European Commission

Broadband investment handbook

2024

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Executive summary

This handbook aims to assist public authorities in planning, implementing, and monitoring broadband projects within their territories. It primarily addresses the deployment of access and backhaul segments of fixed broadband networks and the adoption of broadband services. Additionally, the forthcoming version of the handbook will incorporate insights from other domains, particularly mobile broadband networks.

The handbook's structure builds on the 'The high-speed broadband investment guide' published in 2015. It has been comprehensively updated to encompass the latest technological, policy, regulatory, and financial developments. Notably, a new chapter on State aid has been introduced to reflect the updated Broadband State Aid Guidelines and other developments.

The handbook is structured in eight chapters.

Chapter 1
Introduction of key concepts and context

Chapter 2
The importance of designing a broadband plan

Chapters 3 to 6 present the **four critical strategic choices** that public authorities must make to fulfil the objectives set out in their broadband plans:

Chapter 3
Investment model
The public authority's role concerning the implementation, operation, ownership, and management of the infrastructure.

Chapter 4
Network type
The factors that a public authority should consider in making infrastructure and technology decisions.

Chapter 5
Business model
The advantages and disadvantages of each business model.

Chapter 6
Financing tools
The alternative financial tools available to a public authority for supporting capital and operational expenditure.

Chapter 7
Action plan and execution
Once these choices are made, an action plan needs to be defined and executed. As explained in Chapter 7, this process must be monitored closely to ensure that the broadband plan goals are achieved.

Chapter 8
Broadband investment and State aid
Finally, Chapter 8 gives an overview of State aid rules, explaining their rationale and how they apply to broadband development projects.

