European Commission

Guide to High-Speed Broadband Investment

The guide is the result of a joint effort of four experts in broadband:
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as well as the contribution from the regions involved into the Engage Project[1] (High Speed Broadband for Rural Europe).

The document is meant to be updated over time with information on technologies, policy initiatives and new regulatory provisions as well as new models of investment and successful projects that achieve the highest socio-economic impact. The latest release of this guide is available online at the European Broadband Portal[2].

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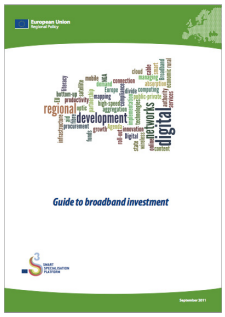

The present guide replaces the previously published European Commission's ***Guide to Broadband Investment***, 2011.

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PREFACE

Over the last decade or so, our social, economic, cultural and political interactions have become mediated through ICT networks, services and technologies.

Paraphrasing Thomas Jefferson famous quotation that "information is the currency of democracies", today the increasing channelling of information into communication networks is turning them into the "synapses", and collectively, into "the nervous system" of our modern democracies and economies. Indeed, access and use of these networks have become increasingly important for the lives of citizens of modern democracies that even their most basic necessities, such as education, health care, transport, electricity etc. have become more and more dependent on the well-functioning, the reach and access to ICT networks.

However, the effects of ICT networks differ depending on the way they are exploited by individual users and organisations. One of the latest quarterly report on the Euro area[3] highlights that it is just these differences in the exploitation of ICT that are primarily responsible for the gaps in productivity across the world and that ICT represents "a significant driver of growing internal euro area divergences in the post-1995 period".

The inclusion of the Digital Agenda for Europe (DAE) as an EU flagship initiative is a clear evidence that the Europe 2020 strategy has recognised the role of ICT in the achievement of the objectives of smart, sustainable and inclusive growth.

In 2013 the "basic broadband for all" target set up in the DAE[4] has been reached through a mix of terrestrial fixed and wireless as well as satellite technologies.[5]

Next DAE broadband targets for 2020 are 100% coverage of 30 Mbps internet and 50% penetration of 100Mbps service in the EU.

Although the bulk of the investment needed to meet these ambitious targets is expected to be undertaken by private operators, public funding will be required in areas affected by market failure.

Given this background, it should come as no surprise if more and more regions and rural authorities are increasingly viewing open access to a good quality and affordable communication network infrastructure as an integral part of the their policy responsibility towards their citizens and the territory they administer.

Investing in ICT networks and services has become a critical element for the efficient delivery of good quality public services, preventing depopulation and relocation of economic activity, promoting social and economic development and increasing cultural and political participation.

This guide to broadband investment aims to assist public authorities in finding their own path to investment by posing appropriate questions about a set of critical decisions, highlighting their implications, at each step of the way to full high speed broadband coverage.

Guido Acchioni, Broadband Unit, DG Connect

INTRODUCTION

Local and regional public authorities have a crucial role to play in the deployment of Next Generation Networks (NGN) both in rural and urban areas. This guide is a tool to support you in your role as a local or regional public authority in making choices about critical issues and assist you in planning their investments in line with relevant policy objectives and regulation. In this chapter, we introduce the key concepts of broadband networks, the motives for network upgrade, the roles of the market and the public sector, and give an overview of the European policy and regulation context.

Why this guide?

First generation broadband has had a large and measurable impact on the European society and on the way that business is conducted; consumers can access services, public services can be delivered more efficiently and SMEs can reach global markets in ways that were hitherto unimaginable, or simply unaffordable.

To ensure that Europe remains competitive in the global economy it is important that the underlying communication infrastructure is upgraded so that all citizens, businesses and public services can benefit from the development of new digital applications and services.

Local and regional public authorities and the public sector in general have a crucial role to play in the deployment of this new communication infrastructure. This guide is a tool to support you in as a public authority in defining their role and plan their effort.

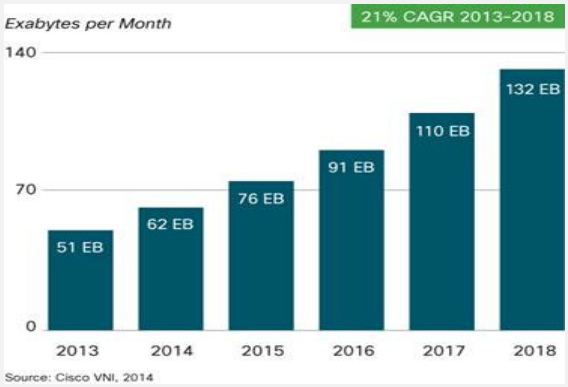
The goal of the guide is not to provide ready-to-apply recipes on how you should go about investing in broadband in its region or municipality. It rather aims to assist the public authorities in formulating the important questions, and to provide the conceptual tools and the information needed to make the right decisions matching their needs.

The document guides you through the steps of producing a broadband plan, making the appropriate strategic choices for their territories and implementing the plan so that the Next Generation Network (NGN) infrastructure for society is deployed. It highlights the important strategic choices that need to be made in terms of investment models, infrastructure type, business models and financing tools.

It also presents important issues like citizen involvement, collaboration with market actors, coordination between different units within the public authority and with neighbouring municipalities and regions, monitoring and evaluation, etc.

Increase in data traffic

Based on current trends, data traffic is expected to grow significantly in the coming years. The graph below is an estimate[6] on the evolution of the total data traffic in exabyte per month (1 EB = 1 million TB, or terabytes, see info box on page 20 for more on bytes and bits).



Why move from basic broadband to NGN broadband infrastructure?

When the existing telecom networks were built, the process was mostly driven by monopolistic and state-owned telephone companies to deliver the telephony service. Towards the end of the last century, these networks (and in some cases TV-

distribution networks) started being used for data services.

Initially synonymous with the *"Internet"*, these digital have evolved rapidly and today's so-called broadband networks carry a plethora of services of all types, both of commercial and societal interest. Individuals, enterprises, organisations and the public sector are increasingly not just users but also producers of digital information. And it is not only people that are connected: machine-to-machine (M2M) communications is driving the information society to a stage where everything is connected. The vast amount of data generated, (so called "Big Data") is both a great opportunity in terms of new services, improved safety and increased quality of life, but also a challenge in terms of managing the traffic by a digital communications infrastructure.

As more information services and tools are developed and greater volumes of data are transmitted, advanced communications networks are required to meet the need for speed, capacity, quality and reliability. While until recently fixed networks could be built using existing copper infrastructure, bandwidth demand from users and providers is quickly reaching a point when a new generation of digital communications infrastructure will be needed, in which optical fibre is brought closer and closer to the end-user and supports a wide range of fixed and wireless technologies.

The three layers of a broadband network

A broadband network consists of a **passive infrastructure** (ducts, cables, masts, premises) and **active equipment component** implementing the technology (transponders, routers and switches, control and management servers). On top of that, **services** are delivered.

Similarly to other types of infrastructures (like roads, power lines, water distribution pipes, etc.) broadband passive infrastructure is typically characterised by high capital expenditure (CAPEX), low operational expenditure (OPEX), low economies of scale, stable returns from low rates over a long period, and is highly local, hard to duplicate and inherently subject to regulation because it most often constitutes a natural

Basic versus next-generation broadband

There is often a great deal of confusion when it comes to broadband, Internet and next generation network. A broadband connection is the channel over which digital data services such as Internet, digital TV, IP-telephony, security and e-health, etc.) can be delivered. Broadband connections can be classified as follows (ordered in increasing quality):

- **Dial-up connections**: this type of connection was introduced on the mass market in the 1990's. It involved accessing the regular PSTN phone line and a modem whenever one wants to connect to the Internet (during which time the phone line is busy); connection speeds are typically up to 128 kb/s (or 0.1 Mb/s).
- **First generation** always-on **broadband connections:** the ones most common in Europe today. They can be achieved using telephone lines, coax cables for TV distribution, satellite dishes, or wireless connections (see below). These connections (mostly ADSL) are typically asymmetric: the download speed is typically a few Mb/s while the upload speed is below 1 Mb/s. The DAE targeted 100% broadband coverage by 2013.
- **Next generation network (NGN) broadband connections**: these are connections becoming common in the many parts of Europe. Like basic broadband, they can be achieved on most transmission media, but their speed typically ranges between 30 Mb/s and 100 Mb/s. They are most often asymmetric and special conditions need be satisfied for them to work on traditional infrastructure (typically distance of the user from the first aggregation node, number of users sharing the line, and the installation of advanced equipment in the first aggregation node). The DAE targets 100% fast broadband coverage (>30 Mb/s) over the whole EU by 2020.
- **High Speed NGN broadband connections**: these are connections with speeds above 100 Mb/s, often 1 Gb/s is taken as typical speed. They typically require dedicated fibre connections to the home or the building (FTTH/FTTB) with other types of infrastructures playing little role so far.

Services	e-health, elderly care, (connected) TV, Internet, phone, video-conferencing, entertainment, teleworking, e-gov, e-education, e- commerce, smart monitoring, internet of things, cloud computing, etc.		
Active equipment	Switches/routers, data centres	Switches/routers, p2p microwave equipment	Switches, DSLAMS, DOCSIS, radio base stations
Passive infrastructure	Fibre	Fibre, antenna sites	Fibre, copper, antenna sites

monopoly. On the other hand, technology (active equipment) is characterised by high OPEX, economies of scale and is subject to limited regulation.

Moreover, infrastructure is a permanent asset (once the cables are deployed they have an economic life that can be measured in decades), whereas active equipment is subject to fast obsolescence due to the rapid technological development and to the electronics aging (currently, typically below 10 years).

Passive infrastructure represents today the most critical bottleneck in the process of upgrading and deploying a Next Generation Networks. It is in this area that the public authorities have a crucial role to play.

Your role vis-à-vis the market

Most of the investment in high-speed broadband is related to passive physical infrastructure. The task essentially involves civil engineering works such as digging trenches, holes, laying duct and fibre, or running new fibre overhead: this phase is highly capital intensive and is characterised by long payback periods[7]. Being so capital-intensive, it is considered as a natural monopoly.

Private investment in new broadband infrastructure in "white" areas constitutes a challenge because of:

- **High risks** - infrastructure deployment outside urban/high income areas by private sector operators or resulting from public-private co-operation, are perceived as high risk investment, which requires a higher return on investment
- **Longer pay-back periods**, incompatible with the short-term return horizons of service providers and telecom operators (especially if public companies);
- **Insufficient size**: promoters may be too small to attract the interest of large financial institutions or to attract cheap financing;
- **Lack of evidence** substantiating the viability of the business model – broadband is still an emerging asset class as opposed to transport and energy sectors (especially in non-urban areas.
- **Open wholesale access** may be imposed by ex-ante regulation (for incumbents only);

White, grey and black areas

Your area is classified according to its existing or expected future NGN broadband infrastructure deployment status, thereby defining the market situation both for basic and for NGN broadband networks. Your area may therefore be:

- A **white area** if no NGN broadband network is currently present or planned to be operational within the coming three years; in this case, state aid may be allowed.
- A **grey area** if there is only one NGN broadband network being operational (or planned to be so within the coming three years); in this case, your area could be eligible for state aid but a more detailed analysis will be necessary.
- A **black area** if there are or there will be at least two NGN broadband networks in the next three years; in this case, in the absence of a clearly demonstrated market failure state intervention is not allowed.

That is where your role becomes important. Investment in passive infrastructure may require different level of involvement of the public administration. As public authority you are not only competent for infrastructure planning, for granting permits for "rights of ways" and leverage the fact that it owns ducts, land and buildings (schools, hospitals, etc.). The public sector is, in many instances, the largest single users of broadband services. Moreover, there is an increasing tendency[8] for public authorities that invest in the passive infrastructure, also to establish an operator-neutral network, over which private actors can deliver services.

Operator-neutral networks represent the best precondition to prevent conflict of interests (between the actors operating on the different layers of the network), avoid market monopolies and to facilitate competition in the active layer (which drives new services, better quality, and freedom of choice and lower prices). In your broadband plan, you should make the case for the type of intervention to opt for, why is intervention needed, and at which level.

EU policy and regulatory context

The European Commission has recently adopted several measures and policy proposals aimed at facilitating the deployment of high speed broadband networks:

- a recommendation on consistent non-discrimination obligations[9] and costing methodologies;
- New EU Guidelines for the application of state aid rules in relation to the rapid deployment of broadband networks[10];
- A Commission Regulation (declaring certain categories of aid compatible with the internal market[11] including Aid for broadband infrastructures;
- a directive on EU rules for cutting the cost of rolling out high-speed Internet[12];
- a proposal for the "Connected Continent" on how to reach European Telecom Single Market.

The regulatory context and policy initiatives are expected to increase the role of private investment in the financing an estimated total investment of €250 billion[13] required to achieve the EU NGN 2020 objectives.

However, even in the rosiest scenarios, most rural, remote areas and less developed regions with lower income and education levels are likely to require some form of public investment following a range of investment models.

