployment of the SIRO's FTTB network will make high-speed fixed broadband available where it was previously not. SIRO's planned fibre deployment does not include areas covered by the UPC cable network. According to the analysis of the European Commission, in the areas where the SIRO's FTTB network overlaps with Eircom's FTTC network, the SIRO will result in the presence of an alternative network, providing increased choice for telecommunications operators looking to use that infrastructure to provide retail services.[87]

Originally, the incumbent Eircom had focused on a network offering speeds of up to 100 Mbps to 1.6 million homes by the end of 2016. However, after the JV was announced,

85 European Commission (2014), Case COMP/M.7307 – Electricity supply board / Vodafone Ireland / JV, 24.10.2014, C(2014) 8058 final, p. 2.
86 European Commission (2014), p. 3.
87 European Commission (2014), p. 11.

Eircom decided to increase the footprint of its network. In their strategic response to the JV, Eircom selected 66 locations across the country for the new FTTH service.[88]

After the SIRO JV was announced, incumbent Eircom decided to increase the footprint of its network.

As of December 2016, SIRO has passed approximately 64,000 homes and has contracted with four separate service providers such as Vodafone, Digiweb, Westnet and Carnsore Broadband.[89] Based on its market analysis, ComReg expects that SIRO's network coverage will reach about 200,000 premises by the end of 2017 and the SIRO's initial target of passing 500,000 homes by the end of 2018 appears to be achievable.[90] SIRO continues to sign up wholesale customers, and recently reached an agreement with BT, enabling BT to offer its corporate, public sector and wholesale customers access to SIRO's local access network,[91] thereby contributing further to competition in fibre-based services in Ireland.

2.4 Upcoming initiatives

In 2016, the European Commission adopted the Gigabit Society strategy, highlighting the importance of future-proof infrastructure capable of gigabit speeds not only for schools, hospitals and other drivers of socio-economic welfare including business parks, but for the backbones of future 5G mobile networks and for the public as a whole.[92]

At the same time, the Commission acknowledged the important role played by wholesale only operators in the context of its 2016 proposals for an EU Electronic Communications Code.[93]

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88 https://www.boards.ie/b/thread/2057315844.

89 ComReg (2017), Market Reviews Wholesale Local Access (WLA) provided at a Fixed Location Wholesale Central Access (WCA) provided at a Fixed Location for Mass Market Products, p. 6.

90 Ibid.

91 https://siro.ie/siro-broadband-partners/.

92 The Gigabit Society Strategy includes common EU broadband targets for 2025. https://ec.europa.eu/digital-single-market/en/policies/improving-connectivity-and-access.

Specifically, the Commission proposes that by 2025 all schools, transport hubs and main providers of public services as well as digitally intensive enterprises should have access to internet connections with download/upload speeds of 1 Gigabit of data per second. In addition, all European households, rural or urban, should have access to networks offering a download speed of at least 100 Mbps, which can be upgraded to 1 Gigabit and all urban areas as well as major roads and railways should have uninterrupted 5G wireless broadband coverage, starting with fully-fledged commercial service in at least one major city in each EU Member State already by 2020.

93 The proposed EU electronic communications Code contains provisions that would promote wholesale-only models of historic and new SMP operators by clarifying their potential right to a lighter touch regulatory regime, unless there is evidence of market failures that require further intervention. See discussion in Impact Assessment http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=17190

These political signals, coupled with the growing rural urban divide in ultrafast broadband speeds[94] are likely to foster a renewed interest by local and regional authorities, as well as by commercial investors, in exploring wholesale only infrastructure companies as a means to bridge the broadband gap.

Recent city network initiatives include a project by the City of Dublin to commission a neutral fibre infrastructure to serve the knowledge economy in Dublin Docklands. Meanwhile projects in Austria provide an example of how wholesale only public initiatives can help to serve rural communities with the support of state aid. These cases are further described in the following sections.

Certain commercial initiatives have also targeted gaps in the market where investors consider that telecom operators have failed to meet or anticipate growing demand.[95]

2.4.1 Dublin Docklands Network[96]

Dublin is one of the most attractive global locations for Foreign Direct Investment (FDI) and is ranked as the best location globally for availability of skilled workforce, investment incentives and openness.

The success of the Internet and social media cluster at Grand Canal Basin, with high-profile companies such as Google, Facebook, Dogpatch Labs, Windmill Lane Studio and Pulse College, is such that the area has become known as ‘Silicon Docks’. The cluster effect has extended to neighbouring areas with the presence of LinkedIn, Twitter, Zynga Games and Giltgroupe which, in turn, has attracted smaller firms and start-ups.

Due to their economic and social importance, the North Lotts and Grand Canal Dock have been designated as a Strategic Development Zone (SDZ)[97] . The availability of high-speed broadband is critical to attract investment into the area and ensure its economic competitiveness.

The Docklands has a population of 27,000 households and a workforce of 44,000. A further increase in the working and living population by 20,000 and 15,000 respectively

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94 According to data prepared for the European Commission (Broadband Coverage in Europe report), FTTP coverage reached an average 23.7% on a national basis as of 2016. However, rural FTTP coverage stood at only 8.8%.

95 Cityfibre provides an example of a wholesale only commercial provider in the UK, although it recently signed a deal with Vodafone which would give Vodafone marketing exclusivity during specific periods. See http://www.vodafone.com/content/index/media/vodafone-group-releases/2017/vodafone-and-cityfibre.html Commercial wholesale only investors have also stepped in to address the fibre void in rural areas in the Netherlands, as discussed in the following chapter.

96 Some of insights as regards to Dublin Docklands Network are generated via the interviews from 18-01-2018 conducted with Derek Kelly, Manager, and Seamus Storan, Senior Executive Engineer, in the Dublin Docklands Office of Dublin City Council as well as with Emmanuel Kennedy, Director of Operations at Novegen.

97 The SDZ Area comprises some 66 ha of the overall 520 ha Dublin Docklands Area.

is expected in next five years. Commerce and trade plays a major role in the Docklands, with transport and communications as the second largest industry group in the Strategic Development Zone (SDZ).[98] Of the total households recorded, 93% of households in the SDZ live in apartments compared with 61% in the wider Docklands.[99]

Although there are seven existing infrastructure-based providers, Dublin City Council (DCC) was concerned about the pace of network expansion to meet the needs of incoming residents and industry. DCC also noted that because of the historic features of the Dublin Docklands area, they were concerned that many network operators would not be able to fund high costs of the digging of new ducts.

DCC and its predecessor the Dublin Docklands Development Authority (DDDA) therefore undertook on themselves to ensure the availability of suitable infrastructure, building on existing infrastructure owned by the Council.[100]

In August 2015, the DDDA invited applications for the provision of Fibre-Optic Network and Infrastructure Management Services in the Dublin Docklands Area. As a result of this process, Novegen were awarded a contract to manage the existing fibre optic network and extend the network into the Docklands SDZ area. Although the tender process did not stipulate a business model, Novegen's proposal to deploy a wholesale only fibre network was considered a positive aspect of its bid.[101]

"The new fibre infrastructure will improve economic competitiveness of Dublin Docklands and contribute to environmental sustainability by reducing the need to travel through enabling e-working and e-commerce"
Dublin City Council

The Framework Agreement will operate for 10 years to enable the development of long-term relationships with DCC clients and service providers.[102]

The total investment for the new fibre deployment in Dublin Docklands is expected to amount to around €8 million, with fibre being deployed in stages to meet expanding demand as businesses expand and relocate to the area. The deployment will provide extra duct capacity for future requirements and every building will have multiple points of access for each building.