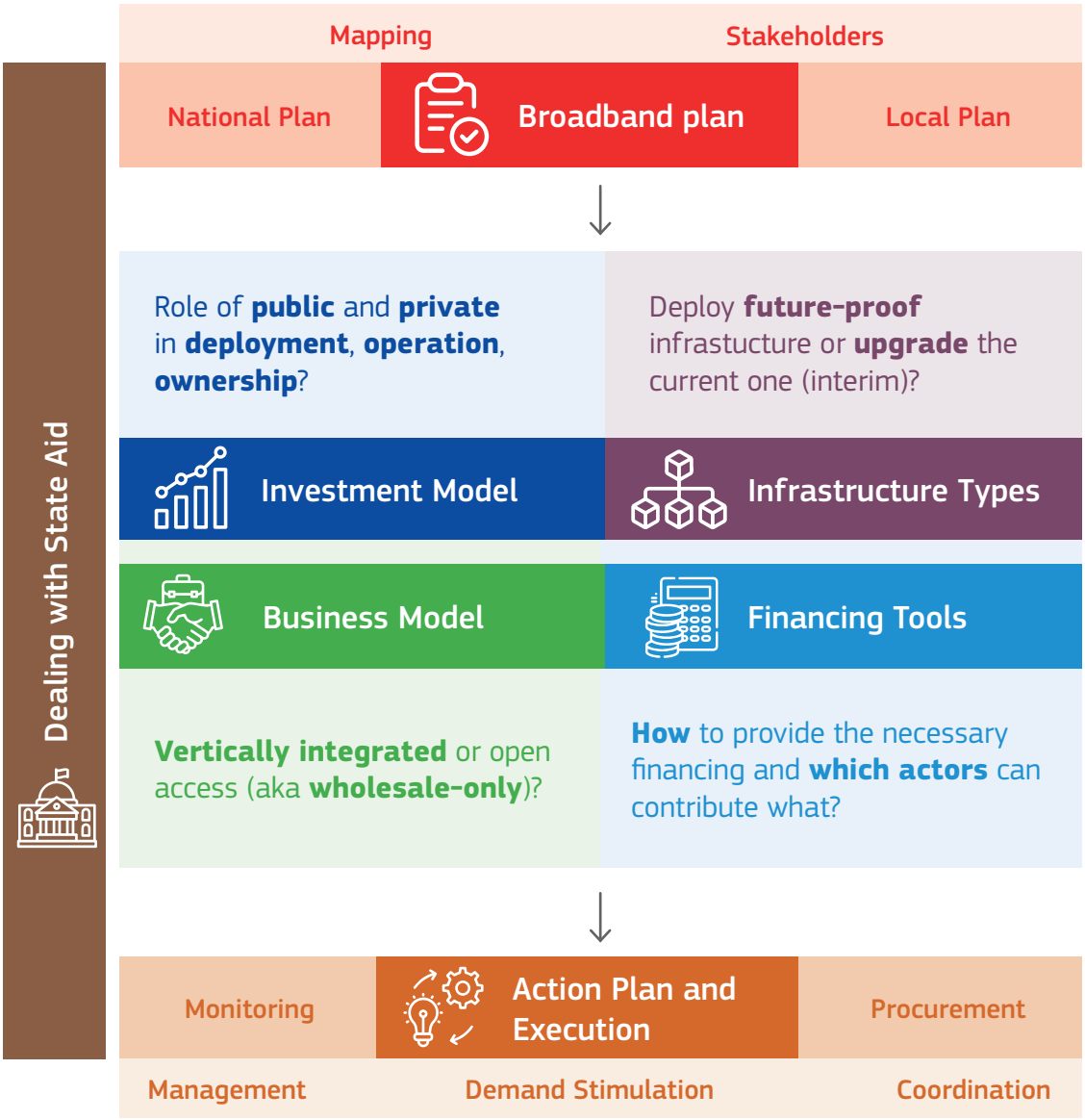


Figure 1 *– The topics covered by the handbook*

Readers who are familiar with the previous version of this handbook ('The high-speed broadband investment guide') should note that some updated concepts and definitions have been introduced to improve consistency with the latest terminology used in the sector.

1

Introduction and key concepts

In this chapter, we introduce key concepts concerning broadband networks, the main motivations driving a network upgrade as well as the role of the market and the public sector. We also provide a short overview of the European Union policy and regulatory context.

1.1 Objective of the handbook

The handbook is written primarily for public authorities, notably local and regional, who wish to drive broadband development in their territory in order to foster social cohesion and economic progress.

The handbook can also be a useful reference for all stakeholders involved in broadband development, such as citizens, SMEs, consumer associations, operators and infrastructure owners.

1.2 What is broadband?

It is important to clarify several key terms used in this handbook from the start.

A **broadband connection**[1] **or broadband network** is the channel over which broadband services are delivered to an end user, such as a household, a business or a public administration. The broadband network relies on passive and active components. **Passive components** include, for instance, ducts, poles, masts, dark fibres, cabinets and manholes. **Active components** include, for instance, transponders, routers, switches and active antennas.

Examples of **broadband services** include internet[2], digital TV, IP-telephony[3], but also e-health, smart home or cloud computing applications, among others.

The **internet** is therefore just one of the services that can be delivered over a broadband network. What makes it a **special service** is that it is itself used as a communications platform, over which a plethora of applications and content can be delivered.

1 In Chapter 4, we will see that a broadband connection consists of a passive and an active layer.

2 Meaning connection to the open Internet: the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to communicate between networks and devices.

3 Internet, digital TV and IP telephony are sometimes collectively referred to as 'triple play'.

Many broadband services can also be delivered as **applications** on top of the internet service (for example, audio and video communication, e-health, smart home, entertainment). For this reason, applications are sometimes called **over-the-top** (OTT) **services**, or simply **OTT**, and the term **digital services** is normally used to designate both broadband services and applications. Unlike broadband services, an OTT service does not usually need direct access to a specific end user's broadband connection: it just needs to be available on the internet (typically relying on a server) in order to be accessed by all end users, irrespective of their geographic location.