The European Structural and Investment Funds (ESIF) for 2014-2020[14] have identified ICT as one of four Thematic Objectives for thematic concentration of the European Regional Development fund (ERDF) which will support the deployment of Next Generation Networks in all type of regions.

The Rural Development fund (EAFRD) will also play a key role in rural areas with the financing of both small and large projects[15]. EAFRD's legal basis see in fact broadband as public goods and basic services (see Art. 20 of 1305/13) in rural areas available to a very wide public[16].

The 2014-2020 regulation also establishes that access to EU funds to support the deployment of ICT will require a prior fulfilment of two **ex-ante conditionalities:**

- The first requires the formulation of a digital growth strategy to finance measures on services and to support demand.
- The second ex-ante conditionality requires the development of an NGN plan for measures to support high speed and very high speed networks.

For the fulfilment of these two conditions please refer to sections A.2-1 and A.2-3 of the Guidance to the fulfilment of the ex-ante conditionalities[17] available on the *Inforegio website*[18].

The structure of the guide

The guide is structured along six chapters, and a number of appendices, which explore specific issues in more detail.

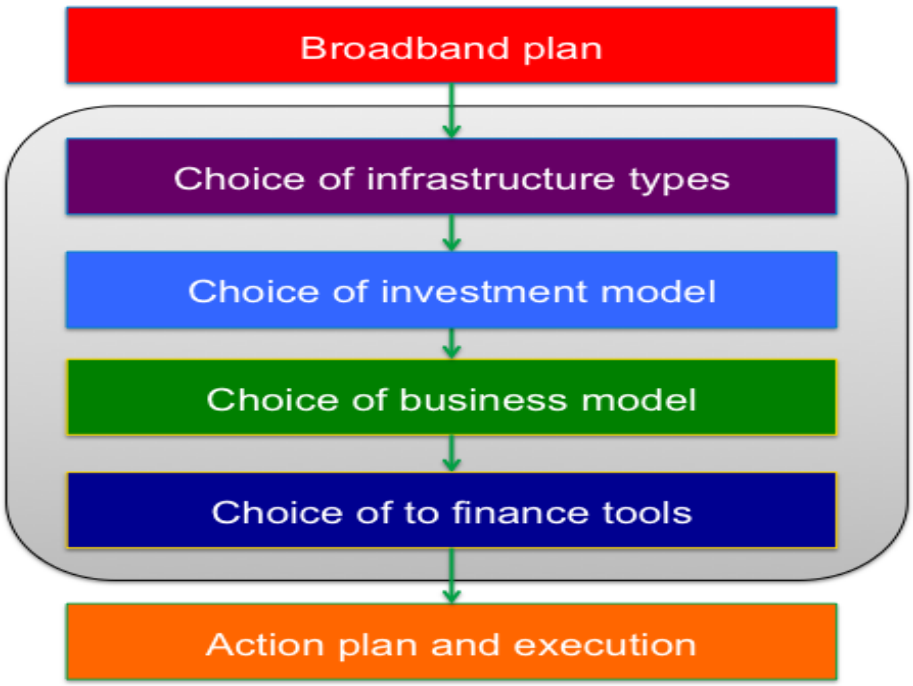
The first chapter introduces the importance of defining a **broadband plan**, which is the high level strategy of what a public authority planning the intervention wants to achieve. A sound broadband plan is a politically supported document containing an analysis (including mapping) of the current situation, the goals to be achieved, the financial support and a mechanism on how to implement it.

The ensuing four chapters present the four key strategy choices that need to be made in order to achieve the goals defined in the broadband plan. These four choices are:

1. Choice of the **infrastructure type**.
   Do the Public Administration aim at deploying a new future-proof broadband infrastructure or would it be sufficient to upgrade the existing infrastructure, considering the pros and cons of the two choices?
2. Choice of the **investment model**.
   What role does the public authority want to play with respect to the implementation, operation, ownership and management of the infrastructure?
3. Choice of the **business model**.
   Should the public authority opt for a vertically integrated or an open-access network model? Which one is most likely to maximise the financial sustainability of the project, broadband coverage and penetration (also beyond an individual project), promote competition and, most importantly, the socio-economic development of the affected community?
4. Choice of the **financing tools**.
   How can the public authority ensure an adequate financial coverage for building and operating the new infrastructure and what can it contribute in terms of capital, expenditure and assets?

Once these choices are made, an **action plan** needs to be defined and executed, and the process must be monitored closely to ensure that the goals are achieved. This will be tackled in the last chapter.

Finally a **check-list** is provided to keep track of all the steps to be taken and all the aspects to be covered during the whole process.



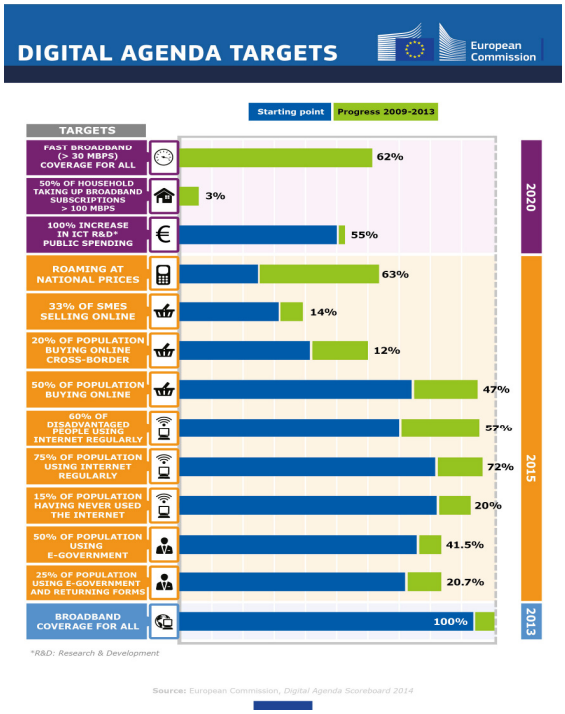
The first step in the process is to define a politically supported local/regional broadband plan. An effective broadband plan should clarify how broadband investment will help to achieve the objectives of the overall local/regional development programme. This chapter gives an overview of the questions that you should consider when writing a broadband plan.

Policy context

For your broadband investment to be successful it is essential that you define a broadband plan which is in line with the overall European, national and local digital development policy.

At EU level, the Digital Agenda for Europe (DAE) sets the overall policy goals to 2020. National and regional policy makers are called to plan investment in order to support the main objectives of regional or rural development policy. Planning broadband in these domains would typically include considerations about:

- How NGN broadband infrastructure can help to leapfrog development, speed up innovation and learning, underpin business start-ups and growth, not only for the digital sector, but also across all across other sectors of the economy.
- The role of NGN in closing the gaps in social, economic and territorial cohesion to ensure equal access services to all areas and population sectors (broadband access is becoming as important as access to other utilities like water and electricity);
- The reform of public administration and the transformation of public services to deliver greater efficiencies and better quality, and speed up innovation in all sectors from education, to health, research, agriculture, manufacturing, energy efficiency, environment, tourism, culture, etc.;
- The prevention economic activity relocation, and the departure of young people, help raise business productivity, and facilitate product and service innovation;
- The need to ensure that citizens can benefit fully from the new digital services and that as few as possible suffer from digital exclusion.



We move towards a society where not only people and organisations, but ever more devices are connected online. Next generation broadband has an impact on other policy agendas including the development of smart cities, smart rural areas, new approaches to telemedicine and telecare and education/training, the development of energy smart grids and smart metering systems, etc.

To identify how and where to intervene, you need to answer these basic questions:

- What are the social and economic development objectives of the region in the next 10 to 20 years?
- How does high-speed broadband fit into those overall objectives and how can it contribute to its achievement?
- What are the needs for services based on high speed broadband among the socio-economic actors in the regions?

- What are the problems to overcome for the rapid deployment and for facilitating usage of high speed broadband in my region?
- Which benefits will broadband create for residents located in the different areas of the region (urban, rural and more sparsely populated areas) and for society at large in terms of economic growth, business development, employment, tourism, education, culture and leisure etc.?

The questions above point to the need for the public authority to carry out an in-depth analysis of the current socio-economic context to map the current situation, verify citizens and business demand, and sustain these needs through a healthy competitive market in high speed broadband services.

Mapping the current situation and the investment need

Your broadband plan should include a market and infrastructure analysis of your region's broadband situation. Mapping enables you to identify the areas for intervention[19] and establish the likely costs. These are some of the key questions that should be answered:

- What are the socio-economic, demographic features of the territory?
- Which are the public services to be delivered (exclusively) online in the coming 5-15 years?
- What are the current coverage, quality and price of broadband access[20]?
- What coverage of NGN broadband will our region most likely achieve commercially, if no intervention is made?
- How credible are these plans for private investment for the next three years? Which is the demand for services required by the household and enterprises?
- How strong is competition for broadband services in the region? Is it delivering good quality and affordable services as required by the territory?
- What publicly owned infrastructure – particularly ducts, fibre and other "passive" elements – can be brought into the mix?
- What other utility infrastructure – e.g. energy distribution – could be reused to save cost of investment[21]?
- What role can local communities play in aggregating demand and contributing to investment?
- Are there community or private-sector-led "bottom up" initiatives emerging in the region?

One of the key elements of any business case for infrastructure deployment is **consumer and business demand** and one of the drivers of demand is a healthy **competition** in services. National regulatory authorities[22] gather relevant statistics and can play a key role in assessing the current situation for retail competition, local loop unbundling and services offered by the different providers.

The analysis of the socio-economic and demographic features of the territory (income, education, ICT skills, ageing structure, large presence of micro enterprises/SMEs, etc.) can also help to provide a first picture of the potential demand for services. However, a more realistic mapping of demand can best be obtained through the direct involvement of the local population and businesses.

Defining the goals

The broadband plan[23] should define concrete goals for broadband coverage in the municipality or region, for instance:

- What percentage of the population shall need to be covered by high-speed broadband in the year 2020?
- What is the percentage in terms of household penetration (actual subscriptions) I wish to achieve by 2020?
- What is the quality of the infrastructure (the downstream and upstream *actual* speeds, latency, downtime, etc.) to put in place capable to support the combination of services required in the territory in the next 5-15 years?
- Is this quality in line with the Digital Agenda for Europe 2020 targets?
- What other measures should I put in place to sustain demand?
- How upgradable shall the new infrastructure be towards longer-term goals (e.g. within the next 10-20 years)?

Identifying stakeholders and establishing collaboration

There are many stakeholders involved in a broadband project. A broadband plan that creates the right conditions and incentives for all the relevant stakeholders to participate in the project will be able to better leverage on the resources, competence and assets present in the region and ultimately will have higher chances to be a success.

Some stakeholders (e.g. financial and institutional partners) are key to enable the successful deployment of the infrastructure, others (operators) to "switch on" the network, and others (service providers) to deliver communications, entairtainment and societal services. Other important stakeholders (citizen associations, local businesses, housing companies etc.) are critical in ensuring take-up, i.e. that these services are indeed used and the NGN network economically sustainable.

Important stakeholders can be found in the private sector, and the project will increase significantly its success chances by making them business partners:

- Other companies owning infrastructure (especially fibre, or last mile connections to the end user);
- Operators and service providers interested in selling services over the network;
- Network providers interested in placing active equipment in all the nodes and to deliver those services (see page 27);
- Other telecom companies willing to lease the dark fibre, e.g. 3G/4G operators, cable TV operators, service providers, and any other operator needing backhauling;
- Non-telecom companies wishing to lease dark fibre for their own needs (banks, large corporations, TV production companies, etc.);

There are then important stakeholders requiring access to end-users to deliver social benefit through advanced social ICT services; these stakeholders could are also among the largest potential customers of the new broadband network. These include:

- Hospitals;
- Schools;
- Elderly and social housing companies/associations;
- Police, security/safety; militaries;
- Emergency services;
- Utilities;
- Public administration authorities and offices.

The broadband plan should define how the public sector can include its own demand for services and thus act as an "***anchor tenant"*** to reduce demand risks in the short/medium term (while waiting that demands pick up over the medium/long term).

Extremely crucial to the successful engagement of the local population is the involvement of stakeholders with direct access to private end-users (e.g. property ownership or associations):

- Public and private housing companies and property owners (with rental apartments);
- Multi-dwelling unit (MDU) co-operatives
- Single house owners;

Support in drafting the broadband plan

Neighbouring municipalities and regions can be a source of inspiration for your broadband plan. It is important that the broadband plan is designed to suit your territory, but others' plans and strategies can serve as precious sources of inspiration.

Contact and collaborate with your neighbours (also across your country borders). Regional collaboration in broadband planning and deployment lead to important benefits, both in terms of size (economies of scale, achieving contractual power, standardised business and technical interfaces) and in terms of mutual in support (on the practical work on the plan and on the action plan).

Get input from public sources. Use the information that is available publicly (e.g. your national regulatory authority, national and European associations of local authorities, relevant government entities responsible for broadband and digital growth, as well as non-governmental organisations.

Consult and visit the websites of local organisations, business associations and consumer organizations and citizens groups to verify the needs from their respective communities.