98 Dublin City Council (2014), North Lotts and Grand Canal Dock, Planinning Scheme 2014, Chapter 2, p. 20.
99 Ibid.
100 The DDC owns a multi-operator network in the Docklands of nearly 7,000 m and 50 km cabling, primarily fibre optic
101 http://www.novegen.com/services/
102 The service is classified as a service concession and therefore not subject to the requirements of Directive 2004/18/EC including duration rules on frameworks (DDDA, 2015, p. 5)

A rate card is available to all service providers provide access conditions on a non-discriminatory basis. Return on investment is expected in around 3-4 years, although this depends on take-up.

The DCC is confident that the new fibre infrastructure will improve economic competitiveness of Dublin Docklands and contribute to environmental sustainability by reducing the need to travel through enabling e-working and e-commerce. Moreover, the fibre infrastructure will support data-driven innovation and be a platform to facilitate the Council's 'Smart City' initiative.

The DCC notes in this context that it is using the Dublin Docklands as a 'lab' for its dedicated Smart City Unit, testing out IoT and Wifi solutions to see if they would work more widely. Examples of IoT applications that are being considered include 'weight management' to test whether remotely whether rubbish bins are full, rather than having to send staff to check every day. Another initiative may be to collect data from heat maps to assess how people move through the area's major convention centre.

DCC notes that the increasing importance of services to the economy, in particular those that are structured around electronic transactions and information flows, makes it essential that Dublin Docklands has access to advanced and cost competitive communications services. For service providers, DCC notes that effective use of the neutral fibre infrastructure should allow them to compete more effectively with their counterparts, by reducing costs and improving the quality of services to their customer base. It also means that customers will be able to access the service provider of their choice without the need for costly and disruptive civil works.

> **"Customers will be able to access the service provider of their choice without the need for costly and disruptive civil works"**
> *Dublin City Council*

2.4.2 Nögig (Austria)

Some of the nine Federal States in Austria are not satisfied with the fibre availability in their states and have taken or are currently taking initiatives of their own to accelerate fibre deployment in their respective federal state.

The most prominent and first initiative has been undertaken by Niederösterreich (Lower Austria). Niederösterreich founded the Lower Austrian Fibre-optic Infrastructure Company (nöGIG) in 2015 as a 100% owned company of the federal state. The mission of nöGIG is to ensure universal coverage of FTTH in Niederösterreich within 10 years. NöGIG itself should roll-out fibre not in competition with private fibre initiatives but

should focus its deployment on areas where no private fibre initiatives are present or could be expected.

The federal state provided initial equity financing of €37 million to nöGIG.[103] In parallel nöGIG successfully applied for state aid contributions from the broadband program of the Federal Government in its region to roll-out fibre in unprofitable areas. Thus far the company has received around €40 million in state aid supporting investments of around €100 million. The first wave of deployment will cover 34,000 homes in municipalities in remote and rural areas.

NöGIG is already making plans for a fibre roll-out for a second wave of municipalities at a much larger scale than the first wave, and is negotiating with potential equity partners as well as with banks to provide debt financing. Notwithstanding private equity participation in nöGIG, the Federal state will ensure through the governance structure that the underlying fibre infrastructure will remain under public control.

The business model of nöGIG is based on the construction and rental of the passive fibre capacity to network operators which contribute the active network elements, operate the network and lease capacity to service providers on a wholesale basis. This three layer open access network structure received the European Broadband Award 2016 from the Commission as an innovative model for providing open access.

NöGIG has already concluded agreements with several operators, including the incumbent, to operate their network at the second layer of the network.

Other regions have taken inspiration from this model. Oberösterreich announced in November 2017 the establishment of its company Fibre Service OÖ (FIS) which will also involve the construction of an open fibre network on a wholesale-only basis. It is envisaged that FIS will invest €100 million within the next five years in fibre infrastructure.

Market observers expect that the Federal States of Steiermark and Kärnten will also shortly establish their own fibre companies.

103 These funds are notified at the European Commission under the AGVO rules and under SA.46731.

3 The investor perspective

The previous chapter highlighted how wholesale only initiatives have brought competitive high speed broadband access to consumers, businesses and the public sector – in both urban and rural settings.

KEY FINDINGS

Wholesale only models can attract new capital from infrastructure funds, that would not otherwise invest in telecom networks and services.

A key attraction of the model for these investors is to use multiple service providers to support demand. Considerable pent-up demand can be seen especially in rural areas – where investors have been able to achieve pre-commitment rates of 60%. Investors consider there may also be an opportunity in other areas where only copper is available, and the incumbent has failed to make significant investments.

Wholesale only fibre investments have delivered attractive returns for investors, compared with other essential infrastructures.

Fibre is demanded not only for broadband access, but also for mobile backhaul, Wifi and other applications such as CCTV. The business case can be improved by servicing all needs – some fibre investors have expanded to offer towers for example.

A number of high profile commercial and publicly-backed infrastructure investors have also bought into the wholesale only model, as a way of minimizing the risk of fibre investments, thereby enabling deployments where they might otherwise not be viable.

In this section, drawing on interviews with Gabrielle Gauthey (Caisse des Depots) and Randolf Nijsse (Communication Infrastructure Partners – formerly of CIF), we look at wholesale only networks from an investor perspective.

3.1 Interview with Gabrielle Gauthey Caisse des Dépôts

Caisse des Depots (CDD) has been a major investor in FTTH in France, and a key proponent of the wholesale only model over a period of 20 years.

Gabrielle Gauthey explains that “We see the network as an essential infrastructure. Analysis has shown that there is no economic viability for two competing passive infrastructures on around 80% of the French territory. There is however considerable scope for competition at the active layer.”

“We see the network as an essential infrastructure.”
Gabrielle Gauthey, Caisse des Depots

Gauthey considers that a core problem (for much of France and at the EU level) has been that regulation has been based on the mistaken idea of duplication of passive access (infrastructure competition). “Brussels has never accepted that passive infrastructure is an essential infrastructure and has been reluctant to consider it as a monopoly. This has done damage to competition as it has not put everyone on level playing field,” says Gauthey.

She observes that France provides a case study which illustrates within one country the effects of leaving deployment entirely to the market vs managing deployment through local public initiatives.

The background is that, after hearing from French telecom operators that only around 50% of households would be viable for commercial deployment, the French Government decided to divide the country between private initiative areas and public initiative areas. While in the private initiative areas, vertically integrated telecom operators were expected to invest, in the public initiative areas, fibre would be promoted by the local regions, who would tender for concessions to deploy infrastructure, with the aid of subsidies.

Caisse des Dépôts played an important role in defining business models for the public initiative deployments by setting criteria under which it would provide funds. The first criterion is to minimise public money – CDC prefers initiatives to be privately run and (for the most part privately financed). CDC also requires partners to be subject to contractual obligations to roll-out in due time, with penalties for failing to do so. Lastly, its partners must operate on the basis of open access – in this respect CDC prefers wholesale only models without any engagement in the retail market. In order to ensure ongoing public benefits, Caisse des Dépôts also requires in its contracts that the network cannot be sold to a vertically integrated operator.