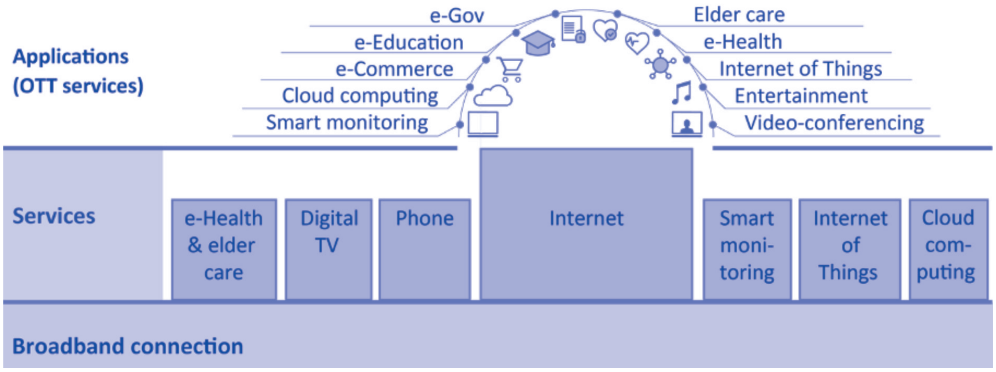


Figure 2 *– A broadband connection allows the delivery of different types of services, from TV and telephony to e-health. One of these services is the Internet service, which can function as a channel to deliver many different applications which can increasingly replace broadband services. These applications are therefore referred to as OTT services.*

INFOBOX 1

Broadband quality of service: key concepts and terms

In the press and in everyday language, broadband networks are classified according to how 'fast' they are, and this speed is measured in terms of data rate or bandwidth. However, there are several other parameters that determine the quality of a broadband service and how it is experienced by the user. As a set, these parameters make up the **Quality of Service** (QoS). Here are the key terms and concepts:

- **Information** is measured in binary units, called **bits** (b).
- The **data rate**, commonly referred to as **connection speed** or **bandwidth**[4], expresses how much information is transmitted per second and is usually measured in millions of bits per second (one million bits is referred to as a megabit; the data rate is therefore measured in megabits per second, Mbps[5]), or gigabits per second (1 gigabit = 1,000 megabits)[6].
- **Downlink speed** is the most commonly used QoS parameter. It measures the rate at which data are downloaded from the network to the end user. The majority of services are designed for the user to consume more data in downlink than they would send in uplink. However, for some services, such as video conferencing, there is a more symmetric flow of data across downlink and uplink. In the future, uplink speeds will become increasingly important for the use of interactive applications, including web 4.0, multiverse and cloud computing, which require a high degree of symmetry in the data flow.
- **Connection symmetry** refers to the upload speed being as high as download speed. While entertainment services like TV and video-on-demand only require high download speeds, others require high upload speeds as well, such as video conferencing, social media, certain e-health and e-education applications, and Internet of Things (IoT), among others.
- **Peak-time conditions** refer to the conditions under which the network is expected to operate at 'peak time': the network load is usually at its maximum when the highest number of users are simultaneously sharing network capacity[7]
- The **capacity of a channel, a network or a broadband connection** is the total maximum data rate achievable over it, often stemming from the characteristic of the medium as well as the technological and design characteristics of the channel.
- **Contention** refers to when the overall available capacity must be shared among many active users, causing the **actual connection speed** experienced by the end users to drop significantly below the **nominal speed** of the connection.
- **Latency** is the time it takes for a packet of information to reach its destination or for a data transfer to start, irrespective of data rate. Some applications are time-critical and may require low data rates but very fast response times inside the network. Examples of applications with stringent low latency requirements are stock exchange data transfer, self-driving vehicle applications, remote surgery, gaming and video conferencing.
- **Jitter** is latency fluctuation. Applications sensitive to latency tend to suffer greatly from jitter as well.
- **Network availability** (also known as uptime) is the percentage of time the network is fully operational.

4 The technical term bandwidth has a specific meaning (for a physical property which in turns influences achievable data rates, see INFOBOX 11), but it is often used as a synonym or even a substitute for 'data rate', especially in policy documents. In fact, the term broadband itself is connected to the idea of having broad bandwidth, meaning high data rates.

5 The scientific notation for megabit per seconds is Mb/s, although Mbps is more widespread in everyday contexts.

6 Note that, for historical reasons, information storage is measured in basic units of bytes (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). So, for example, downloading a 1 GB file at a data rate of 1 Gbps will take 8 seconds.

7 As explained in section 8.8, the European Electronic Communications Code (EECC) and the latest 'Guidelines on State aid for broadband networks' (referred to as the 'Broadband Guidelines') introduced the notion of peak-time conditions. According to this notion, if a network is supposed to provide a certain performance, this performance must be provided under peak-time conditions.