Consulting support from relevant and unbiased experts is also advised.

- Broadband cooperatives;
- Business/Farmers Associations;
- Chambers of commerce.

Finally, institutional stakeholders obviously play an important role in terms of regulation and support:

- The political and administration officers at local level
- Neighbouring municipalities and regions, which are precious sources of collaboration and inspiration
- National government
- National Telecoms regulators
- EU regulators and grant bodies.

It is important that you take responsibility for the project and act as the "glue" between the stakeholders.

Aggregating and federating with other municipalities and regions

A federation (or close collaboration) of small municipal and regional networks could give rise to a bigger player, capillary infrastructure assets, with a single point of contact towards the market and higher contractual power. An integrated infrastructure would make it easier to lease out fibre (long continuous links can be offered rather than short unconnected sections), hence increasing revenue potentials.

When it comes to attracting operators onto the network, a network federation would make it easier to connect to major data and interconnection centres in the large cities, where operators can then obtain connectivity to all the networks in the "**federation**", hence reducing the risk of having an "empty network", and instead increasing competition at service level.

Moreover, many administrative and management operations (including sales and marketing) could be centralised in order to optimise resources, streamline operations and ensure quality. A good example of this is found in e.g. Norrsken in Sweden.

Next steps: four strategy choices

Having considered the overall socio-economic picture, the broadband endowment and the policy context for your region, you have the information needed to decide between the various commercial and investment options for your intervention to have best effect. Four strategy choices on four different levels need to be made:

1. Choice of the **infrastructure type**.
2. Choice of the **investment model**.
3. Choice of the **business model**.
4. Choice of the **financing mix**.

These are explored in more details in the four following chapters.

Of the three network layers presented in the introduction, the passive infrastructure layer often represents the bottleneck for broadband development and also the most suited layer for intervention by a public administration or public authority. This chapter helps to distinguish the concepts of infrastructure, technology, and network design. It gives an overview of the different infrastructure types, and provides a rough guide on how to plan for an infrastructure deployment in the different parts of a municipality or region.

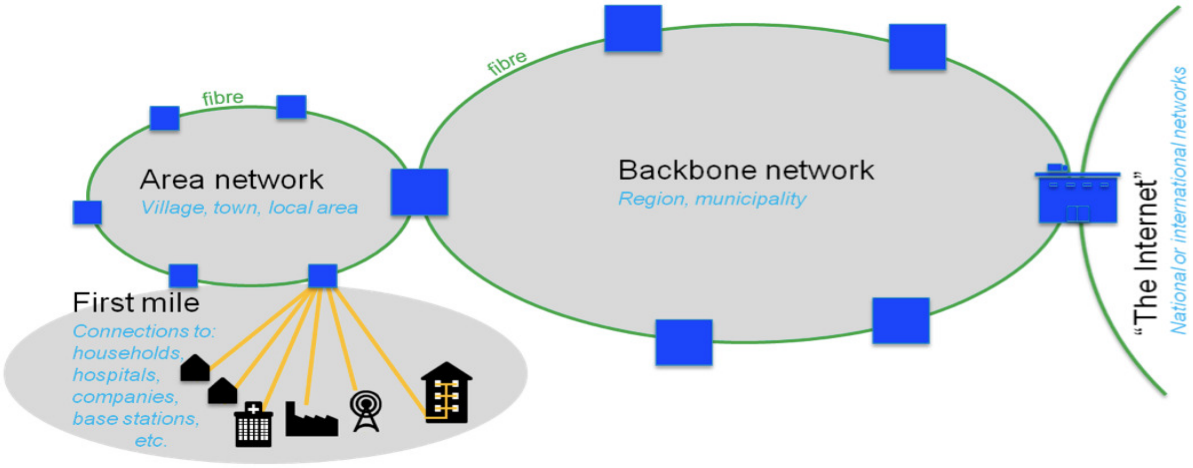
Geographical parts of a broadband network (horizontal dimension)

A broadband access network is generally made up of three distinct parts: the *backbone network*, the *area networks (aka backhaul)*, and the *first-mile connections* to the end-users.

The **first mile-connections** are the links from the end users (which may be single homes, multi-dwelling units, companies, hospitals, schools, local administration offices, radio base station sites, etc.) to the *access nodes* (AN) where the first traffic aggregation takes place.

The **area networks** connect several AN aggregating the local traffic further up in the network. This is also often done with a ring of optical fibre cable, although tree topologies can be used (generally cheaper, but less robust). If a relatively low number of end-users are to be connected in the area and funds are limited, microwave links may be used as a short- to medium-term solution.

The **backbone network** generally consists of a ring of fibre optic cable (one cable contains several, even hundreds of optical fibres) connecting different areas of the municipality or region. It is here where all the traffic from all users in the region/municipality is aggregated.



Infrastructure vs. technology

One common source of misunderstanding is the confusion of these closely related but fundamentally distinct concepts:

- **Infrastructure** is the physical medium over which information can be transmitted. This can be a twisted pair of copper wires (traditionally used for telephony), coaxial cables (traditionally used for TV distribution within buildings), optical fibres (traditionally used for transmission of very large amount of data over very long distances), or antenna towers and sites if transmission is done wirelessly (e.g. for radio and satellite transmission). Infrastructure typically has a life span >50 years.
- **Technology** is what enables us to transmit information over the infrastructure. In practical terms, it refers to the active equipment needed to encode the information into physical signals to be sent over the cables/ether (the infrastructure). Active equipment typically has a life span 5-15 years.

Each infrastructure type has specific physical properties, which define a sort of upper limit for connection speed. The performance of a broadband connection is the result of how effectively the physical properties of an infrastructure are used by a specific technology. Think infrastructure as a road and technology as car and you are close enough.

As we will see in the Business Model chapter (on page 27), the distinction between infrastructure and technology also has important market and business implications, suggesting different roles for public authorities and for market players.

Infrastructure types

There are mainly five types of physical (passive) infrastructure that can be deployed to deliver broadband services:

- Optical fibre lines, consisting of cables of glass fibre currently used in most long-haul, high-speed communications systems.
- Copper phone lines: Legacy telephone unshielded twisted pair cables
- Copper “cable”: TV-distribution coaxial cables

Network infrastructure topologies

The topology of a networnk describes how the different parts of a network are connected. The most relevant topologies for the backbone and area networks are:

- **Tree**: the traffic from each element is aggregated upwards in a hierarchical manner; A tree topology is generally cheaper, but less robust: in case of a fibre cut or other fault certain parts of the network will be disconnected for long periods of time; moreover for each step up the hierarchy, traffic originating from more nodes shares the same physical connection
- **Ring**: each network element is connected to two elements in such a way that all connections form a ring. The ring topology has the advantage that any node is connected to two neighbouring nodes (this is sometimes referred as “redundancy”), so if a fibre cut or other fault occurs, traffic can be rerouted the other way often automatically, while the fault is repaired.
- **Meshed**: each network element is connected to several other elements; this is the most robust but also most complex and most expensive topology.

For the first mile, two main basic topologies:

- **Point-to-multipoint** (**p2mp**): the first aggregation node is transmitting information to a number of end-users over the same shared medium, using one transmitter. This take place both in wireless communications but also in wired communications, if the physical medium is simply split along the way between the aggregation node and the end users (e.g. fibre point-to-multipoint used in PON, or coax cable TV networks): in this case the same physical signal is received by all end users, which are then sharing the bandwidth.
- **Point-to-point** (**p2p**): the first aggregation node is transmitting information to a number of end-users over dedicated physical channels, using a corresponding number of transmitters. In wireless communications this can be achieved if the communication beams do not overlap with each other (radio links), while in wired communications a dedicated line connect the aggregation node with each end user (e.g. fibre point-to-point, and telephone lines)

Infrastructure	Current commercial technology (now)		Fundamental properties of physical medium (future)		
	Top technology	Data rate (down/up)	Shared medium in 1st mile?	Available bandwidth	Basic transmission reach
wired					
Fibre p2p	GbE	1/1 Gb/s	No	50 000.00 GHz	80 km
Fibre p2mp (PON)	GPON	up to 2.5/1.2 Gb/s	Yes	50 000.00 GHz	20 – 45 km *(32 – 8 users)*
Coaxial cable	DOCSIS 3	up to 300/50 Mb/s	Yes	1.00 GHz	0.5 – 3.0 km *(high – low speed)*
Twisted pair	VDSL2	up to 60/10 Mb/s	No	0.05 GHz	0.2 – 1.5 km *(high – low speed)*
wireless					
Terrestrial wireless	LTE	up to 60/10 Mb/s	Yes	0.10 GHz	*several km*
Satellite	Ka-band systems	up to 20/8 Mb/s	Yes	10.00 GHz	--

Source: Acreo Swedish ICT

- Antenna sites/towers for terrestrial wireless communications: point-to-point (p2p) microwave, or point-to-multipoint (m2mp) radio
- Satellite dishes (once a satellite is built and launched, generally by commercial actors, no local network is needed, but more costly active equipment is required)

The table below shows the two most basic physical properties of different infrastructure types (physical media): the available bandwidth (following our metaphor: how broad a road is), and the attenuation loss, expressed as distance after which the signal attenuates to 0.1% of the initial power (in our metaphor: how smooth the road is). There is an enormous fundamental difference between traditional infrastructure (such as coax and twisted pair), and fibre.

Choosing the right infrastructure type for the backbone and area networks

A regional **backbone network** generally consists of a ring of fibre optic cable (one cable contains several, even hundreds of optical fibres) connecting different areas of the municipality or region. The ring topology has the advantage to be robust against single fibre cuts or other faults (see info box on page 17). More advanced topologies (e.g. meshed) are sometimes used in the backbone section of the network.

The **area networks** are also often implemented with a ring of optical fibre cable, although tree topologies can be used. If funds available for the moment are very limited the total end-users to be connected in the area are relatively few, microwave links may be used as a short- to medium-term solution.

Choosing the right infrastructure type for first-mile connections

The optimal infrastructure choice for **the first-mile connections** is the subject of heated debate and the advocates of different solutions are often driven by partisan commercial motives. What we can say is that each situation will present different logistic, economic, demographic conditions, and hence different infrastructure solutions may be best suited.

Fibre: FTTH/FTTB… and FTTC? and FTTx?

Sometimes, the term FTTx is used as a catch-all but confusing term to describe any infrastructure that contains fibre at least in some portion of the access network. Let's make some clarity.

When the fibre reaches the end-user's home or apartment, we speak of fibre-to-the-home (FTTH);

When the fibre only reaches e.g. the basement of a Multi Dwelling Unit (like in a block of flats) and from there each apartment is connected by a dedicated non-fibre in-building network (generally owned by the property owner) we speak of fibre-to-the-building (FTTB).

This can be seen as a first-mile infrastructure if the MDU is seen as the end-customer and the tenants share the connection.

Fibre-to-the-Cabinet (FTTC) refers to the situation in which fibre is used to connect a cabinet to which copper first-mile connections (generally operator-owned) are terminated. Hence FTTC is not a first-mile infrastructure.

Although a **fibre connection (FTTH/FTTB)** is reputed to be the ultimate long-term solution a mix of infrastructures can help to satisfy different requirements. The final solution will depend on the level of ambition of the region, the type/number of services required by the territory, and whether a state-of-the art infrastructure could help to substantially increase the attractiveness of the area to business and individuals alike. The solutions available are listed below, while their pros and cons are summarised in the table at the end of this chapter.

The infrastructure most commonly used in the early phase of broadband is **legacy telephone unshielded copper twisted pair**, over which technologies, such as ADSL, have been successful in providing basic broadband connections in the past decade or so. This solution has the advantage

that a copper telephone line is already present in most households. For it to be able to carry fast (or in some cases even basic) broadband connections, however, it often needs to be upgraded and this is not always possible. For short distances (few hundred metres) and good copper lines, VDSL technology can deliver fast broadband today.

A second infrastructure option for first-mile connections is represented by **coaxial cables**, typically used for TV distribution within buildings and in some urban areas also connecting buildings to a TV distribution network. Technology has slightly more room to deliver higher broadband speeds than on telephone lines. Fast broadband is becoming available on many cable-TV networks, and if infrastructure is properly upgraded and distances kept short (tens or few hundreds of metres) ultra-fast speeds may become possible in the short-medium term.

Whenever the upgrade of the wired infrastructure is not possible, and funds for FTTB/FTTH are not available for a certain area, an option is to build infrastructure for terrestrial **wireless** broadband, mainly **antenna sites for point-to-multipoint** connections. WiMax, Wi-Fi, but also 4G/LTE solutions) have the advantage that no first mile infrastructure needs to be deployed except for the antenna sites. These also have the potential to cover areas in which telephone lines are too long, or too bad quality to be used for xDSL.

Satellite connections can be used to cover large, very sparsely populated areas. Satellite connections do not need to use the regional backbone and the area networks, but require the purchase of end-user equipment. See also Guide to the implementation of a satellite vouchers scheme[24].