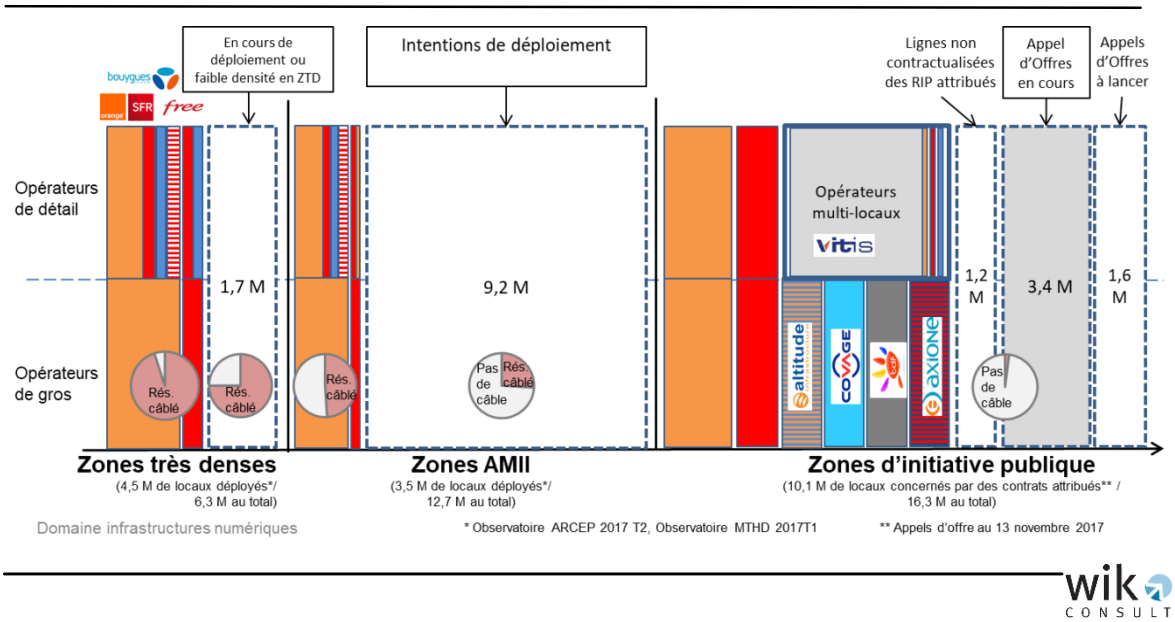
4 specialist operators emerged to deliver the wholesale only model as propounded by CDD including Axione (subsidiary of the infrastructure company Bouygues), TDF (previously a wholesaler focused on broadcasting), Altitude and Covage – financed by Cube. These 4 operators serve roughly two thirds of less dense areas. Caisse des Dépôts is a co-investor in most of these cases – taking the role of a minority investor together with private investors such as the operators themselves, and/or specialist

investors such as Cube and Marguerite. These operators are well financed, both with equity and with debt.

The incumbent Orange won concessions across most of the rest of the areas (one third) where public initiative contracts have been signed. However, Gauthey notes that Orange refused to adopt the wholesale only model, and has not co-invested with Caisse des Dépôts.

Gauthey considers that the effects of the wholesale only public initiative vs vertically integrated models can be clearly seen. Whereas contracts for fibre deployment have been settled in 60% of the public initiative areas (with a proportion of 80 % of FTTH) less than 30% of the private initiative areas outside the very dense zones have been deployed. Rather, most of the commercial deployment has to date been focused on duplicating networks in the most dense areas. A problem in this respect, is that unlike in the public initiative areas, commercial operators 'promised', but never formally committed to deploying fibre.

Figure 3-1: Existing and prospective coverage of very high capacity broadband in France, by zone



Source: ARCEP

Gauthey observes that the different models have also resulted in differing outcomes at the retail level. Whereas, there are numerous service providers offering services over the public initiative wholesale only networks including specialised business providers serving SMEs, the number of retail providers in areas without wholesale only networks is limited, resulting in less competition for urban than rural customers in many cases. Gauthey notes that some SMEs have moved to less dense areas because there is

more competition. Gauthey also highlights the importance of these neutral networks for mobile operators, especially with the move to 5G.

In addition to achieve positive results for consumers – through higher coverage and greater competition, Gauthey observes that wholesale only models are positive for investors. Take-up on wholesale only networks is typically higher because the service is being marketed by multiple service providers. Gauthey also notes that although the period of the concessions is typically 15-20 years, the payback period is often shorter. CDD engages in co-investment for a variety of other infrastructures in France such as highways, railroads and energy, but has found that some of the best returns are on fibre investments. Fibre investments also have significant leverage effects. Gauthey notes that CDC has made €4bln fibre investments possible because when CDD invests – there is a multiplier effect of 7.

Several other countries have pursued a wholesale only model as a national strategy, including the New Zealand, Australia, Peru, Mexico and some African countries. Gauthey observes that the key to success is to bundle more profitable areas with less profitable areas when offering concessions and associated subsidies. Pursuing this strategy resulted in the New Zealand incumbent deciding to separate voluntarily – it then won concessions across 80% of the territory with associated obligations to deploy fibre. In contrast, as the profitable and unprofitable areas where treated as distinct regions in France, the incumbent had no need to pursue this strategy.

Gauthey considers that the best way to attract investment in fibre is to have a vision from Europe through to national and local Govts – that the access network is essential infrastructure. This means that the concept and desirability of infrastructure competition should be reconsidered. The key is a political vision involving 3 layers where the passive layer is provided by a regulated monopoly. The middle active layer can achieve some competition, but should also deliver open access. This could enable investment by opening up investment in access networks to infrastructure funds. Passive access networks are a very different investment beast than service providers, concludes Gauthey.

3.2 Interview with Randolf Nijsse, Communication Infrastructure Partners

Randolf Nijsse works as an advisor on telecom investment strategies as a partner in Communication Infrastructure Partners. Previously, in 2008, Randolf was one of the founders of the Rabo Bouwfonds Communication Infrastructure Fund (CIF), focused on investments in telecom infrastructure.

Randolf has been involved in many FTTH investment projects ranging from the development of the business model to organisation of the roll-out.

A key project in recent years has been an investment programme to invest in rural areas in the Netherlands, which have been left out of the plans of typical telecom operators on the basis that they are not considered profitable. It focuses on areas which are not served by cable, and are underserved by DSL, and is purely based on commercial financing.

Under Nijsse's strategy, these areas have been addressed through a local approach which includes local marketing, the appointment of local ambassadors and co-operation with municipalities.

Costs are higher than in more densely populated areas – because the cable length is longer, so the proposition focuses on reducing demand risk by signing up subscribers in advance (demand aggregation) and charging a supplement to account for the greater cost.

> **"In rural areas, we achieved our target take-up every time, with an average sign-up of above 60%."**
> *Randolf Nijsse, CIP*

The programme organises a neighbourhood gathering, with a subsequent 6 week sign-up period. If 50% sign-up is reached, the project is given the go-ahead. Thus far, Nijsse notes that they have **achieved their target-up target every time – with an average sign-up of above 60%.**

Customers can choose either to pay an upfront contribution to the deployment cost (typically €1,000-€2,000) or pay a small additional fee on top of their monthly subscription directly to the infrastructure owner.

Nijsse invests in passive dark fibre infrastructure on a wholesale only basis. However, in order to deliver the service, he works closely with selected service providers, who lease the infrastructure depending on the number of active subscribers. The retail price for a triple play package is the same as in the rest of the Netherlands – starting at €45 and going up to €60-70. However, unless they pay a one-off fee for connection, customers pay €10-15 extra per month to cover the costs of living in a rural area.