1.3 Broadband connection classification

This handbook focuses on the deployment of broadband infrastructure[8] and uses the following definitions:

- **Basic broadband** is the first generation of 'always-on' connectivity[9] and can be proffered using telephone copper lines (such as ADSL[10]), coaxial cables[11] for TV distribution (such as DOCSIS[12] 2.0), satellite connections (to non-enhanced systems), wireless connections (such as 3G mobile networks or systems based on unlicensed spectrum like WiMAX[13] or Wi-Fi networks). These connections are usually asymmetric with download speeds below 30 Mbps, typically limited to a few Mbps. As foreseen in the Digital Agenda for Europe (DAE), 100% basic broadband coverage had been achieved in the EU as of 2013.
- **Next Generation Access (NGA) broadband** is wired access networks which consist, either wholly or in part, of optical elements and which can deliver broadband access services with enhanced characteristics (such as higher throughput) as compared with those provided solely over existing copper networks. They usually provide download speeds of 30-100 Mbps. The most common designs of network topologies are FTTC (Fibre-to-the-Cabinet, which combines fibre and copper using VDSL[14] technology) and HFC (Hybrid Fibre Coaxial, which combines fibre and coaxial cable using DOCSIS 3.x technology).
- **Ultrafast broadband** allows download speeds of **over 100 Mbps.** As with basic broadband, this level of connectivity can be achieved over most types of infrastructure but requires the use of more sophisticated technology. Ultrafast connections deployed today are most often asymmetric and special conditions must be met for them to work on traditional infrastructure, such as copper. These conditions include short distance from the first aggregation node to the user, limited number of users sharing the line, and installation of advanced equipment at the first aggregation node (for example, G.Fast[15], DOCSIS 3.1 or higher).
- **Fixed very high-capacity networks** (VHCN) are a subset of ultrafast broadband networks consisting wholly of **optical fibre elements at least up to the building** or capable of offering a **similar quality of service** (QoS). The Body of European Regulators for Electronic Communications (BEREC), has defined VHCN QoS as follows: among other parameters (including for fixed wireless access - FWA), VHCN are networks capable of offering download speeds of at least 1 Gbps (for fixed-line connection) and 350 Mbps (for wireless connection) as well as, among others, low latency and high service availability (see INFOBOX 2 for a full list of the QoS parameters to be met by fixed-line VHCN).

1.4 Fixed broadband and mobile broadband

By **fixed broadband** we mean broadband services delivered to a fixed location (such as a household or a workplace) irrespective of whether a landline or a wireless connection is used. By **mobile broadband** we mean broadband services delivered to mobile devices. This handbook only covers fixed broadband.

It should be noted, however, that fixed networks can be used to deploy a mobile network, for example, by acting as backhauling for a mobile service operator, while wireless networks can be used to connect remote households in so-called fixed wireless access (FWA), using 5G for example. Because the entities connected are fixed, this is generally treated as fixed broadband from the market and regulation point of view.

8 In Chapter 4, the concepts of infrastructure, technology and services are explained in detail.

9 'Always-on', to distinguish broadband from so-called dial-up connections, which involved accessing a regular copper phone line with a modem whenever one wanted to connect to the Internet; connection speeds were typically up to 128 Kbps (or 0.1 Mbps).

10 ADSL: Asymmetric Digital Subscriber Line

11 Coaxial Cable: electrical cable consisting of an inner conductor surrounded by a concentric conducting shield, with the two separated by a dielectric (insulating material).

12 DOCSIS: Data Over Cable Service Interface Specification

13 WiMAX: Worldwide Interoperability for Microwave Access

14 VDSL: Very High Bitrate Digital Subscriber Line

15 G.fast is a digital subscriber line (DSL) protocol standard for local loops shorter than 500 meters, with performance targets between 100 Mbps and 1 Gbps, depending on loop length. High speeds are only achieved over very short loops.