What FTTH/FTTB: PON or Ethernet point-to-point

In general Ethernet p2p has the advantage of using dedicated connections to deliver very high speeds using cheap standard electronics, while Passive Optical Network (PON) has the advantage of having considerably smaller footprint (i.e. requiring less physical space) at the aggregation node and much fewer fibres to deal with at the aggregation node. However, these are technology choices and as such are best left to the network provider, or the operators dealing with active equipment and service provisioning. Economic, strategic and historical considerations often determine the choice. As a rule of thumb, incumbents and large operators tend to prefer PON, while independent service providers tend to prefer Active Optical Network (AON).

The type of topology chosen for the passive infrastructure, however, has an influence on the degree of choice. Specifically, a p2p infrastructure may be used to deploy both PON and Ethernet point-to-point, whereas a p2mp infrastructure is only suitable for PON.

The cost of deploying p2p tends to be marginally more expensive than p2mp (which less fibre between the aggregation node and the splitter) so it should in general be preferred. On the other hand, situations may exist in which deploying more fibre is indeed significantly more expensive (for instance in the case of an existing duct with enough capacity for only one of few fibres).

Issues concerning quality and affordability of service often make satellite and wireless as complementary rather than alternative infrastructures, even though in specific circumstances (e.g.: very remote/mountainous areas) this may be the only viable alternative.

Some questions that should be answered when choosing the first-mile infrastructure to use are:

- What is the existing infrastructure available: can it be upgraded to reach the DAE goals for 2020? What about the longer perspective?
- Is the connection to the end-user upgradeable?
- Is the owner of the existing infrastructure interested in collaboration?
- Is the main goal for the public authority to reach the DAE goals for 2020 at minimum cost today (and review the infrastructure in ten years), or do we aim at a future-proof infrastructure?
- What are the needs of the territory in terms of type and quality of service (upload, download speeds, contention, monthly data capacity, etc.)?
- Does the infrastructure provide services that are affordable to the population and business of the area?
- Is there sufficient funding for future-proof infrastructure?
- Are there users in remote or sparsely remote areas?
- How do we plan for the longer-term upgrade of interim-solutions?

Data rate, contention, latency and symmetry

Information is measured in binary units, called bits (b).

The **data rate** expresses how much information is transmitted per second and is usually measured in millions of bits per second (megabit per second), or Mb/s. 1,000 Mb/s = 1Gb/s (gigabit per second)*. Data rate is what is commonly (though somewhat inaccurately) **referred to as connection speed**.

By contention it is meant that information transmitted from/to different users must share the same physical medium. This may lead to situations in which the total available bandwidth must be shared among many active users, and hence the **actual connection speed** the end users see may drop significantly below the **"up to" speed advertised by operators**. Another factor significantly the actual speed below the "up to" advertised speed is the length of the fist-mile connection, most significantly in copper lines.

Latency is the time it takes for a data transfer to start. Some applications are "time-critical" and require low data rates, but very fast response times. Examples of applications with stringent latency requirements are stock-exchange data transfer, gaming and video conferencing.

Connection **symmetry** expresses the **upload/download** ratio. While entertainment services like TV and video-on-demand only require high download speeds, others require high upload speeds as well: e.g. cloud computing, video conferencing, social media, certain eHealth and e-education applications, internet of things, etc.

*Note that, due to historic reasons, information storage is measured in basic units of byte (symbol: capital B), whereby 1 byte = 8 bits. Hence file sizes as well as storage capacity in electronic devices are expressed in megabytes (MB) or gigabytes (GB).

First-mile infrastructure	Pros	Cons
FTTH/FTTB (benchmark)	Future proof, extremely high level of service, symmetry.	High investment in passive infrastructure
Telephone copper line	Relatively low investment needed for passive infrastructure Least disruptive for the end users	High (download) speeds depend on the length of copper line, the number of users, the type of applications, the amount of data traffic and the technology used. New copper-based technologies (e.g.: vectoring, G.fast) can deliver high speeds but suffer from the same limitations[25]. xDSL technology is heavily asymmetrical: upload speeds are generally much lower than download speeds: this may hamper new services like cloud computing, videoconferencing, teleworking, tele-presence, etc. Higher investment needed in active equipment (with a life-time of 5-10 years). Interim solution: investment in fibre infrastructure most likely only postponed by 10-15 years.
Coaxial copper line	Relatively low investment needed for passive infrastructure Least disruptive for the end users	Bandwidth shared among several users: peak traffic periods of the day will reduce the available bandwidth for each user The impossibility of unbundling makes service competition basically absent in the cable market. Seldom present in the digital-divide areas Interim solution: investment in fibre infrastructure most likely only postponed by 10-15 years
Antenna sites for wireless	First mile wire connections not needed. Infrastructure can be used for commercial mobile services as well	Bandwidth shared among several users: peak traffic periods of the day will reduce the available bandwidth for each user. Signal strength decreases fast with distance, and affected by weather. Bad weather and disturbed line-of-sight may reduce signal quality Interim solution: investment in fibre infrastructure may be needed within 10-15 years.
Satellite dishes	Backbone and area networks not needed: low investment needed for passive infrastructure[26]. Easy to connect users scattered over a relatively large area (regional, macro-regional or even national)	Limited total number of users can be covered in one region Inherently high signal latency due to the propagation time to and from satellite: this hampers certain applications Relatively high cost of end-user active equipment. Bad weather and limited line-of-sight may reduce signal quality Data consumption typically capped monthly or daily in current commercial offers

There are different ways for a public authority to become involved in the broadband development of a region. In this chapter we will review four major investment models and the role that the public authority takes in each of them. The choice of one model over another is a political decision based on the cultural and socio-economic situation, the ambition level of the public authority, and the medium and long-term development goals for the region.

Four investment models

A fundamental choice you need to make is how much to commit, and what role to take vis-à-vis the market, the citizens, and the businesses in the region. This should be considered separately from the public authority's role in deciding on the best financial resources (see page 32). Four investment models can be identified:

- Direct investment: the **publicly run municipal network model** (also known as Public DBO, though it can include PPP elements)
- Indirect investment: the **privately run municipal network model** (also known as public outsourcing, or concession model)
- Support of community-led initiatives: **the Community broadband model**
- **Operator subsidy** (also known as gap-funding or private DBO)

The four models are described in more detail below and have been employed in different areas across Europe, often in different parts of the network (see info box on page 16), and with different levels of success. Please note that a municipal network refers to a network typically delivered within the jurisdiction of the public authority adopting the model, whether a municipality, county or region. In all cases, it is built specifically to deliver broadband to that area.

As we will see in the following chapters, once you have chosen the investment model and your role in the deployment and operation of the NGN broadband infrastructure, important choices need to be made over three dimensions: the **infrastructure type**, the **business model**, and the **financing model** (each described in detail in the following three chapters). Of course, the degree of influence you will have in these choices depends on the role you have chosen to take, as described below.

The publicly run Municipal Network model

In the publicly run Municipal Network model, the public authority builds a broadband network in the municipality, county or region, hence is it sometimes referred to as public design, build and operate (public DBO), although this may take place in collaboration with the market as a public-private partnership (PPP). What defines the model is that the deployment is run and directly controlled by the public authority. For this, a company or a dedicated division within an existing utility typically needs to be established. This entity deploys the network either directly, or through standard procurement to the market (civil engineering and network deployment companies, not telecom operators).

The public authority keeps ownership of the network and runs operation and maintenance (mostly at passive but sometimes even at active layer). The network is then generally made available to all market actors under fair and non-discriminatory conditions (at the passive or active layer, depending on the business model chosen, see page 27).

Municipal networks: built with tax money?

People tend to associate broadband investment run or driven by public authorities with taxpayers' money. As a matter of fact, this is often a minor part of the total financing.

The prime example is probably the City of Stockholm's fibre project, one of the most successful and widely known examples of publicly owned and operated broadband network in the world. The only public money used by the City of Stockholm was the 50,000 SEK (roughly €5,500) to register the Stokab company, which is in charge of the fibre deployment and operation. The rest of the money came from bank loans, and revenues from dark fibre lease.

When a PPP is used (which is advisable in case a private actor already owns key infrastructure and is willing to make it available to the project), a new company is typically set up as a public-private joint venture. This new company will then integrate existing public and private infrastructure (typically through indefeasible right of use (IRU) or shorter term concessions from the public and private owners) and operate in a similar way to the publicly owned company described above. Care should be taken in dealing with public financing and state-aid aspects (see info boxes on state aid on page 34 and 35).

The public-run municipal network model is very common in the Nordic countries (from Stockholm to Suupohja in rural Finland) and has led to very successful deployments, in terms of coverage, service availability, end-user sign up, competition levels, and financial sustainability. The Southern Swedish region of Skånet has followed a PPP-enabled version of this model, leveraging on the presence of a private actor with extensive fibre backbone and willing to collaborate.

The privately run Municipal Network model

In the privately run Municipal Network model, the public authority procures the building and operation of a broadband network in the municipality, county or region from a private actor. This is sometimes referred to as public outsourcing, or concession model.

In this model, there is no need for a dedicated company being established by the PA, and the competence required, as well as the financial risks taken, are rather limited. The contracted private firm generally builds an open, operator-neutral network over which competing service providers can deliver their services to all end users. The public authority keeps ownership of the passive infrastructure but the operation contract with the external firm is typically in the form of indefeasible right of use (IRU) of e.g. twenty years. In order to guarantee fair and non-discriminatory conditions to all service providers (operator neutrality), the private firm building and operating the network should ideally be barred from delivering its own services, although this is not always the case, mainly due to the scarcity of operator-neutral network providers and of independent service providers (see page 27) in certain member states, as well as low awareness of this possibility.

The contracted firm commits the investment (often complemented with significant public financing) and takes all the revenues as well as the business risks for the whole contract period. A the end of the contract, the network infrastructure remains with the public authority, which may then decide to renew the contract, to sign a contract with another company, or even change its involvement altogether, and adopt a public-run Municipal Network model.

This involvement type is becoming relatively common in continental Europe (e.g. in the Nièvre rural county in France or in the Piedmont region in Italy); though most projects are still at a relatively early stage.

The Community Broadband model

In the community broadband model, the broadband investment is done as a private initiative by the local residents, in a so-called bottom-up approach. Projects employing this type of involvement have generally been very successful in driving the take-up rate among the end users and in building financially sustainable cases. The degree of competition varies between projects: many are using an open network business model (see page27) with good levels of competition; others prefer to act as vertically integrated

operators, or to procure services from one operator for a number of years.

The role of the public authority in this case is to provide support if and where needed. This may take the form of co-financing (using one the tools described in the financing tool chapter on page 32), but also of advising, right-of-way (RoW) granting, regulation and coordination with other infrastructure deployments and access to public infrastructure and points of presence (and as major data centres) to provide backhaul connections. Public authorities can also play the important role of the honest broker that helps in establishing the fair conditions for all operators seeking access to the infrastructure.

Member states may already have national guides, as well as financing programmes or incentive schemes that make shares in enterprises like this more tax-efficient for investors. It is recommended that every region produce a guide on how to start a cooperative for broadband deployment, based on the local pre-conditions and support financial tools available.

A vibrant sector of broadband co-operatives and small private initiatives has grown up notably in the Nordic countries, the Netherlands and parts of the UK. In some cases community-led networks bring broadband infrastructure and services in the first-mile and local area and connect to e.g. municipal networks for backhauling (network parts were described on page 16). In other cases these networks extend over the backbone as well and connect directly to a data centre with access to national and international networks, such as in some Finnish regions.

Village networks in Sweden

Broadband in the countryside in Sweden has grown really fast thanks to a model developed by the government's broadband commission, the national regulatory authority, and the agriculture ministry. Areas that earlier have been classified to be impossible to have "true" broadband are now connected with FTTH. Behind this is a concept, a movement, called "fibre to the farm".

With great engagement and their own personal work, citizens in villages have built fibre networks in sparsely populated areas. These projects are initiated by individuals, the municipality, other organisations or even an operator. Generally, the inhabitants form a cooperative which builds the area network and the first mile connections to their homes and farms. The network is then connected to an operator's network to get the services. Because the major part of the costs is represented by digging, the network deployment is coordinated with other civil works, in order to reduce the cost.

For the project to succeed it is important that the villagers support with voluntary workforce. In most of the villages several people have a digging machine, everyone gives permits to dig their land share the costs among all the connected. Some financial support is normally available from the EC, and by local funding. Hundreds of villages have built networks in Sweden and that has built up considerable experience on how to do that.

The Operator subsidy model

In the Operator subsidy model, the public authority decides not to become directly involved with the broadband deployment in the region, limiting itself to subsidising one market actor (typically a major telecom operator) to upgrade its own infrastructure. Risks associated with building new infrastructure and attracting sufficient customers are borne by the recipients of the funding.

Incumbent telecommunications operators and large alternative providers usually own both the passive infrastructure, active equipment and offer services to end users in a "vertically integrated" model (as described on page 30).

In the operator subsidy model, the public authority funds the gap between what is commercially viable and the coverage that the public authority aims to

achieve. In this case the funding is offered as a grant to one or more private operators to deliver the desired outcome (see more on page 34).