The network is based on (passive) point to point FTTH over which (G)PON can still be applied. Nijsse says that **an important point in selecting the architecture was that it should be accessible to multiple service providers and should allow switching of service providers to prevent lock-in**.

> **"An important point in selecting the architecture was that it should be accessible to multiple service providers and should allow switching of service providers to prevent lock-in."**
> *Randolf Nijsse, CIP*

Thus far the Dutch rural investment programme has delivered over 20 different projects and signed up 80,000 customers. Nijsse believes that an additional 200,000 customers could be served in this way. In general an investor for this type of project would target a return on equity of 8-12%, with a return on the project as a whole ranging from 6-7% up to 8-9% including leverage.

Nijsse notes that the programme focuses on rural areas because of the obvious demand from consumers in those areas. People may start with only 1Mbit/s download and hardly any upload capacity, so they really need data connectivity. The business case is different and more challenging in densely populated areas, because there is likely to be competition from existing cable and VDSL infrastructure, which is easier to upgrade. Nijsse has nonetheless conducted successful projects in cities. He notes that the key is to look at how business case looks locally, including the competitive environment, and the local cost of deploying infrastructure. It is also important to work closely with service providers.

Nijsse is aware that there are even bigger rural investment opportunities outside the Netherlands, because the Netherlands is already relatively well served with broadband infrastructure. He has investigated Germany, where he considers that there is huge need. However, thus far he has found it a harder market to enter and secure agreements with good quality service providers of sufficient scale. He hopes that further talks with German operators may trigger opportunities. In general, the best commercial opportunities can be found in countries with a significant gap in the quality of infrastructure between urban and rural areas, because if the population is not sufficiently digitalised, they don't feel the need for fast connections.

Nijsse has not thus far experienced regulatory challenges which undermine the business model they are pursuing, but is keen to ensure that regulators maintain fair pricing rules on regulated operators and the assurance that regulatory rules will not change, because the risk that regulators could step in to change the price after investments have been made is a serious concern for investors.

3.3 Interview with Laurent Chatelin, Marguerite

Laurent Chatelin is Investment Director for Marguerite, an organisation specialising in funding infrastructure in the EU, with the backing of European public financial institutions. Marguerite is involved in two major broadband projects in France – in Alsace, with a €400m investment, and in Grand Est with a €1.3bln investment.

Chatelin explains that investment funds invest equity into companies or projects that have infrastructure-like features. The markets these funds invest in typically require large amounts of capital and have barriers to entry, but present good visibility on future cashflows. Roads, airports, energy and other regulated assets all fall into this category. Chatelin notes that these industries are typically regulated, because they are effective monopolies. As Marguerite invests in 'challenge' areas where only one high speed infrastructure is viable (often requiring state aid) regulation can be expected for Marguerite's broadband investments too. "We can accept price regulation, and even coverage obligations, with penalties for failing to meet targets," explains Chatelin. "However, what investors are looking for in return is a reasonable regulated return on investment and protection from cherry-picking by other network providers."

According to Chatelin, a challenge in the telecom sector, is that the EU has promoted infrastructure competition. This results in parallel infrastructure and inefficient, making the case for infrastructure funds difficult.

> ***"The pent-up demand goes beyond fixed Internet access. There is also demand for Wifi, IoT services and CCTV, all of which can be done easily on fibre"***
> *Laurent Chatelin, Margueritte*

As part of its business planning, Marguerite seeks engagement with the local community, as this can help to drive penetration, which is a key factor in enabling a viable business plan. "Often the demand is so great that we find 40-50% of the local population wanting to join public meetings," says Chatelin. " It can be a problem to find rooms that are big enough." Often these communities have experienced very poor copper access, with some companies having access to less than 1Mbit/s, but the pent-up demand goes beyond fixed Internet access. "There is also demand for Wifi, IoT services and CCTV – all of which can be done easily on fibre," says Chatelin.

In the case of Alsace, the contract was signed in April 2016, and the network began operating in July 2017. Only 7 months later, penetration had already reached 20%. Marketing is supported by signing up retail service providers with attractive offerings – there are often a number of specialised business providers in addition to those targeting residential markets. Chatelin is positive about wholesale only models because it means that others can help market the service. However, he considers that offerings must go

beyond passive access to include active services so that smaller operators can enter the market. Chatelin is also actively looking at additional infrastructure services that could be added to their offering. For example, in Grand Est the offer includes access to 150 towers.

> ***"There is scope for disruptive entrants in areas where there is no alternative to copper e.g. in the periphery of big cities – and elsewhere where the incumbent is not doing its job"***
> *Laurent Chatelin, Margueritte*

Marguerite takes a long-term perspective on its investments – targeting a rate of return between 12-15% over a period of 30-35 years. They expect that fibre take-up will eventually reach 85-90%, but the question is how quickly will customers move from copper to fibre. Their current expectation is that it will take 10-12 years.

Chatelin believes that the window of opportunity for wholesale only fibre networks in urban areas has largely closed. However, ***there is scope for disruptive entrants in areas where there is no alternative to copper e.g. in the periphery of big cities – and elsewhere where the incumbent is not doing its job***. Chatelin noted that Marguerite faces pressure to look outside the initial catchment area to serve regions where there has been a failure to deploy.

4 Implications of wholesale only for 5G and IoT deployment and applications

In this section, we look into the role that neutral fibre infrastructure is likely to play in the context of 5G deployment and 5G applications such as automated driving, as well as its potential to support applications in the fields of healthcare and smart buildings.

4.1 The road to 5G

KEY FINDINGS

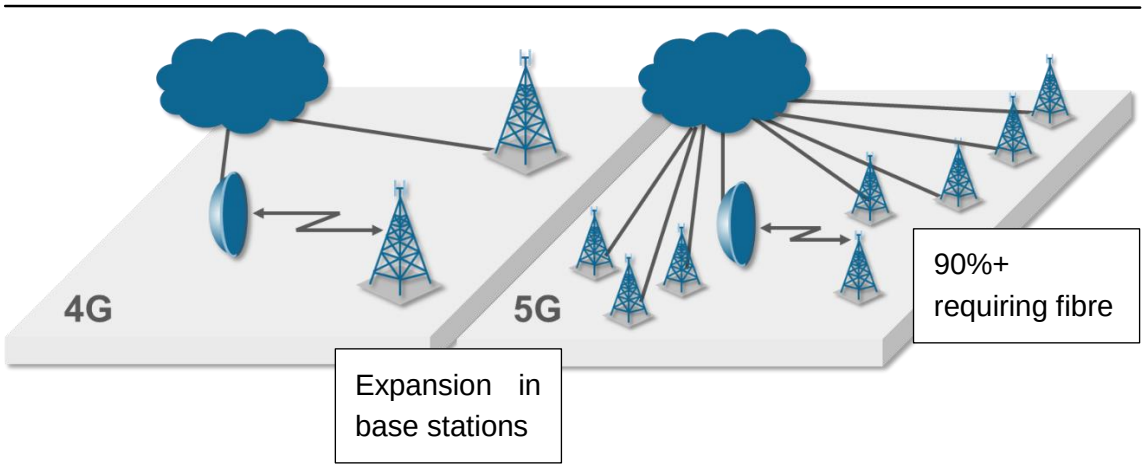
5G mobile networks will require fibre deeper into the network as the number of base stations and requirements for high speed capacity increase. Wholesale only fibre networks offers one solution which could support faster deployment and competition in 5G, as well as new business models and specialist providers for services relying on mobile connectivity such as automated driving.