16 See table of references at the end of the Handbook: BEREC 2023

17 Y.1540: Internet protocol data communication service - IP packet transfer and availability performance parameters.

INFOBOX 2

Fixed VHCN criteria

The EU Electronic Communications Code (EECC) defines fixed VHCN as either a fixed network which consists 'wholly of optical fibre elements at least up to the distribution point at the serving location' or one 'capable of delivering, under usual peak-time conditions, similar network performance in terms of available downlink and uplink bandwidth, resilience, error-related parameters, and latency and its variation'.

Based on the EECC, BEREC has recently updated its VHCN Guidelines to include a set of criteria to be satisfied for a network to be classified as a fixed VHCN[16].

A **fixed VHCN** is:

a) *either* a network consisting of fibre at least up to the multi-dwelling building (FTTB or FTTH, see INFOBOX 12)

b) *or* one capable of delivering, under usual peak-time conditions, services to end users with the following quality of service (QoS) parameters:

- Downlink data rate ≥ 1000 Mbps;
- Uplink data rate ≥ 200 Mbps;
- IP packet error ratio (Y.1540[17]) ≤ 0.05%;
- IP packet loss ratio (Y.1540) ≤ 0.0025%;
- Latency, in terms of round-trip IP packet delay (RFC 2681) ≤ 10ms;
- Jitter, in terms of IP packet delay variation (RFC 3393) ≤ 2ms;
- IP service availability (Y.1540) ≥ 99.9% per year.

INFOBOX 3

The EU Electronic Communications Code (EECC)

The EU telecoms rules aim to stimulate competition that drives investments and strengthens the internal market as well as consumer rights. The EU Electronic Communications Code (EECC)[18], aims to:

- Promote connectivity and **take-up of VHCN,** including fixed and mobile networks, for all EU citizens and businesses (including defining QoS criteria);
- Promote the interests of EU citizens (**effective competition, network and services security, consumer protection,** as well as addressing **needs of specific social groups**);
- Facilitate market entry and promote **competition** in the delivery of telecoms networks and associated facilities;
- Foster the development of the **internal telecom market** in the EU, by featuring **common rules and predictable regulation** (radio spectrum, open innovation, trans-European networks, availability and interoperability of Europe-wide services, and end-to-end connectivity).

The EECC also sets out the **responsibility of Member States in terms of cooperation** with each other and with the European Commission in the strategic planning and coordination of radio spectrum policy, avoiding harmful interference, through a Radio Spectrum Policy Group; as well as defining a competent authority to undertake the tasks set out in the Code. Member States should ensure that the National Regulatory Authorities (NRAs) are independent of telecoms equipment manufacturers and service providers and protected against external intervention or political pressure which might jeopardise their independent assessment. Member States should also ensure that NRAs have budget autonomy and adequate financial and human resources to carry out the tasks assigned to them.

The EECC introduces a series of **new objectives and tasks:**

- **Strengthened consumer rules**, for example, regarding switching service providers and bundled services.
- **Over-the-top (OTT)** services (see Section 1.2) to be classified as telecoms services.
- **Affordable and adequate broadband internet access must be available to all citizens.**
- A **public warning system** to be set up by Member States in the event of major emergencies.
- **Regulation certainty and new frequency bands for 5G investment.**
- A **regulatory regime** easing investment in new VHC infrastructure.

The latter includes relaxation of access regulation of wholesale-only networks and of small local projects (see INFOBOX 23).

18 The EECC was defined in a Directive issued in 2018; see table of references at the end of the Handbook: EU 2018 EECC

The broadband plan

The first step in the process of broadband development is to define a politically endorsed broadband plan for the territory, be it at local, regional or national level. **An effective broadband plan should explain how broadband investment will help achieve the objectives of the overall development programme in the territory.**

This chapter gives an overview of the questions that should be considered when writing a broadband plan.

2.1 Writing a national broadband plan

Broadband development policy varies between Member States. In some cases, development is mainly defined and planned at national level, while in others it is the prerogative of the regional or even local level.

In all cases, however, a **national broadband plan (NBP)** is crucial for broadband development. It sets the priorities, defines investment schemes, financing tools and business models, adapting generic models to the specific market and socio-economic conditions of the Member State. It also defines roles at national, regional and local level, and defines how the necessary information, support and coordination should be provided to regional and local actors responsible for broadband development in their territory.