Using an operator subsidy model does not automatically mean that the recipient will be an incumbent operator. However since the model is likely to be based on the incumbent's financial "gap" and where often the incumbent is the only operator with existing passive infrastructure in the region, there is a substantial advantage in any competitive procurement.

One advantage for the public authority is the comparatively simple contractual arrangements and thus the potential for relatively rapid deployment. Another potential advantage is offsetting the risks to the grant recipient since the public authority has no direct involvement in the network deployment. However the drawback is that the public authority does not obtain financial returns from the project that can be reinvested in future network deployment. Instead, new funding will likely become necessary at each deployment phase, ending up with a larger public investment than initially intended.

Some of the concerns with the operator subsidy model revolve around the extent to which procurement can be made genuinely competitive and demonstrate value for money for the public authority. Regulating conditions[27] that provide access to existing passive and active infrastructure for alternative providers can reduce the automatic incumbent advantage. Working to reduce the demand risks can also be beneficial – e.g. by public sector commitment to use the new infrastructure and by ensuring that third party SPs have easy access to the new infrastructure with low transaction costs[28].

Choosing the model

The choice of one model over another is a decision based on the budgetary and socio-economic context of the area, your ambition level, and the development goals for the region. For instance, inability to use or to afford ICT (due to ageing, low education, low ICT skills, presence of many SMEs/micro enterprises and a poor culture of innovation) may slow down penetration and, consequently, also penetration of ICT.

Such contexts would, in most instances, be able to sustain best long term investment models that allow enough time for penetration to growth and consequently for a gradual socio-economic impact to take effect. Furthermore, since most of the benefits of an NGN infrastructure accrue mostly to the overall society and economy, short term investment models are unlikely to match the medium-long term development perspective implicit in both regional and rural development policies.

The investment model adopted in a project can also significantly influence future investment. A model that involves providing grant funding to meet the commercial gap for an operator may achieve short term results and require less funding than a direct involvement model. However, it is also much less likely to create an engine for sustained future investment than a model that involves the reinvestment of profits to enlarge coverage. This may well result to be more expensive over the longer term particularly where large areas (with even lower level of population density) remain uncovered.

Some questions that a public authority will need to answer in the choice of the investment model are:

- How can we create an engine that ensures future investment in infrastructure beyond the immediate project and funding available?
- Are there benefits in keeping control and ownership of the passive infrastructure and in defining the deployment priorities?
- Would we rather be better off keeping the ownership of the infrastructure but let an operator define and execute the deployment?
- What are the pros and cons to involve vertically integrated operators (incumbents

and others) to upgrade or expand the network?

- Do we also see scope to support local bottom-up citizen initiatives?
- Given the socio-economic conditions on the ground, which level of competition is required to facilitate penetration of high quality and affordable services?

The table below summarises strengths and weaknesses of the four models.

	Degree of neutrality between whosaler and retailer	**Transfer of financial risk to market actors**	**Revenue generation for network expansion**	**Control over project**	**Availability of an infrastructure for society**
Public-run Mun. Net	High	Low	Potentially high	High	High
Private-run Mun. Net	Medium	Low	Medium	Medium	Medium
Community broadband	Medium	Low	Medium	Low	Medium
Operator subsidy	Low	High	Low	Low	Low

This chapter describes the different business models available to public authorities and other market actors. The business model defines the roles and responsibilities of different actors in the broadband value chain, with special focus on the public authority. The chapter is opened by a brief definition of the three main business roles, and the different actors in the value chain.

Network layers and business roles

As outlined in the introduction, a broadband network broadly consists of a **passive infrastructure** (ducts, cables, masts, premises), and **active equipment** (implementing the technology: transponders, routers and switches, control and management servers). On top of that, **services** are delivered. The three layers are characterised by different technical and economical features. Three main business roles can be identified:

- the **physical infrastructure provider (PIP)**, which owns and maintains the passive infrastructure;
- the **network provider (NP)** which operates (and typically owns) the active equipment (incumbent operators, new independent operators, broadband companies)
- the **service provider (SP)** which delivers the digital services (e-health, elderly care, TV, Internet, phone, video-conferencing, entertainment, teleworking, smart monitoring, etc.)

Basic business models

Depending on which market actors take up which roles (PIP, NP, SP), different business models arise. If one market actor takes all three roles, it is said to be vertically integrated, and the resulting business model is referred to as:

- a vertically integrated model (all large telecom operators)

In some cases, especially if the vertically-integrated actor is deemed to have significant market power (SMP), regulation imposes that network access be opened to competitors, either at the passive or the active layer, as discussed in the section below. In that case, the network owner designs the network

Actors in the broadband value chain

The basic roles of PIP, NP and SP can be taken by different stakeholders or actors.

The **backbone PIP** owns and operates the passive infrastructure in backbone and to some extent in the area networks. It can be a public or private actor with long-term investment plans or, in some cases, a local cooperative.

The **access area PIP** owns and operates the first-mile connections and to some extent also the passive infrastructure in area networks. It can be a telecom operator, a housing association, a local cooperative, the MDU owners, the municipality or the home owners also with long-term interests in the area.

The **service providers (SP)** can be small or large companies, either locally or nationally, selling services to the end users over an NP's connectivity network. They only need to place equipment in a central location (e.g. the regional data centre) and interface to the NP's equipment.

The **network provider (NP)** leases dark fibre from the PIP to offer SP connectivity to the end users. It places equipment in all access nodes to which any of its end-users are connected. In the PLOM model, some NP's may offer their own services (possibly in addition to those from other SP's): they are then referred to as **integrated NP+SP**, or **infrastructure-less operators**.

The **end user** may be a private citizen, a small or large company, a hospital, a school, a public administration, etc., who is purchasing services over the network.

The **wholesale customers** are entities who lease dark fibre from the backbone PIP, or connectivity from the NP for their own communications needs. These can be 3G/4G operators, cable TV operators, banks, large enterprises, the public sector, etc.

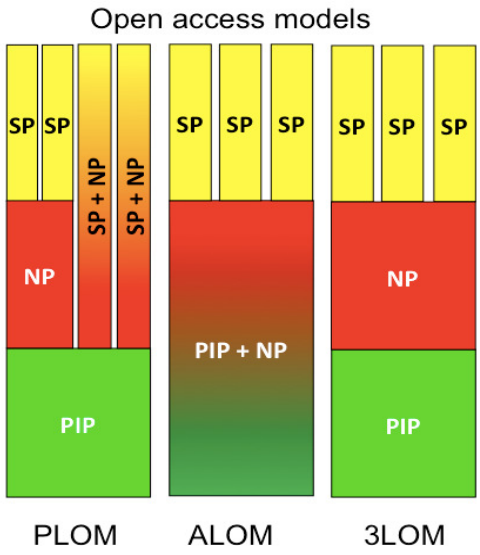
to deliver its own services and gives access to its competitors in forms compatible with the network design. Although sometimes incumbents refer to this model as “open access”, this is in reality a vertically integrated model with unbundling (either at physical layer, called local loop unbundling (LLU), or at the active layer, called bitstream access), see figure below.

If, on the other hand, the roles are separated, we talk of an open network model. In an open network the infrastructure that is available to all market participants at equal conditions. This can take different forms, depending on whether the network owner (e.g. a PA, a cooperative, or a private firm running a municipal network) operates at PIP level alone, or also at the NP level. If the network owner is only involved at the PIP level, it has two further choices: it may decide to leave the higher layers to market players (competition in the market), or it may decide to contract the NP role to one market actor for a number of years (competition for the market) (typically three to five), with the task of providing end-user connectivity to competing service providers.

Consequently, three open network business models can be identified:

- Passive-layer open model (**PLOM**)
- Active-layer open model (**ALOM**)
- Three-layer open model (**3LOM**)

In all these models, if enough fibre has been installed, fibre in the backbone network is generally leased to third parties (such as 3G/4G operators, cable TV operators, service providers, as well as non-telecom companies like banks, TV production companies, large corporations, etc.), independent on whether competition in the retail market (first mile connections) is at the passive (PLOM) or active layer (3LOM or ALOMs). This maximises the return on the fibre investment: the major cost in fibre deployment is not the fibre cable per se, but rather the civil works to install it, hence tens or hundreds of parallel fibres are usually deployed. Moreover, it directly or indirectly increases infrastructure-owner revenue, which can be reinvested for network expansion.



In the figure in next page, the generic value chain for the open network model is shown. This will actually look slightly different in each of the three variations, but all can be described referring to the same figure.

The next three sections describe the three open network models in more detail. The subsequent section gives an overview of the vertically integrated model because of its prevalence among large telcos.

Passive-layer open model (PLOM)

In this model, an entity (e.g. the PA, a local cooperative, or a private investor, depending on the investment model chosen) builds and operates passive infrastructure to be made available to all market actors under fair and non-discriminatory conditions. This entity deploys the passive infrastructure either directly, or through standard procurement to the market (civil engineering and network deployment companies, not telecom operators). The PIP keeps ownership of the passive infrastructure and runs operation and maintenance.

In such a model, the broadband network is open at the passive layer and competing operators (integrated NP+SP, or open-access NP selling connectivity to service providers) get access to the end users through physical connections directly.

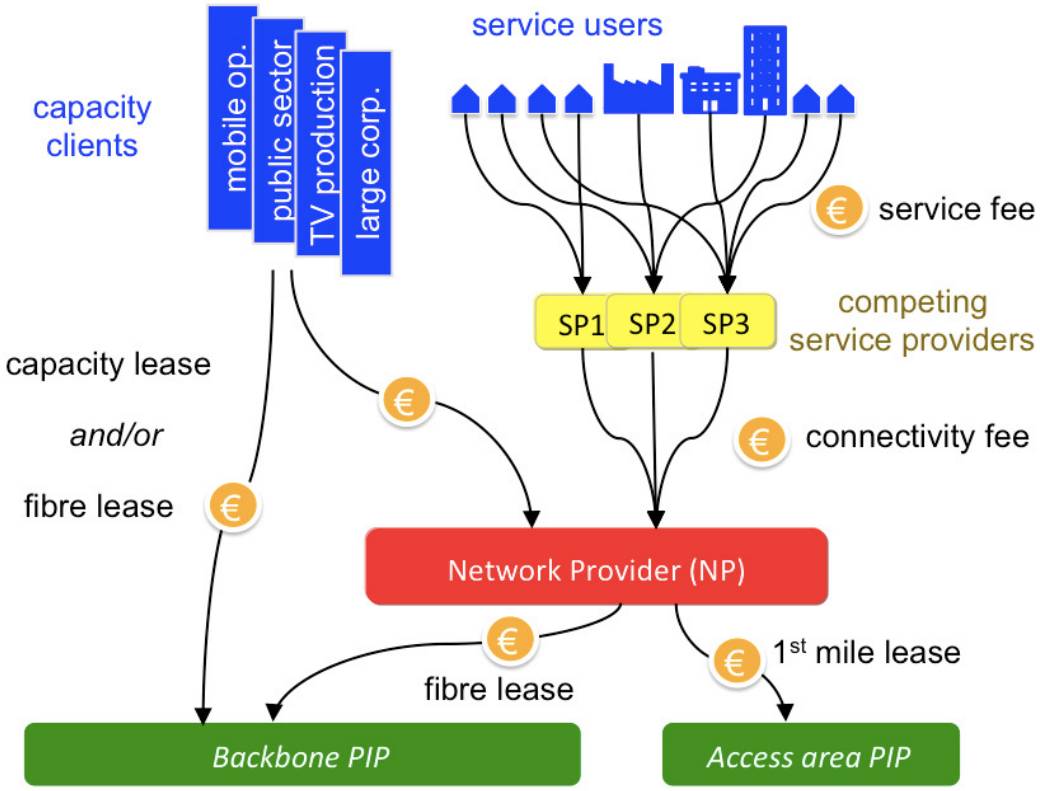
Generally, we can distinguish between backbone PIP (connecting the different parts of the region, county or municipality) and the local area PIP (delivering first-mile and sometimes area network). In some areas, the same entity takes both roles.

Referring to the figure, the NP and SP roles may be integrated in some operators, while other SPs may prefer to rely on the connectivity services provided by network providers active in the market. The backbone PIP receives revenue from operators, who lease dark fibre to deliver their services (or those from their customers) to the local areas. Here they lease passive connections (fibre, copper, or simply antenna sites and wireless frequency bands) from the access area PIP to deliver services to the end users. End users may or may not pay a fee for that. Like in all other open-network models, the end users choose the services from their operator of choice for a service fee. The access-area PIP may receive revenue from the end users in form of a (one-off) connection fee and/or a monthly network fee (in some cases included in the monthly rent as an extra housing service, the same way as a lift or other common area maintenance).

The PLOM has the advantage of giving operators maximum freedom and control in the design of their access network. The drawback is that in this model, each competing operator needs to deploy active equipment in the access node of each area they want to serve (unless a sharing agreement is reached): if the population density is too low, each access node only aggregates a low number of users making it economically not viable to have more than one operator in each area. This reduces competition and keeps OPEX and CAPEX costs high. Hence the passive-layer open model is best suited for relatively large and densely populated areas, e.g. larger cities.