Fibre connectivity has also supported innovation in the field of IoT. Some examples include smart buildings, traffic management and health applications. The availability of dark fibre from wholesale only providers could provide a neutral platform on which industry can play a direct role in innovating to meet the needs of customers.

In a study conducted for Stokab in 2017,[104] WIK found that wholesale only networks had played a significant role in enabling the swift deployment of 4G (LTE) networks by alternative operators in Stockholm. It is particularly notable that there was less difference between the mobile broadband speeds offered by the four mobile operators in Stockholm than in other cities studied. Although there could be various reasons for this discrepancy including spectrum assignment and challenges associated with rights of way, it seems likely that the availability of neutral fibre infrastructure has contributed to increased competition in mobile broadband.

104 WIK-Consult (2017), A tale of five cities: The implications of broadband business models on choice, price and quality, a study for Stokab.

Figure 4-1: Fibre requirements in a 5G environment



Source: WIK-Consult, based on operator interviews

In an interview for this study, Peter Bryne, an independent consultant who was previously Head of Core and Transmission for Net4mobility, the joint venture between the mobile operators Telenor and Tele2 in Sweden, noted that "***Net4mobility would have been completely in the hands of Skanova (the wholesale division of incumbent Telia) if municipal networks had not been available as an alternative***".

Net4mobility sourced fibre from a large number of local and municipal suppliers as well as using wholesale access from Telia. Their aim inter alia to ensure futureproof connectivity for 4G upgrades and early 5G deployments, was to install fibre to as many as possible of those base stations using 2.6GHz frequencies. *Ultimately they deployed fibre to around 50% of their base stations on average – or 85% in dense areas. However,* **in Stockholm which benefits from municipal infrastructure from Stokab alongside Telia, they achieved fibre backhaul coverage to nearly all their base stations.**

Bryne noted that "A core benefit of the municipal networks is that they introduced competition in the market. City networks were also able to be more flexible in how and where they build and in their pricing. Importantly, city networks were also able to place value in wider social objectives and recoup investments over a longer period. In contrast commercial companies have a shorter term focus and have incentives to cherry-pick, deploying fibre selectively e.g. only to business premises. The resulting lack of widespread fibre coverage results in higher costs and prices for those premises for which fibre is installed."

The availability of dark fibre will become even more critical for mobile operators as they upgrade to 5G technologies which use higher frequencies with a lower range and therefore require build-out of additional base stations over time especially in

densely populated areas. Interviews conducted by WIK with a number of mobile operators across Europe suggest that 5G is likely to require fibre to the vast majority of base stations (more than 90%), in comparison with today's networks, which still make use of microwave radio links for a significant proportion of connections.

> ***"The availability of fibre city networks which have already been used to provide backhaul for 4G may enable a more rapid evolution towards 5G."***
> *Peter Bryne*

As the economics of dense fibre networks are challenging, the role of neutral wholesale only providers is likely to be important in working with network operators to serve the required locations and enable quick deployment and competition. As Bryne notes: "***The availability of fibre city networks which have already been used to provide backhaul for 4G may enable a more rapid evolution towards 5G. Such networks will in particular provide an advantage for the second and third player in 5G compared with countries in which wholesale dark fibre is not available to the same degree."*** Co-investment could provide an alternative solution in countries and areas where this approach has been taken towards fibre deployment.

As Bryne notes: "***The availability of fibre city networks which have already been used to provide backhaul for 4G may enable a more rapid evolution towards 5G. Such networks will in particular provide an advantage for the second and third player in 5G compared with countries in which wholesale dark fibre is not available to the same degree."*** Co-investment could provide an alternative solution in countries and areas where this approach has been taken towards fibre deployment.

4.2 The role of neutral fibre networks in transport

4.2.1 Monitoring traffic flows

This increasing number of urban citizens requires better possibilities for sustainable travel and the city planning must therefore follow this development. In order to be able to build and develop sustainable urban areas, new and effective measuring techniques are needed to facilitate true and accurate data.

The Swedish company Viscando has developed a system for automatic traffic monitoring which utilizes state-of-art 3D computer vision technology. It is the only automatic system in the world that can detect and classify all traffic types in a single system.[105] The flows including behaviors and interactions with pedestrians, cyclists and

105 Iverlund, H. and A. Larsson (2014), Mobile 3D Traffic Measurement: Stakeholder mapping and design of a new housing solution, Chalmers University of Technology, Sweden.

vehicles are detected by analyzing images collected using dual video camera. The collected data is used by the traffic authorities in order to better understand the traffic trends as well as plan and follow up on actions to improve traffic flow and traffic safety. Viscando Otus 3D simplifies and enhance this work by providing automation and high quality data.

The Traffic Office in Stockholm has a framework agreement with Viscando OTUS3D for automatic counting of pedestrians in the city during 2017 - 2019.[106] The Traffic Office in cooperation with the wholesale-only fibre provider Stokab will connect Viscando's measurement stations to the fibre network in the city. Thus, measurement data will be transmitted in real time to the city.

Continuous measurement of track flows gives the city the opportunity to plan the operation and maintenance of pedestrian and cycle tracks.

The project is a part of the Stockholm City's strategy for accessibility. Earlier measurements of pedestrians were manual and temporary. With Viscando, the city has been given the opportunity to receive continuous measurement data through automatic counting of pedestrians at a number of locations in the city. Continuous measurement data gives the city the opportunity to plan the operation and maintenance of pedestrian and cycle tracks. Furthermore, it enables monitoring of the impact of the weather on the citizens' choice of modes of transport as well as energy optimization changes to the infrastructure, such as places that are relevant to heat loops.

4.2.2 Future applications in automated driving

With higher automation levels and increasing connections of vehicles to the Internet and with each other, the automotive industry is currently undergoing significant technological transformations. The automobile industry sees two main trends associated with increased connectivity: autonomous driving and road safety and traffic efficiency services.[107] In order to deal with increasing complex road situations, autonomous vehicles will have to rely not only on their own sensors, but also on those of other vehicles. These trends pose significant challenges to the underlying communication system, as information must reach its destination reliably within an exceedingly short time frame – beyond what current wireless technologies can provide.[108] At the same time, with the next iteration of mobile networks, 5G technology is expected to gain Gigabit speeds, ultra-high capacity and ultra-low latency, making it an important development to support these applications.

106 http://www.viscando.com/en/node/85.
107 5G PPP (2015), p. 13.
108 5G PPP (2015), 5G Automotive Vision.