All Member States currently have an NBP, with varying levels of detail and not always in the form of a single document. In general, successful NBPs consider their respective starting positions and describe concrete measures that take advantage of individual strengths, as well as defining measures to mitigate the effects of weaknesses[19].

While there is no one-size-fits-all solution for broadband strategies across Europe, and an NBP is not fully transferrable from Member State to Member State, some measures implemented in one Member State can be taken as an example for implementation in another Member State, provided it is done under the right conditions.

Member States have been called to update their broadband plans to address the new European Union targets for 2025 and 2030, and many Member States have already done so. The European Commission has emphasised the importance of NBPs in its Guidance to Member States' Recovery and Resilience Plans[20].

19 See table of references at the end of the Handbook: SMART 2014/77

20 See table of references at the end of the Handbook: EU 2020 RRF

2.2 Writing a regional or local broadband plan

While the NBP sets the general strategy for broadband development for each Member State, regional and local authorities also need to define a plan for their territory. Where national plans envisage local interventions, consistency should be ensured by the concerned regional and local authorities. The level of detail and ambition of regional and local broadband plans will vary depending on the scope and level of detail of the national plan, as well the resources and responsibilities allocated at regional and local levels.

Although in some cases an implementation and monitoring strategy may be all that is needed, in most cases, regional and local authorities will need to define a plan that includes key strategic choices on investment models, financing tools, infrastructure type and business models, as well as an implementation plan. These choices should be made within the scope of any schemes and models defined at national level, and their State aid implications will need to be understood.

2.3 Policy context: Europe's strategic connectivity objectives

The broadband plan needs to take into account the overall EU, national, as well as regional and local development policies and the role that digitalisation, and connectivity in particular, play within them.

At EU level

1. The Digital Decade Policy Programme

On 15 December 2022, President of the European Commission Ursula von der Leyen signed the **European Declaration on Digital Rights and Principles**[21], which underlines the EU's commitment to a secure, safe and sustainable digital transformation that puts people at the centre, in line with the EU's core values and fundamental rights.

The European Commission sets a framework for action through the **Digital Decade Policy Programme** (DDPP)[22] which is intended to equip the EU with secure and performant sustainable digital infrastructures by 2030. The DDPP is the first ever **digital governance tool**, putting it on a par with the European Green Deal:

- It introduces a framework for cooperation to ensure consistency and synergies among all policy initiatives, actions and measures in the digital sphere.
- It will also facilitate investments in **multi-country projects** to reap the €2.2 trillion worth of digital potential for the EU, as well as to ensure that we capitalise on the new digitalisation trends instigated by the COVID-19 pandemic and the unprecedented opportunity for digital investment provided by the **Next Generation EU's Recovery and Resilience Facility** (RRF).

The rapid launch of multi-country projects will be facilitated through a mechanism to combine investments from the EU budget, Member States and the private sector, building on the RRF and other EU funding sources. Envisioned projects include a European Blockchain Service Infrastructure and European Common Data Infrastructure and Services.

In addition to multi-country projects, under the RRF, Member States will invest in **skills, connectivity, transformation of business and transformation of public administration**.

2. The connectivity objectives

To meet these needs and prepare Europe's digital future, the European Commission has defined strategic connectivity objectives for the Digital Decade:

a. **By 2025**: *the European Gigabit Society objectives*

- **All main socio-economic drivers**, such as schools, universities, research centres, transport hubs, all providers of public services such as hospitals and administrations, and enterprises relying on digital technologies, should have gigabit connectivity **(download/upload speeds of 1 Gbps)**.
- **All European households**, rural and urban, should have access to connectivity offering **download speeds of 100 Mbps minimum, upgradable to 1 Gbps**, reflecting the Commission's expectation that, as the decade progresses, households will increasingly need 1 Gbps symmetric connections.
- **All urban areas as well as major roads and railways** should have **uninterrupted 5G coverage**, the fifth generation of wireless communication systems.

b. **By 2030**: *Europe's Digital Decade objectives*

- **All European households** should be covered by **gigabit network connectivity** (line or wireless)

21 See table of references at the end of the Handbook: EU 2022 DIGRIGHT

22 See table of references at the end of the Handbook: EU 2023 DDPP

- **All populated areas** should be covered by **5G** with its full capabilities, or by other wireless networks with characteristics **at least equivalent to those of 5G networks**.