The solution which many Public authorities have taken in more sparsely-populated areas is either 3LOM, or ALOM, in which competition between service providers is achieved by offering network openness at the active level, so that network cost (network design, active equipment acquisitions & deployment as well as network operation & maintenance) is low enough to encourage market entry.

The PLOM is typically used by public-run municipal networks in large cities, in which the public authority takes the backbone PIP role. A prominent example is the Stockholm fibre network.



Active-layer open model (ALOM)

In this model, one entity deploys and operates the passive and active layer (hence acting as an integrated PIP+NP). This entity places active equipment in all access nodes and builds an open, operator-neutral network over which all service providers can deliver their services to all end users.

The value chain for the ALOM, as shown on page 28, sees the backbone PIP and NP roles joined. The backbone NP+PIP receives revenue from service providers to deliver their services to the end users (or, in some cases, receives revenue directly from end-users), through its backbone network and onto the first mile connections (fibre, copper, or simply wireless frequency bands), which it leases from the access area PIP, and for which it may or may not pay a fee. Again, the end users choose the services from their operator of choice for a service fee. In a variation of this model, the network fee is paid directly to the PIP+NP. In both cases, like in the PLOM, the access-area PIP may receive revenue from the end users.

Three-layer open model (3LOM)

In the so-called three-layer open model, the roles of PIP, NP and SP are explicitly separated. In this case the public authority has the same role as in the PLOM, but at the active layer, the NP role is assigned by procurement to one company (or possibly to one company per geographic area). The NP places active equipment in all access nodes and builds an open, operator-neutral network over which all service providers can deliver their services to all end users. In order to guarantee fair and non-discriminatory conditions to all SP (operator neutrality), the NP is typically barred from delivering its own services.

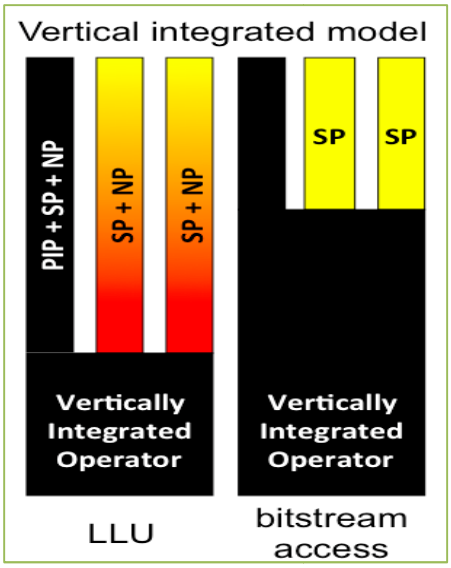
The typical value chain for the 3LOM is shown in the figure on page 29. The backbone PIP receives revenue from the NP for dark-fibre lease. In order to reach the end-users, the NP also leases passive connections (fibre, copper or simply wireless frequency bands) from the access area PIP to deliver services to the end users. Again, the end users choose the services from their operator of choice and pay a service fee. The service fee from the end user to the SP generally includes a network fee, which is then passed to the NP.

In a variation of this model, the network fee is paid directly to the NP. The access-area PIP may receive revenue from the end users in form of a (one-off) connection fee to the PIP and/or a monthly network fee.

Vertically integrated model

Incumbent telecommunications operators (and to some extent large alternative operators) usually own the passive and active infrastructure and offer services to end users in a “vertically integrated” model. There are variants where the operator offers access to competing service providers at the wholesale level. There have been many instances where public authorities have built broadband networks following vertically integrated models. This was indeed not uncommon in the pioneering years of municipal networks (e.g. in Scandinavia). The model has however been progressively abandoned in favour of 3LOM or public run ALOM, This change was mainly due to the conditionality of public financial support but also in the realisation that some roles are more effectively taken by the market.

If the – as typically is the case of an incumbent – the vertical opearator has *significant market power* (SMP), or if it has received public funding, network access to its competitors is normally mandated, either at the physical layer (*local loop unbundling*



or LLU) or at the active layer (this is generally referred to as *bit stream*). In the former case, competing operators can place their equipment in the access nodes of the areas they want to serve, provided there is physical space for their equipment. In the latter, they place their network equipment in a data centre, where they can interface with the network owner. The latest copper upgrade solutions, such as FTTC+VDSL (see info box on page 18) may be incompatible with local-loop physical unbundling in cases where there is lack of space for competitor operators' equipment in the street cabinets, or if vectoring is used[29]. However, virtual unbundling can be provided in an increasing number of technologies provided certain conditions are respected[30].

Choosing the business model

The table below shows how different business models can be applied to each investment model. Depending on its level of involvement, a public authority will have more or less say in the definition of the business model.

Demographic, commercial and cultural conditions also play a role in the adoption of one or another model. In general, a business model which allows for a win-win situation for all stakeholders (including the end users, the local businesses, and the service providers, as well as the incumbent) will increase a project's chance of success. Some of the questions that should be asked are:

- How densely populated is the region? How is the population distributed?
- Is the physical infrastructure allowing for easy end-user access at physical layer for a number of operators? Is the market big enough to make this business case (PLOM)?
- Is significant amount of infrastructure owned by an operator already active as a service provider? What business model is it operating?
- Is there enough technical competetnce within the public authority to take up the NP role? Are there sufficient economies of scale?
- Are there market actors interested in taking up the NP role?

BUSINESS MODEL

INVESTMENT MODEL	PLOM	ALOM	3LOM	Vertically Integrated
Publicly-run Municipal Netw.	Ownership: PA • PIP: PA • NP: Open market • SP: open market	Ownership: PA • PIP: public authority • NP: PA • SP: open market	Ownership: PA • PIP: PA • NP: market by proc. (3-5y) • SP: open market	
Privately-run Municipal Netw.		Ownership: PA • PIP: market by proc. (IRU 20 y) • NP: market by proc. (IRU 20 y) • SP: open market		Ownership: PA • PIP: market by proc. (IRU 20 y) • NP: market by proc. (IRU 20 y) • SP: market by proc. (IRU 20 y) and LLUB/bitstream access
Operator subsidy		Ownership: telco JV • PIP: owners • NP: owners • SP: owners + open market		Ownership: telco • PIP: owner • NP: owner • SP: owner + LLUB/bit. acc.
Coop support		Ownership: coop/investors • PIP: owner/market by proc. • NP: owner/market by proc. • SP: open market	Ownership: coop/investors • PIP: owner • NP: market by proc. • SP: open market	Ownership: coop/investors • PIP: owner/market by proc. • NP: owner/market by proc. • SP: owner/market by proc.

HOW TO FINANCE THE PROJECT?

This chapter describes the different financing models available to a public authority wishing to invest in a broadband project. The financing model defines how the deployment, operation and management of the broadband network can be financed by public and private funds. The chapter also includes considerations on state-aid, especially in the case of public-private co-investment.

Different tools

A PA can finance a broadband project in many different ways. Typically a mix of financing tools is used. In the following sections, the main financing tools available are presented:

- **Revenue-based financing**: self-financing through the re-investment of revenues from network connection fees, fees to service and network providers, dark fibre rental revenues, etc.
- **Private capital and financial markets**: Equity and debt raised on the financial markets (corporate financing), as well as equity and debt contributed by the partners in a joint ventures (project finance)
- **Government-backed bank loan and bonds** (guarantees)
- **Public funds**: soft loans, project bonds, grants, sovereign funds
- **Bottom-up community financing**: from the end users, or local associations

Revenue-based financing

If the public authority chooses a public-run municipal network investment model (see page 22), it generally receives revenue from wholesale dark fibre lease and/or transmission services, as well as retail infrastructure lease or connectivity fees (or network fees) depending on the business model in place (see page 27). This can indeed become a major financing source, when the network is complete and companies, public bodies and end users start using it.

Most notably, the City of Stockholm currently raises around €20 million in revenue per year from

operators and companies using the fibre infrastructure, while the London Borough of Hammersmith & Fulham is currently tendering a Concession Agreement for the use of their CCTV ducts in order to encourage commercial broadband across its area.

Of course, this source of financing only materialises once the core of the infrastructure is in place and services are being offered over the network. It is therefore suitable to recovering public sector funds, to accelerate infrastructure deployment or lower costs, but to sart the project other sources are neeed.

Private capital and financial markets

Financial markets can be accessed for investment funds. Financial markets provide equity or debt financing, although hybrid solutions (mezzanine funding) are more and more common. Investment funds looking for a stable return on investment may focus on safe, tangible assets such as next-generation broadband infrastructure. These are primarily:

- Project financers such as banks, investment funds and private equity investors may be interested in providing early-stage financing,

looking for a higher risk premium. These equity or debt investors may look for an exit between 3 and 7 years once the business is established as be replaced by other investors looking for a low-risk, long-term returns on their investment

- Infrastructure Funds, Pension Funds and other Institutional Investors may invest in and established infrastructure from the above after 3-7 years and seek long term investment at lower interest rates.

Other sources, such as venture capital, are not normally investing in infrastructure and are likely to be less suitable as they are focused on short-term higher risk opportunities- and demand high interest rates with early exit options as a result.

Government-backed bank loan and bonds

Many public authorities have secured a large portion of their initial financing through soft or commercial-terms bank loans. For this to be sustainable, a valid business plan must be presented (see page 37), in which medium- and long-term revenue exceeds the negotiated loans (principal + interest).

If special conditions (e.g. favourable interest rates in soft loans) are obtained thanks to the government backing guarantee, this should be treated as state-aid. If on the other hand, it can be proved that the loan was received according to market conditions, then the MEIP principle applies[31] (see the info boxes State Aid regulation).

Public funds

Natioanl and European public funds can generally be used to finance the project, subject to any specific conditions that they may be attached to their use.

Grants are focused on enabling economic and social improvement and are available at local, regional and national government levels, as well as at a European Union level through the so called European Structural and Investment Funds [32]. The most notable such fund is the European Regional Development Fund (ERDF), which provides funds to each European Region to trigger business growth. ERDF has a track record of supporting broadband deployment initiatives on a co-financing basis. The co-finance rate varies across the different categories of regions.

Other EU funds that can be used for broadband development are the European Agricultural Fund for Rural Development (EAFRD), and to some extent the European Social Fund (ESF), the Cohesion Fund (CF).

The Connecting Europe Facility (CEF) is a new fund specifically dedicated to the goals of the Digital Agenda for Europe. It has a budget of €1.14 billion, of which €170 million for broadband development.

Grant co-financing can come from other public as well as private sources. Other social enterprise or charitable funds could also provide the matched funding.

Bottom-up community financing

Communities can raise finance to support the development of infrastructure in their areas. Typically this takes place in community broadband projects (see investment models chapter), particularly in isolated rural communities (or clusters of these), but also in smaller urban communities. In general this scheme is more suitable to villages or other communities with strong commitment in bringing broadband to their local area.

Generally, these finance schemes consist of selling “stock” or shares in a community company, which either implements and runs the network themselves, or commissions this through suppliers. In-kind contribution from citizens (in the form of voluntary digging work and equipment) is also often successfully used especially in rural areas.

Citizens are often also asked for a commitment or “pre contract agreements” to take next-generation broadband services once the network is operational as part of the stock package. This has the added benefit of driving early take-up, which significantly strengthens the business case.

It is recommended that every region or member state produce a manual on how local initiatives can manage the bottom up financing and how to match it with other financing tools.

Financing of public-private joint ventures and private-run deployments

Sometimes, private actors owning existing infrastructure are willing to cooperate with the public authority to build a municipal network (public- or private-run). In this case, the investment effort is partly supported by the private actor, which becomes directly involved in the deployment and operation of the CAPEX-intensive passive infrastructure.

This is very attractive to other private investors as it provides greater stability to the equity base of any scheme and may improve the credit rating of the project company or joint venture. This encourages further private investment; in other industry sectors (e.g. construction) patient capital has been able to raise 2 to 5 times the public funds applied.

Equity Finance. In a public-run municipal network, the public authority invests in a commercial entity (which may or may not be co-owned by a private partner) that will build and operate the broadband network. This finance can take the form of:

- Cash or bonds that the entity can use as security;
- Physical assets such as ducts, fibre cables and street furniture such as lamp-posts, equipment cabinets etc.

The authority would receive shares equivalent to the value of the investment in the entity. These must be treated in the same way as any other share paid for by "normal market investors" in the entity alongside the authority. This is an important test of whether the Market Economy Investor Principle (MEIP) applies (see info box on the side). In particular:

- The value of the equity share would increase in value as the value of the assets increases
- The share would attract dividends declared by the entity on any profits achieved.

Debt Finance. The authority can offer finance by providing a loan to the entity. This loan would:

- normally be cash; but could also be
- long term use of assets where the authority retains ownership and title; or
- a guarantee or security against other loans taken out by the entity.

The authority can offer to facilitate this finance with banks on attractive terms to encourage other investment, in the same way as "patient capital" above. As long as the terms and any related interest rate are equivalent to those that would be offered by commercial markets, this finance would not be considered as state aid, as the MEIP would apply[33].