Autonomous-driving cars have the intelligence to recognize, decide and control accordingly. One of the biggest benefits of autonomous driving through enhanced vehicle-to-everything (V2X)[109] communications and autonomous functions is reducing road accidents. For instance, the concept of vehicle platooning[110] refers to vehicles traveling together by following a lead vehicle. The creation of closely spaced multiple-vehicle chains on a highway would lead to increased safety and comfort, reduced traffic congestion and efficiency improvement.[111] Since on-board sensors are not able to cope with short distances, vehicles within a platoon will constantly exchange their kinematic state information in real time.[112] Autonomous driving requires therefore a very low latency to be able to react in real time to drivers' behavior and to moving obstacles. This means that 5G technology is essential for providing real-time services in future vehicles.[113]

Moreover, traffic safety and control include all the services to ensure maximum safety and efficiency in any driving situation. These applications include large-file and real-time data exchange and rely on the principle that connected vehicles periodically provide either status information[114] or event information[115]. This information is usually packed into stateless, individual messages which are either locally disseminated to neighboring vehicles or sent to a central point (base station) where it can be aggregated and then again disseminated to other vehicles to make use of it.[116] In addition, the status information will be extended by more complex information which is provided by the vehicle's on-board sensors like camera, radar, ultra-sound. Consequently, a single autonomous vehicle with always-on sensors and cameras is expected to produce enormous amounts of data.[117] The data will be then transmitted over a very short distance wirelessly to a small cell, and then over a fiber optic network to a control center. Thus, the network architecture of 5G itself will require additional fiber to support 5G.

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109 Vehicle-to-Everything (V2X) refers to all types of vehicular communication such as exchange information within vehicles (V2V), between vehicles and roadside infrastructure (V2I), a backend server or Internet (V2N), a pedestrian (V2P) etc. (5G PPP, 2015, p. 13).

110 Vehicle platooning refers to group of vehicles that share common mobility patterns, maintain a formation (typically inter-vehicle distances and speed alignment) and exchange information about intended maneuvers. Contrary to a convoy, a platoon has a leader that manages the group (5G PPP, 2015, p. 6).

111 Yu, H., Lee, H. and H.Jeon (2017), What is 5G? Emerging 5G Mobile Services and Network Requirements, Sustainability, 9, 1848.

112 5G PPP (2015), p. 23.

113 5G is envisioned to provide a latency of 1 ms for the air interface – with a resulting 5 ms end-to-end latency for infrastructure mode and 1 ms end-to-end latency for direct mode – which is compatible with the stringent requirements of autonomous driving (5G PPP, 2015).

114 E.g., position, speed, acceleration etc..

115 E.g., traffic jam, icy road, fog, etc..

116 5G PPP (2015), p. 23.

117 According to the prediction of the Intel CEO around 40 terabytes (40,000 GB) of data might be generated and consumed by an autonomous car during eight hours of driving,15 and much of this data may need to be transmitted somewhere (https://www.networkworld.com/article/3147892/internet/one-autonomous-car-will-use-4000-gb-of-dataday.html; 5G PPP (2015), p.8).

In order to handle the projected demand of 5G networks both fronthaul and backhaul fibre capacity will need to be increased. Firstly, in contrast to traditional networks[118], the deployment of 5G will be accompanied by a different network architecture called Cloud Radio Access Network (C-RAN) which places the main processing power away from the local small cell site deeper in the network and aggregates the processing of many small cells into one location.[119] The C-RAN enables an efficient processing of the complex radio signals required for 5G in a central location instead of at each small cell site. For the processing power at the centralized locations, 5G will require a high capacity fronthaul which provides data speed rates that are up to 10 times higher than those in the backhaul connections for 4G LTE.[120] Secondly, all information will need to be transmitted from the C-RAN processing location to its final location through the core network for which a high backhaul capacity will be required.[121]

The above described autonomous driving as well as road safety and traffic efficiency services are likely to rely on widespread 5G coverage. While deployment of small cells is a promising way to boost capacity, the need for cell densification leads to an increase of overall capital expenditure and challenges around planning and site acquisition.[122] In order to ensure network efficiency and to reduce the cost of network deployment, a single shared network infrastructure for the automotive and telecommunications sectors is indispensable, where operators can share the C-RAN in many locations. Although there is one C-RAN, this may not necessarily belong to one operator or company, and different providers may deliver coverage in different areas or using different technologies and amalgamate these into a single virtual network.[123]

With the advent of small cells and 5G, a neutral wholesale-only shared infrastructure is likely to become more prominent.[124] The neutral wholesale-only infrastructure could be owned by network operators wishing to co-invest to share the risk, or independent wireless infrastructure providers, or fibre network providers who may choose to diversify into the provision of sites for small cells, or local authorities (e.g. the local council, or road/highways agency) who wish to utilize their assets such as street lights and ducts.[125]

"With the advent of small cells and 5G, a neutral wholesale-only shared infrastructure is likely to become more prominent."
Department for digital, culture, media and Sport, UK Govt

118 Traditional networks have had computing and processing power co-located at the small cell site with the wireless antenna and transmission equipment (5G PPP, 2015).
119 FBA (2017), The road to 5G is paved with fiber, White paper, p. 12.
120 Ibid.
121 Ibid.
122 Department for Digital, Culture, Media & Sport (2015), 5G Network Deployment Pilots: Call for Views, UK Government, p. 10.
123 LS telcom, VVA and Pliy Tracker (2016), Study on Spectrum Assignment in the European Union, a study carried out for the European Commission, p. 70.
124 Department for Digital, Culture, Media & Sport (2015), p. 10.
125 Ibid.

The wholesale-only provider could then supply connectivity and other services to automobile vehicles on the roads, taking the burden of such costs from the MNOs, and sharing any spare capacity with them. Alternatively the infrastructure builder could operate the service in commonly available spectrum and then sell services directly to the MNOs.[126] This would result in different forms of infrastructure sharing like sharing of passive elements such as masts, to active elements such as antennas and baseband units. Spectrum resources can also be pooled or shared in certain geographic areas through such as roaming, network slicing or other forms of wholesale access.[127]

4.3 Fibre networks in the healthcare sector

> ***"There is a great need for fibre connections that can prioritise welfare services with a guaranteed bandwidth and reliability. The access to open municipal networks in the Stockholm region simplifies the connection of additional e-Health services"***
> *Susanne Bayard, CIO, Stockholm County health care area*

With the availability of secure, reliable fibre optic networks, healthcare facilities can implement big data, the Internet of Things (IoT) and wireless remote technologies to deliver personalized treatment and improve the quality of patient care while reducing operational costs. In this context, senior public health officials have observed "a great need for fibre connections that can prioritise the welfare services with a guaranteed bandwidth and reliability."[128] and note that "digital health care services are going to drive the expansion of the fibre network, regardless of a connection through the mobile or fixed broadband"[129].

The developments that are driving these bandwidth needs are further discussed below. Access to municipal networks, such as in the Stockholm area, are considered to have simplified the connection of additional e-health services. [130]

126 LS telcom, VVA and Pliy Tracker (2016), Study on Spectrum Assignment in the European Union, a study carried out for the European Commission, p. 70.
127 Department for Digital, Culture, Media & Sport (2015), p. 10.
128 Interview with Susanne Bayard, CIO, Stockholm County health care area, in Stokab (2017), Focus on eHealth services: Healthcare providers and businesses describe the importance of dark fibre networks for meeting future health and social care needs.
129 Interview with Håkan Cavenius, Senior Advisor at RISE (Research Institutes of Sweden), in Stokab (2017), Focus on eHealth services: Healthcare providers and businesses describe the importance of dark fibre networks for meeting future health and social care needs.
130 Interview with Susanne Bayard, CIO, Stockholm County health care area, in Stokab (2017), Focus on eHealth services: Healthcare providers and businesses describe the importance of dark fibre networks for meeting future health and social care needs.