These connectivity objectives are supported by the current EU seven-year budget, the 2021-2027 Multiannual Financial Framework (MFF) (see INFOBOX 20 for a description of relevant EU programmes); a regulatory framework based on the EECC (see INFOBOX 3); as well as other legislation, such as the European Commission's proposal for a 'Gigabit Infrastructure Act' (GIA)[23].

At national level

Investments and reforms should support reaching the Digital Decade targets.

Member States' strategic national roadmaps[24] (October 2023) include the main existing and planned policies, measures and actions to achieve the Digital Decade objectives and targets with their assessment and a timeline for their implementation.

Mobilising private resources may be done under the new **InvestEU** programme, which allows the European Investment Bank (EIB) and National Promotional Banks to make use of the EU guarantee and leverage public resources by attracting additional resources from the private sector. Participation of private investors in blended finance schemes is undoubtedly an important way to achieve the 2030 targets.

With a €2 billion budget, CEF Digital[25] is the first programme under the Multiannual Financial Framework (MFF) 2021-2027 directly managed by the Commission, through the Health and Digital Executive Agency (HaDEA), devoted to gigabit and 5G connectivity deployment.

CEF Digital supports the deployment of 5G:

- For **'5G corridors'**, supporting **connected and automated mobility** along major **transport paths**;
- For **'smart communities'**, supporting sectoral industries and public authorities as providers of **services of general interest** (SGI)
- For **'digital global gateways'**, providing **secure backbone connectivity** including submarine cables and critical digital capacities, such as quantum-secured links, among others.

These investments are important in order to bridge the digital divide while avoiding the crowding out private investment in cases where no market failure exists.

The fast deployment of very high-capacity networks, including 5G and fibre, is expected to benefit society as a whole, such as by providing the appropriate bandwidth and coverage for sectors that are essential, such as agriculture, transport, health and education.

It will also help enhance **Europe's open strategic autonomy**, while reaping the benefits from an open economy by providing support to implement the infrastructure which will be needed for future applications and processes.

2.4 The broadband plan as an enabling condition for ERDF and EAFRD funding

Whenever a Member State or a region administers funding from the **European Regional Development Fund** (ERDF) for broadband development, regulation mandates a corresponding national or regional broadband plan in line with the strategic objectives set in the DDPP.

The European Common Provision Regulation[26] requires that a national or regional broadband plan is in place which includes an **assessment of the investment gap** (see Section 2.5). It must also "justify the planned public intervention on the basis of **sustainable investment models** that enhance affordability and access to open, quality and future-proof infrastructure and services" and "allow for a complementary use of different forms of financing from EU, national or regional sources, adjusted to the market failures identified".

The broadband plan should also outline how it will be executed and monitored, what measures are planned to support and stimulate demand, as well as cost-reduction actions. These and other matters can be covered in a dedicated action plan (see Chapter 7).

Technical assistance and expert advice mechanisms to reinforce the capacity of local stakeholders and advise project promoters should also be put in place. One useful way to do that is through the **Broadband Competence Offices** (see INFOBOX 5).

Member States can also fund the deployment of broadband networks in rural and remote areas (mainly the last mile) through the **Common Agricultural Policy** (CAP), in particular through the **European Agricultural Funds for Rural Development** (EAFRD) (Art. 73.3.f), through their **CAP Strategic Plans**, whose assessment contributes to ensuring complementarity with other broadband interventions as well coherence with the European Green Deal.

23 Gigabit Infrastructure Act Proposal and Impact Assessment | Shaping Europe's digital future (europa.eu): https://digital-strategy.ec.europa.eu/en/library/gigabit-infrastructure-act-proposal-and-impact-assessment

24 See also: Guidance to the Member States on the preparation of the national Digital Decade strategic roadmaps | Shaping Europe's digital future (europa.eu)

25 See table of references at the end of the Handbook: EU CEF

26 See table of references at the end of the Handbook: EU 2021 CPR

2.5 Mapping the current situation and defining the investment goals

A broadband plan should define high-level concrete goals for broadband coverage in the territory.