Authorities may assist an entity by offering to facilitate this loan on more favourable terms with banks than the entity might reasonably expect to achieve on open markets. However, this would provide a benefit to the entity and would be considered as state aid.

Grants. An authority may choose to provide an entity with a grant to assist in building and operating the next-generation passive infrastructure and active layer as required by the strategy and necessary level of intervention. This is extensively used in the operator subsidy model.

Measures not constituting State aid

You might focus your activity on specific measures to support broadband deployment in your area which usually are not constituting State aid if[34]:

- you are rolling-out an NGN broadband network for **non-commercial purposes** (i.e. only to satisfy your own needs), under certain circumstances; under this arrangement, however, it becomes very tricky to use the network to connect your citizens (consult your national State aid contact point for further advice);
- you are placing capital, directly or indirectly, at the disposal of an undertaking and such support corresponds to "normal" market conditions (the so-called **Market Economy Investor Principle, MEIP**); in this case you must provide a self-assessment (which raises your risk of a legal challenge in case of a complaint) that your equity participation or capital injection presents sufficient prospects of profitability, even in the long term;

the deployment can be viewed as a **Service of General Economic Interest (SGEI)**; which needs to be approved by the EC; which is one of the most complicated ways to proceed.

As stated above, a grant will always be considered as state aid. It also has the effect of constraining private investment in a scheme. This is because private investors regard the provision of state aid as recognition that market failure exists. This reduces confidence in the returns they could expect from the market in comparison with other opportunities.

The authority can attach a range of conditions and requirements on the provision of the grant, including (but not limited to):

- achieving defined socio-economic outputs that the entity can take responsibility for;
- returning part of the grant if the entity achieves greater than anticipated benefits from the scheme (such as excessive turnover or profits). This is known as "claw back[35]";
- transparency of accounts and performance of the entity in relation to the scheme the grant is provided for.

Other types of support. A region could decide to actively improve demand side conditions e.g. by using "ICT innovation vouchers for SMEs[36], either to cover (part of) the end users' costs of installation or purchase of broadband devices, or of the monthly subscription.

- In case you want to use this instrument you first should check whether you fall under the "de minimis" rule.
- Alternatively, vouchers for SMEs might be block exempted as SME aid or aid to innovative enterprises. If this holds true of your broadband project you are fine because there are no further State aid requirements you need to meet.
- If your support is greater than the "de minimis" threshold of € 200,000 per beneficiary or not block exempted you might, however, fall under the scope of State aid, if indirect aid comes into place. Indirect aid may be the case because the amounts you hand over to e.g. households or SMEs in your area end up with suppliers.
- In cases of extreme remoteness and in very sparsely populated areas, a region may wish to reduce the cost of deployment and arrange vouchers for satellite services:
- In order to be on the safe side you should approach a suitable institution in your country and ask them to check your envisaged measure for legal certainty. A short guide on how to implement this specific type of vouchers scheme is also available (see below).

For further information also see:

- EC blueprint for ICT innovation Vouchers[37]
- ICT Innovation Vouchers Brochure[38]
- Guide to the implementation of a satellite vouchers scheme[39]

Measures constituting State aid but for which no notification is required

Even when the financing of your project constitutes state aid, it will still not require notification if[40]:

- the project fits into a state aid scheme which is already approved; or
- the total amount of grants (cash and in-kind) for the same eligible costs over any period of three fiscal years does not exceed €200,000, or if the total amount of loans is up to €1 million, depending on collateral and duration of the loan (the **"de minimis"** rule);

Moreover, in order to accelerate NGN broadband deployment, a further exemption has been recently introduced:

- The revised **General Block Exemption Regulation (GBER)** [41] exempts from State aid notification aid for broadband infrastructures up to €70 million per project (passive broadband infrastructure, broadband-related civil engineering works, deployment of basic broadband networks and deployment of NGA networks) as long as the investment takes place in white areas, the aid is allocated on the basis of a competitive selection process and the network operator offers the widest possible active and passive wholesale access, including physical unbundling for NGA networks. This also covers risk capital investment in an SME active in broadband deployment.

While the broadband plan defines the overall goals and strategy for the local/regional broadband development, the action plan is a document in which all the different activities are defined and specified. It also contains the cost and revenue estimation in the different phases of the deployment. It specifies the roles and responsibilities of different actors, and how to engage and coordinate the stakeholders, and how to monitor the project execution and outcome. This chapter gives an overview of what should be included in the action plan and some tips on its execution.

The steps to execute the project and the action plan

You have now defined your high level strategy in a politically supported broadband plan, and you have chosen what kind of NGN broadband network you want to build (infrastructure choice), how you want to be involved in the deployment and operation (investment model), how you want different business actors access the network (business model) and how the project shall be financed (financing tools). You now need to take the next steps:

- Mapping of infrastructure needs
- Cost estimate and financial planning
- Deployment planning and procurement preparation
- Procurement/tendering
- Build phase (deployment)
- Network launch and project evaluation.

These phases should be clearly defined in an action plan, which concretely outlines how the project shall be carried out, according to the strategic choices. Parallel to these steps, several important activities need to be defined in the action plan and carried out during the project:

- Continuously monitor and follow the progress
- Coordinate the different stakeholders
- Involve the local population, businesses and the housing sector to stimulate demand; possibly identify a broadband champion
- Define agreements and contracts with NP, SPs, and other users of the network: from mobile operators and media companies to public sector actors such as schools, hospitals and public administration.

Some aspects of these different steps and activities are developed further in the following pages.

Mapping current infrastructure

The broadband plan analyses the current state of broadband infrastructure in detail. The incumbent telecom operators, alternative wire-line or wireless operators and cable providers, as well as public sector organisations and utilities may all have existing infrastructure in the region and this, together with their expansion plans, should be mapped as much as possible in order to fully identify the scope of the problems and any opportunities.

For further information see the results of the EU study on "Mapping of broadband and infrastructures"[42] which review different mapping initiatives and proposes a methodology to conduct the mapping of infrastructure, services, investment and demand.

Note that if any infrastructure owners are brought into the overall plan this will have an impact on the type of investment and business model selected as other business actors possibly become investors in the new infrastructure.

Cost estimate and financial planning

Deployment costs should be estimated in the action plan and matched to the possible customer base: indicative key figures are generally not hard to come by and are good enough at this stage. The technical solution does not differ from ordinary infrastructure deployment and any installation professional can advise on that.

The action plan should also detail how the different financing tools (see page 32) are going to be used, and define the actions to ensure the needed funds are made available.

If you are opting for a direct involvement through the publicly-run municipal network investment model (see page 22), the cost estimate and financing planning will form the core of a **business plan** proper for the project or company being set up to run it, including SWOT analysis, human resources, marketing and sales plan and financial plan.

The directive on cost reduction

The EU Directive on Cost Reduction[43] aims at creating a market for physical infrastructure such as ducts, poles or dark fibre. It requires any network operator to give access to its physical infrastructure for the deployment of NGN broadband networks, upon reasonable request and under fair terms and conditions, including price. In order to enable access to physical infrastructure the following is established:

- Public sector bodies and network operators must provide on request minimum information including a contact point. They must also consent to on-site surveys.
- Any network operator may negotiate coordination of civil works and companies performing civil works fully or partially financed by public means have to meet any reasonable request for coordination of civil works. Planned civil works have to be made public 6 months in advance.
- All relevant information on procedures for granting permits for civil works must be available via a Single Information Point and Member States are encouraged to organise the application for permits by electronic means and any permit decision should be made in general within 4 months.
- All new buildings (and those undergoing major renovations) shall be equipped with physical infrastructure, such as mini-ducts, capable of hosting NGN networks and with an access point, which can be easily accessed (monuments or military buildings may be exempted if a Member State so wishes.)

Note that information about and access to infrastructure is requested at own cost (under fair and non-discriminatory terms and conditions) and may be refused for objective transparent and proportionate reasons such as network security, national defence, public safety or confidentiality. Member States have to appoint one or more independent body/ies to resolve disputes.

Topology and deployment planning

Because municipalities and regions are probably the largest users of broadband in the local market, a plan to connect all buildings with fibre should be made (public administration, healthcare institutes and hospitals, schools, etc.). This generally constitutes the core of the backbone network.

Moreover, since public buildings are generally near other residential and commercial buildings, this will also create good preconditions for the rest of the broadband deployment (area networks and first-mile connections).

You should then make a master plan for the network, so that all parts of the local private market, houses, MDU, business parks and shopping centres are reached. This should result in a mapping of the area and a high-level network design.

Because of the significant civil works implied in broadband deployment, it is important that broadband infrastructure is included when new city planning is produced.

Procurement

Procurement will most likely be a central part of your project. Even in the case of a very direct involvement (e.g. though the publicly-run municipal network model, described on page 22), most practical activities of the network deployment are going to be outsourced to the market, hence proper procurement procedures will need to be put in place.

Procurements can take very different shapes in different member states, and for different investment models, and can be delicate to properly design. Most public authorities, however, are aware of the complexity of procurement and often rely on consultants and procurement specialists on a regular basis.

What you should pay particular attention to is that the procurement is designed in such a way to reach the objectives that you have set out in the broadband plan and that it properly implements the strategic choices. This is generally more delicate in the operator subsidy investment model, where the operator being awarded the grant will directly influence the strategic choices (in particular infrastructure choice, coverage, network access and competition, etc.). Monitoring also becomes more crucial in this case, since there is very direct control over the detailed project execution.

Market awareness is a very important procurement activity: make sure there is proper awareness among the business actors that you think would be most suitable for the investment and business model chosen. For instance, a municipal network model will need an operator-neutral NP: where are these companies located, and how do you reach them?

Also, make sure you build your procurement in such a way that the crucial aspects of your "ideal winner" are given proper weight. For instance, if competition is an important aspect, make sure to include measurable criteria and award points accordingly (e.g. an operator committing not to sell own services guarantees a lack of conflict of interest with its customers and is going to need less price and access regulation than one who is competing with its customers: does your procurement scheme rewards this?).

Procurement size

The issue of size is particularly relevant when an operator subsidy investment model is used which allows the winning bidder to deliver its own services (i.e. vertically integrated business model with LLU or bit stream access).

In such cases, if the procurement call is too large it may risk to have very few potential bidders (often one only) and result in tenders that are poorly competitive. The splitting of procurement in multiple (but still viable) lots, assigned to different providers, may be more appropriate in these cases.

The public authority should consider using expert assistance to produce the specifications and support the procurement.

For further information about the use of EU electronic tendering procedure please consult the Information system for European public procurement[44].

Monitoring

Make sure that the project is properly monitored during execution (use milestones and periodic reviews), and that you put in place tools to evaluate its success.

Indicators that you should consider monitoring (some directly, some indirectly, depending on the role you have decided to take) are:

- **Phyiscal deployment**: ensure the necessary netowork elements (fibre cables, termination electronics, wireless transmitters, satellite ground equipment, etc.) are indeed being deployed;
- **Service availability** on different parts of the network according to schedule;
- **Service quality**, in terms of actual down- and upload data rates, and latency (see page 20);
- **Failure rate**: service or network downtime as notified by customers or discovered by network staff;
- **Maintenance and repair**: ensure that scheduled maintenance and repair takes place;
- **Service and network take-up**: number of new end-user connections activated (residential and business), and amount of fibre and/or capacity leased.

Set out monitoring requirements in the contracts. For instance, in the contract with a network provider (NP), specify the target number of SPs signed up, quality parameters, number of households connected, and a target number of active customers (take-up rate).

Monitoring will allow you to be able to enforce the agreed targets from suppliers and contractors, e.g. by setting penalty payments or by linking payment to specific milestones.

In case of state aid, monitoring is mandated, especially in connection to gap funding to ensure best value for the public money spent, and to possibly invoke the *claw-back* clause (see page 35). Moreover, you should put in place proper monitoring to ensure competition among multiple service providers (and services innovation) over the deployed NGN broadband network. Access (capacity, dark fibre or duct) should be provided to all service providers, without discrimination in terms of time, nor traffic management, or quality of services limitation.

Identify potential customers

If you are building a municipal network (directly or with a commercial partner in PPP or in the case the network is procured to the market through IRU, as described on page 23), your plan should also identify potential customers, not only end users but also future operators and service providers. Mobile evolution (with LTE requiring ever higher data rates to the antenna sites) is expected to drive the need for fibre in the area network and possibly even to some first-mile connections. When a new operator-neutral infrastructure is in place this will support new actors to enter the local market: if infrastructure can be leased, several operators will see a positive business case in delivering services without the need to build their own dedicated infrastructure.

Discussions with service providers and operators should be started early on so they know what is being planned and they can design their sales activities accordingly.

In some regions, a few Service Providers (SPs) dominate the market, controlling a very high percentage of market shares between them. In these situations, the major SPs will have a huge brand presence and profile. This often sets expectations in the minds of consumers, who may think that quality broadband is not available unless at least one of these SPs agrees to provide services over the network. Trying to get these SPs on board should therefore be a prioritised activity in such situations.