Internet of Things (IoT)

IoT is considered as an enabling technology that can revolutionize the current healthcare system with a variety of cutting-edge and highly individualized services and applications.[131] Key technologies driving the development of IoT include the miniaturization of sensors, and corresponding reduction in the amount of power required. One promising medical innovation is, for instance, an ingestible sensor which allows patients and physicians to measure medication ingestion and adherence patterns in real time.[132] The ingestible sensors connect pharmaceutical compliance to important physiological metrics, and take appropriate action in response to a patient's adherence pattern and specific health metrics.

In medical IoT, various medical sensors, devices, smartphones, imaging devices, personal digital assistants and electronic health records act as core parts of the system. These devices monitor important health information which can be effectively utilized by healthcare providers to improve the quality of care and health outcomes. On their own, none of the medical IoT services and applications will generate the traffic needed to make full use of a fibre broadband connection. However, it is anticipated that IoT will create an explosion in the number of connected devices and add to network demands from other applications, contributing to the need for cost-effective, reliable and high speed connections in the healthcare environment. Moreover, due to the increasing complexity of related operations with the addition of diverse applications, IoT healthcare networks, applications, services, and back-end databases should be scalable.

Big data and the cloud

Hospitals are increasingly producing huge amounts of digital patient data. For instance, electronic medical records (EMRs) comprise a large amount on data such as practice management, electronic billing, scheduling, patient demographics, medical reports and patient access portal. The heaviest traffic results from storage of radiology images and uploading the images from different locations to the cloud. The human genome also requires around 3 GB of storage, when compressed, and next generation sequencing, is expected to further add to the data volumes.

The proliferation and scale of health data has stimulated equipment providers to offer platform solutions (e.g. Philips HealthSuite digital platform or GE Health Cloud), enabling the consolidation of this data.[133]

In turn, it is expected that analytical techniques will be applied on health data and behaviour information to gain deep insights into the various aspects of human life, and

131 Latif, S, Qadair, J., Farooq, S. and M.A. Imran (2017), How 5GWireless (and Concomitant Technologies) Will Revolutionize Healthcare?, p. 6.
132 Hafezi, H., Robertson, T.L, Moon, G.D, Au-Yeung, K.Y, Zdeblick, M.J. and G.M. Savage (2015), An ingestible sensor for measuring medication adherence, IEEE Trans Biomed Eng. 62(1), pp. 99-109.
133 Arthur D.Little (2016), Creating a Gigabit Society, a report for Vodafone Group Plc.

provide the necessary support to develop a patient-centric personalized healthcare system in which the right health intervention for a given person and the health problem can be identified in an evidence-based manner.[134]

There are many challenges that need to be resolved before the EMRs can participate in the big data revolution. One challenge involves assuring protection and adequate informed consent by the patients to whom the records refer as well as the clinicians who generated them, creating privacy-preserving analytical strategies and devising ways to integrate over time and space the records for a specific person.[135] However, another challenge which is relevant to this study is that healthcare services are highly time sensitive and require QoS guarantees in terms of important parameters such as reliability, maintainability, and the service level. Secured, high-bandwidth, low-latency fibre networks will therefore be crucial for healthcare services and applications. As the amount of data stored by health platforms increases, high throughput networks will also be required to transmit information on a continual basis among patients, hospitals and other care givers.

Wireless connectivity

The exploitation of ubiquitous wireless technologies in the healthcare system will likely be strengthened by the development of 5G wireless technology, which will provide much better performance in terms of throughput and latency compared to pre-5G technologies. Future technologies like Ultra-Reliable Low Latency Communications (URLLC) and Massive Machine Type Communications (mMTC) enabled by 5G will make health communications more resilient and will open many new healthcare opportunities like remote diagnosis and remote surgery.[136] URLLC provides strict requirements, especially in terms of latency and reliability, while MMTC supports a very large number of connected devices and typically transmitting a relatively low volume of non-delay-sensitive information.

One of the most prominent e-Health applications in the 5G context is remote healthcare with use of bio-connectivity. Bio-connectivity promises to decentralize hospital services and enable the provisioning of medical care on the move.[137] This will open a new era of advantages from enhancing performance in hospitals to new ways of monitoring the patients' health, disease progression and individualized pharmaceutical analysis.[138]

Remote robotic surgery is another major change occurring in healthcare, which will require wireless connectivity to capture and transmit the movements required. Current developments in robotic surgery are illustrated by products such as the da Vinci

134 Latif et al. (2017), p. 6.
135 Brennan, P. (2017), Is the EHR the new big data?, https://datascience.nih.gov/BlogIsTheEHR.
136 Popowski, P. et al. (2017), Wireless Access for Ultra-Reliable Low-Latency Communication (URLLC): Principles and Building Blocks.
137 5G Infrastructure Association (2015), 5G and e-Health.
138 Latif et al (2017).

Surgical System.[139] It enables surgeons to perform operations by translating the surgeon's hand movements into smaller, precise movements of tiny instruments inside the patient's body. The instruments bend and rotate far more than a human hand is capable of doing. One of the instruments is a laparoscope provides a magnified vision system to give surgeons a 3D HD view inside the patient's body by sending images to a video monitor in the operating room to guide doctors during surgery.

Delay and its stability (i.e. jitter) are the major requirement for remote interventions. When a robot is operated remotely, and there is force feedback information being transmitted, the stability of the feedback process can be seriously impaired in presence of substantial time delay.[140] Therefore, major challenges and requirements in the healthcare industry lie in the increased capacity for real-time high-definition video transmission; robust mobility and low latency communications network.

4.4 Fibre networks supporting smart buildings

As more municipalities implement fibre infrastructure, fibre-optic access is causing a shift within the real estate industry. Big data storage, cloud computing, IoT and advanced analytics are just a few applications which real estate companies are increasingly using. In turn, buildings with access to fibre-optic-ready office space have a competitive advantage compared to assets without this amenity.[141]

One area that has the potential to be positively impacted by IoT technology is Smart buildings. Building Internet of Things (BIoT) can be defined as "the overlaying of an IP network, connecting all the building services monitoring, analyzing and controlling without the intervention of humans".[142] BIoT allows focusing on "all the components in a building that could be connected to the network for the purpose of creating operational efficiencies, reducing energy consumption, improving occupant experiences, achieving sustainability goals, and effectively optimizing financial performance".[143]

Open architected, integrated, IP-centric intelligent buildings require communications network with a strong ability to handle unstructured and real-time data.[144] The fibre-

139 Atkinson, J. (2016), 5G to open up new healthcare possibilities, https://www.itproportal.com/news/5g-to-open-up-new-healthcare-possibilities/.

140 Latif et al. (2017).

141 A study based on a US nationwide sample of real estate transactions from 2011 to 2013 shows that a gigabit FTTH connection can add up to 3.1% to the value of a home (Molnar, G., Savage, S.J. and D.C. Sicker (2015), Reevaluating the Broadband Bonus: Evidence from Neighborhood Access to Fiber and United States Housing Prices).

142 Memoori (2014) argues that the value in BIOT is as much in the data as the devices and estimates that the overall market for systems in buildings will grow from $110.9 Bn in 2014 to $181.1 Bn in 2020, with Physical Security, Lighting Control and Fire Detection & Safety representing the three largest segments (Memoori, 2014, The Internet of Things in Smart Buildings 2014 to 2020).

143 Young, J. (2014), BIoT – BUILDING Internet of Thing, 14(4), Realcomm, https://www.realcomm.com/advisory/621/1/biot-building-internet-of-things.