In any case, it is important that discussions with possible customers and users of the network take place early on, and that as many contracts and agreements are signed before deployment is started.

Establishing internal and external coordination and collaboration

A broadband investment is a complex project in that it touches all parts of the public authority and of society. Moreover, like any major infrastructure project, it requires coordination of many different activities. It is therefore important to:

- Assign a Coordinator for the broadband plan. Work on a broadband plan has a wider scope

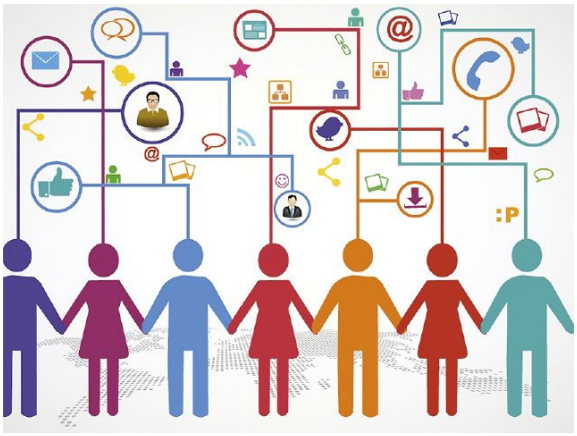
than an IT related issue, and can therefore not be delimited and delegated to the local "IT guy". If you do not have the necessary competence, acquire that by employing a knowledgeable and experienced person to coordinate the different phases and parts of the project.

- Establish coordination between broadband and the upgrading of roads, water and sewerage, electricity, district heating, wind power and other infrastructure with which it is possible to share civil-work costs[45].
- Organise personal interviews and/or workshops with unit managers of your administrative units: the availability of broadband is important for all municipal activities, hence all the public authority administrative units should be involved.

Stakeholder communications and management

Your action plan should include a shareholder communication and management plan. The full engagement and involvement of all the relevant stakeholders (a detailed overview was given on page 14) is essential for a project's success, and you should make sure you consult all of them during the course of the project, and that you give them proper support.

Local residents, businesses and real estate owners are the most important stakeholders to secure demand (see also page 41). You must highlight the PA's profile in this regard and make sure that people can follow and determine how the plan affects different parts of the region and the impact that this is likely to have on society.



The main approach to government agencies is likely to be defined through Service Level Agreements or contracts relating to the provision of funds and/or the commitment to achieving key outputs. There should be formal reporting and meeting arrangements contained in these documents.

You should also seek agreement with construction companies and housing organisations as these often represent the key to the end users. And indeed in many cases these take the role of Access Area PIP.

The main approach to managing relationships with suppliers is through the formal channels established in the various collaboration contracts. These channels should include formal reporting and meeting structures and the frequency of meetings at all relevant levels.

Broadband champion

Citizens and businesses are the stakeholders that generate take-up, utilise services for social improvement and deliver economic benefit to the region. They are also the most unpredictable stakeholder group. Empirical evidence demonstrates that the strongest community engagement is *always* found when it is led and managed from *within the community itself*.

This is best achieved by a Broadband Champion. Some communities have a champion already. In others, the champion has to be found. A champion can be identified through being a person who is:

- already involved in the community, often in another role;
- respected by the community for that role and his/her achievements
- passionate about maintaining the the community "alive"
- frustrated by the lack of broadband and the effect this is having on the community's social and economic life
- a good communicator
- with a good general understanding of broadband

Sometimes, a Broadband Champion can be found among the community's antagonists. These are people who do not believe in the benefits that

arise from a community joining the digital economy. Some of them have many of the characteristics listed above. Awareness, consultation and education activities of the marketing and communication plan (see below) can help them realise these benefits and turn into champions.

However, it is important to remember that while the programme should enable and encourage Champions to learn from each other, they must always stay "rooted" in their community. This is where they add the greatest value and contribute most of everyone to the success of the project.

Marketing and communication plan

In order to ensure consistency across all stakeholders and to maximise take-up (hence the socio-economic impact as well as financial sustainability of the project), you should prepare a marketing and communication plan, and allocate a dedicated resource to implement it and manage it across the entire programme.

The role of marketing the products and services provided over the network is obviously the responsibility of each service provider. However, the public authority has a clear role in:

- raising awareness of the expected economic and social benefits of broadband
- provide an updated map of the broadband availability throughout the rollout of the project
- facilitate demand aggregation from businesses, households and other relevant public authorities

You should also assist in managing the expectations of end-users within the region. Communities can become quickly disillusioned if their expectations are raised too far ahead of availability, which can lead to a significant lack of take-up when NGN broadband is rolled out to them.

The marketing and communication plan must consider the economic and social objectives, anticipated markets, infrastructure roll-out etc., and will most likely include:

- consultations with subsets of the key stakeholders, particularly end-user customers
- benefit awareness days
- "broadband education" events
- scheme and area "launches" throughout the roll-out
- promotions consistent across all media channels
- identification and publication of "success studies" on a regular basis

You can also use all existing communications channels with the population to executing the marketing and communication plan. This will increase the credibility and confidence in the broadband network as well as the SPs using it, and it will strengthen your role as a community leader.

Stimulating demand

The public sector has a significant role in stimulating demand as a major purchaser of services for its own use ("**anchor tenancy**"[46]) as well as potentially procuring the new network. However it also has a responsibility to encourage the development of new services and the establishment of infrastructure. In the long term, using the infrastructure to drive demand in the digital economy is a natural part of regional development and planning and the regional growth.

Local communities can play a very important role in driving demand for new services (and in some cases providing part of the investment needed, as discussed on page 33). There are many examples of successful "bottom up" initiatives developed on a co-operative or private sector basis.

It can sometimes be difficult for smaller local broadband networks to attract a large SP with their own network management system, and limited appetite for small customer gains. Networks should therefore be designed to make it as easy as possible for SPs to interface their systems to and deliver services over them. This can be done by adopting standard business and technical interfaces, and by coordinating and federating with neighbouring municipalities and regions. However, the public authority also has a role to play in encouraging competition by promoting the value of smaller SPs, who may be able to adopt a new

network more easily (and be more willing to do so). This can often accelerate take-up in the early stages, leading to a more sustainable business case.

Decision making

Different levels of involvement (see four investment models on page 16) imply different levels of influence on the decision making on a project.

If the network infrastructure is fully owned by the Public Authority, as in the municipal network models, then the Authority has full control over any decision-making (especially if it even runs the network, either at passive or active layer, as in the public-run municipal network model).

A good approach to take into account the needs of the market is to have a board of public body stakeholders to oversee all decision-making. This approach has the advantage of leveraging private operator expertise to operate the network while retaining overall control within the public sector. This is obviously always the case when the municipality network is built in a private-public joint venture.

Finally, governance can be exercised through alternative methods of influence. This approach may be necessary when the public authority is not directly involved such as in the operator subsidy model, or in the community broadband model. The public authority can still be able to monitor activity on the project, and refer any undesirable outcome to another enforcing body (e.g. the national regulator).

Requirements for revenue-generating operations

For operations which generate net revenue after their completion, the eligible expenditure of the operation to be co-financed from ESI Funds must be reduced in advance, taking into account the potential to generate net revenue over a specific reference period.

Net revenue should be understood as cash inflows directly paid by users for the goods or services provided by the operation, such as charges borne directly by users for the use of infrastructure, sale or rent of land or buildings, or payments for services less any operating costs and replacement costs of short life equipment incurred during the corresponding period.

The potential net revenue of the operation must be determined in advance by either the application of a flat rate net revenue percentage for the sector or sub-sector applicable to the operation (if provided in Annex V of the regulation or a delegated act) or the calculation of the discounted net revenue of the operation by using the method set out in the delegated act[47]. The above provisions do not apply to certain operations e.g. to operations whose total eligible cost before taking into account the potential net revenue does not exceed €1 million or to operations for which support under the programme constitutes compatible State aid.

For major projects, whose total eligible cost exceed €50 million or €75 million as defined in Article 100 of the above regulation, a cost-benefit analysis must be carried out including an economic and a financial analysis, and a risk assessment in order to demonstrate that the major project is worth co-financing from an economic point of view and that it needs co-financing from a financial point of view.

The methodology for cost-benefit analysis of major projects with its key principles is described in the Commission Implementing Regulation (EU) No…/.. In addition, the Commission guide to Cost-Benefit Analysis (last edition published in 2008) is currently being updated and will be available in 2014. It will include specific cost-benefit analysis guidelines for broadband sector and a broadband case study.

ACRONYMS AND ABBREVIATIONS

This is a list of acronyms and abbreviations used in the guide.

ADSL	Asymmetric Digital Subscriber Line, a first mile technology operating over copper phone lines
AN	Access Node
AON	Active Optical Network, a technology for FTTH/FTTB (aka Ethernet point-to-point)
CAPEX	Capital expenditure
DOCSIS	Data Over cable System Interface Specification – a cable TV network solution
DSL	Digital Subscriber Line
EC	European Commission
FTTH	Fibre-to-the-home, a first-mile infrastructure
FTTB	Fibre-to-the-Building (typically an MDU), a first-mile infrastructure
FTTC	Fibre-to-the-Cabinet (from which the first-mile connection starts), a local area infrastructure
GPON	Gigabit Passive Optical Network – a shared-access technology for FTTH/FTTB (ITU-T G.984)
HDTV	High-definition television
IRU	Indefeasible right of use
ISP	Internet service provider, e.g. a SP delivering Internet service
LLU	Local loop unbundling
MDU	Multi-dwelling unit – an apartment block
NP	Network Provider, operates the active equipment and delivers SP's services to the end users
OPEX	Operational expenditure
PA	Public authority
PIP	Physical infrastructure provider, owns and operates the passive infrastructure
PON	Passive optical network, a shared-access technology for FTTH/FTTB
PSTN	Public Switched Telephone Network
RoW	Right of Way
SMP	Significant market power
VDSL	Very-high bit-rate Digital Subscriber Line
SP	Service Provider, sells services (e.g. Internet, TV, telephony, etc.) to the end user
xDSL	Digital Subscriber Line of any type

REFERENCES AND FURTHER READING

Besides the sources mentioned throughout the guide (and listed below), the European Commission has a large amount of information available, for example: Info website of DG regio[48], Digital Agenda for Europe[49], Digital Agenda Scoreboad[50], European Broadband Portal[51], Rural Development[52], EU Guidelines to State Aid on Broadband[53], General Block Exemption Regulation[54], Connected Continent - a single telecom market for growth & jobs[55], Connected Communities[56], Guidance on Ex ante Conditionalities[57], Connecting Europe Facility[58], DAE toolbox[59], Study on Broadband and Infrastructure Mapping[60], Study on the socio-economic impact of bandwidth[61].

Other useful studies and reports have served as background material for this guide and are recommended reads: FTTH Handbook by the FTTH Council Europe[62], Broadband in rural areas (currently only in Swedish)[63]; www.bredbandivarldsklass.se, Beyond Broadband, a guide from INCA[64].

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[14] See: ESIF Regulation: http://eur-lex.europa.eu/JOHtml.do?uri=OJ%3AL%3A2013%3A347%3ASOM%3AEN%3AHTML

[15] An operation may be financed only by one fund (Art. 65(11) Common Provision Regulation)

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[17] See: http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/eac_guidance_esif_part2_en.pdf

[18] See: http://ec.europa.eu/regional_policy/information/guidelines/index_en.cfm

[19] See Handbook for decision makers - The broadband State aid rules explained: http://ec.europa.eu/digital-agenda/en/news/handbook-decision-makers-broadband-state-aid-rules-explained

[20] See also: http://www.broadbandmapping.eu/

[21] Se: http://ec.europa.eu/digital-agenda/en/pillar-iv-fast-and-ultra-fast-internet-access/action-117-reduction-cost-deploying-high-speed

[22] See list of NRAs: http://berec.europa.eu/eng/links/

[23] See also the "Guidance to the ex-ante conditionalities on ICT: http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/2_faq_information_communication_technologies.pdf

[24] See: http://ec.europa.eu/digital-agenda/en/news/maximising-broadband-connectivity-across-eu-using-european-funding-satellite-broadband-access

[25] Regarding access obligations, under EU State Aid Rules when vectoring is used, see section 4.2 and annex A3 of the Handbook for decision makers: the state aid rules explained

[26] Central active and passive infrastructure (the satellites and the earth gateways) is typically provided and financed by satellite operators.

[27] See EU state aid guidelines for broadband: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:025:0001:0026:EN:PDF and/or the Handbook for decision makers: http://ec.europa.eu/digital-agenda/en/news/handbook-decision-makers-broadband-state-aid-rules-explained :

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[34] See the Draft Commission Notice on the notion of state aid pursuant to Article 107(1) TFEU, http://ec.europa.eu/competition/consultations/2014_state_aid_notion/draft_guidance_en.pdf

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[39] European Commission, Guide to the implementation of a satellite vouchers scheme: http://ec.europa.eu/digital-agenda/en/news/maximising-broadband-connectivity-across-eu-using-european-funding-satellite-broadband-access

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