144 Holdowsky, J., Mahto, M., Raynor, M.E. and M. Cotteleer (2015), Inside the Internet of Things (IoT), Deloiite Insights.

optic networks do fulfill the requirements of analytical systems that can handle unstructured data without compromising the scope of data. On legacy network based, batch-oriented data processing does not deliver the low latency required for real-time analysis applications, while fibre-optic networks allow timeliness in real-time analytics.

In a smart building, embedded sensors measure and record user activities, making it possible to predict their future behavior, prepare everything one step ahead according to the individual user's preferences or needs, and provide the most convenient energy efficient services.[145] Using such sensors, the IoT promises to turn any object into a source of information about that object and its environment.

In order to achieve comfort, security, and effective energy management, users can avoid having to perform routine and tedious tasks. The sensors distributed in the buildings can make user life more comfortable. For instance:

- Room heating can be adapted to user preferences and to the weather.
- Room lighting can change according to the daylight.
- Domestic incidents can be avoided with appropriate monitoring and alarm systems
- Energy can be saved by automatically switching off electrical equipment when not needed, or regulating their operating power according to user needs, thus avoiding any energy overuse.

In this sense, IoT is a key enabler of smart services to satisfy the needs of individual users, who apart from being users of the system, can also been seen as sensors in the same way as temperature, thermal, humidity and presence sensors deployed in the building.[146]

In Stockholm, the public-owned[147] property company Sisab[148] is positioned to implement the technology, using IoT-enabled building management systems (BMS) to make building performance more efficient and also use sensor-generated data to enhance building user experience. The aim of Sisab is to provide efficient, flexible and cost-effective premises for the city's educational school and preschool activities and together with tenants to create educational environments with quality, sound economy and long-term environmental considerations.[149] Sisab invests approximately SEK 2

145 Cano, M.V.M. (2014), I2ME2 IoT-IBMS: An IoT-based Informations Management System for Energy Efficiency in Smart Buildings, Ph.D. Thesis, University of Murcia, Spain.

146 Ibid.

147 Sisab is wholly owned by Stockholm Stadshus AB, which in turn is owned to 100% by the City of Stockholm. Established in 1991, Sisab is one of the country's largest real estate companies with a broad and deep knowledge about educational environment. Sisab owns and manages 400 preschools and 200 primary and secondary schools in Stockholm and responsible for a total of 1.8 million square meters, with more than one hundred thousand people staying daily. In addition to the maintenance and management of the properties, Sisab works with extensive renovations and build-ups as well as some new construction projects.

148 Some of insights as regards to Sisab's operations are generated via the interview conducted with Niklas Dalgrip, head of the operations department at Sisab, on 25 January 2018.

149 www.sisab.se.

billion annually in maintenance, renovations and rebuilding of the schools in Stockholm.[150]

In order to convert complex structures into energy efficient Smart buildings, Sisab rents dark fibre from Stokab, a wholesale only provider (see section 2.1), and cooperates with S:t Erik Kommunikation, which is responsible for the management and development of the city's internal communications network. Based on the fibre connections and property network servers, all buildings in the network communicate with Sisab's central data center, where all the information is collected.

Sisab's performance monitoring and management ensures interoperability among different subsystems of the buildings, including smart energy management systems that provide flexible actions to reduce the gap between predicted and actual energy building performance, and continuous monitoring and control during service life. For instance, the property manager uses the data collected by motion and occupancy sensors at a building level to regulate air-conditioning and lighting in real time, thereby reducing energy costs and optimizing the internal environment for its data intended purpose.

Investment by Sisab in climate sensors has generated savings of SEK 190 million in energy costs during the same period (5 years) and reduced energy consumption by about 26 % per square metre

In order to achieve efficiency building energy management, information from heterogeneous sources is collected and analysed through monitoring before concrete actions are proposed to minimize energy consumption. Given that each building has a different static model according to its design, Sisab tries to provide a solution for energy efficiency focusing on analyzing how dynamic conditions affect the energy consumed in buildings.

The continuous monitoring and predictive capability of IoT-enabled buildings can also preempt a repair or maintenance issue by enabling a building manager to take appropriate corrective action. Sisab's monitoring system also provides an overview of necessary maintenance, which creates opportunities to plan the work of building technicians in an efficient way.[151]

Moreover, IoT-enabled buildings can alleviate security concerns for both owners and tenants.[152] Real-time monitoring can bolster internal security, and specialized weather sensors provide advance warnings of adverse weather events.

150 Sisab (2015), Acclaimed fibre solution yields environmental gains in 600 schools.
151 Ibid.
152 Kejriwal, S. and S. Mahajan (2016), Smart buildings: How IoT technology aims to add value for real estate companies, Deloitte Center for Financial Services, Deloitte University Press.

The use of smart building management systems that recognize the changing occupancy profile of a building over the day and through the seasons have enabled huge savings to Sisab. Over the past five years, Sisab has invested SEK 100 million in systems and equipment to monitor the indoor climate, including the installation of 7,000 wireless temperature sensors in classrooms and other school premises. The investment has generated savings of SEK 190 million in energy costs during the same period and reduced energy consumption by about 26 % per square metre.**153** Hence, Sisab's total energy target of 180 kWh/m^2 for the year 2020 will be reached soon. In 2016, the energy consumption amounted to 184 kWh/m^2 compared to 192 kWh/m^2 in 2014; this corresponds to 2.4 % and 4.5% reduction of annual energy use respectively.[154] The reduction in energy consumption is based on the Sisab's energy plan which contains several actions with a dozen measures and is being updated yearly as the control of energy consumption is improved in each property.

153 Sisab (2015), Acclaimed fibre solution yields environmental gains in 600 schools.
154 Stockholm AB, Årsredovisning 2016, p. 43.

5 Conclusions

The case studies and interviews we have conducted for this report lead us to draw the following conclusions:

- Wholesale only companies were amongst the first to deploy fibre in Europe. In recent years, wholesale only has played an increasing role in driving fibre deployment and competition in areas and countries where traditional telecom providers have been slow or failed to invest in upgrading their networks with fibre, as well as bringing fibre to rural areas in which only one high speed network is viable. Wholesale only initiatives are now present across multiple countries, both rural and urban areas and involving private as well as public investors.

- These initiatives have brought significant benefits to consumers through increased fibre deployment and competition. Competition has come both from incumbents, which have responded with fibre investments of their own, and from the multitude of service and application providers, which have been able to invest and innovate higher up the value chain, safe in the knowledge that their wholesale supplier will not compete with them for customers. The competitive advantages of the wholesale only model have been acknowledged in proposals by the Commission to reform the electronic communications Code.

- Wholesale only fibre business models have also unlocked additional capital as they can be attractive to long term infrastructure investors, who would not otherwise invest in integrated telecom companies. Such investors generally view the wholesale only network as an essential infrastructure. A key attraction of the model for these investors is to use multiple service providers to support demand. Wholesale only fibre investments have been found to deliver attractive returns for investors, compared with other essential infrastructures.

- Going forwards, fibre will be required not just to support broadband for homes and businesses, but also for the development of 5G networks, which require an increase in fibre-connected base stations and the Internet of Things. The role that fibre will play in supporting the wider needs of public institutions and industry as an ‘infrastructure for society’ is recognized in the Commission’s Communication on Connectivity for a Gigabit Society.

- Neutral wholesale only suppliers could play an important role in meeting these needs, by providing an open platform for innovation across multiple industries and the public sector in the years to come.