Annex IV of the EU Common Provision Regulation[27] defines the main features of a national or regional broadband plan, including:

- An assessment of the investment gap that needs to be addressed to ensure that all EU citizens have access to very high capacity networks;
- The justification of planned public intervention on the basis of sustainable investment models;
- Measures to support demand and use of very high capacity networks;
- Technical assistance and expert advice mechanisms, such as the Broadband Competence Offices;
- A monitoring mechanism based on standard broadband mapping indicators.

Mapping is necessary to identify the scope and type of investment needed to reach the goals set. Broadband infrastructure mapping enables the identification of areas for intervention and the prediction of costs [28]. It is also a pre-requisite for any investment being supported by State funds and falling under the State aid rules.

At national level, for regulatory purposes, the EECC mandates that Member States conduct a geographical survey (or mapping) of broadband coverage ('geographic reach') by 21 December 2023 and update it at least every three years thereafter[29].

BEREC has released a 'Handbook of BEREC Guidelines on Geographical surveys of network deployments'[30], which also specify how the collected data on address level or inside grid level should be aggregated on different nomenclature of territorial units for statistics and administrative levels (such as municipal or regional), data publication and access by public authorities.

When the deployment of the broadband network is financed with State aid, Annex I of the Broadband Guidelines provides best practices on how to carry out the mapping exercise to fulfil the State aid requirements.

In addition, while not compulsory for Article 22, BEREC recommends annual mapping of credibly planned investments and roll-out plans by different market actors ('undertakings') in order to produce a forecast of broadband coverage as a preliminary basis for potential future investments (including State aid interventions). However, **mapping of credibly planned investments becomes mandatory if public funding is involved**, as explained in the Broadband Guidelines[31].

To mitigate risks effectively, this forecast should undergo verification both before and after implementation. Such verification is crucial to ensure that areas do not miss out on public funding if roll-out plans are not executed as anticipated. It also prevents the scenario where a private investor's infrastructure is ‚overbuilt' due to a failure in declaring future roll-out plans, thereby avoiding potential litigation and uncertainty.

Consumer demand, encompassing both individuals and businesses, is a crucial component of any business case for infrastructure deployment. This demand is often stimulated by **healthy competition in services**. National Regulatory Authorities (NRAs) have a vital role in collecting pertinent statistics and evaluating the landscape of retail competition, local loop unbundling, and the range of services offered by various providers. Analysing the socio-economic and demographic characteristics of the territory, including factors such as income levels, educational attainment, ICT skills, age distribution, and the prevalence of micro-enterprises and SMEs, is instrumental in forming an initial understanding of the potential demand for these services.

2.6 Identifying stakeholders and securing collaboration

A broadband plan must create the right conditions and incentives for all relevant stakeholders to participate in the project. In doing so, it can more effectively leverage the resources, competences, and assets available in the region, thereby significantly enhancing its chances of success.

Stakeholders may assist in identifying demand for connectivity, such as:

- Telecom companies as access seekers interested in passive infrastructure, especially backhaul infrastructure (for example, by leasing ducts or dark fibre);
- Non-telecom companies wishing to lease dark fibre (for example, banks, large corporations, TV production companies).

27 See table of references at the end of the Handbook: EU 2021 CPR

28 See table of references at the end of the Handbook: EU 2022 BB-SA-GL

29 Article 22 of the EU Code for Electronic Communications; see table of references at the end of the Handbook: EU 2018 EECC

30 See table of references at the end of the Handbook: BEREC 2021

The BEREC Handbook contains the following documents:

1. The BEREC Guidelines to assist NRAs on the consistent application of Geographical surveys of network deployments – document BoR (20) 42 (the "Core Guidelines");
2. The BEREC Guidelines on Geographical surveys of network deployments Article 22 (2), 22 (3) and 22 (4) – document BoR (21) 32 (the "Procedural Guidelines");
3. The BEREC Guidelines on geographical surveys of network deployments - Verification of information – document BoR (21) 82 (the "Verification Guidelines").

31 See Broadband Guidelines ANNEX I Mapping of fixed and mobile access networks – best practices referred to in section 5.2.2.4.1 of these Guidelines: Publications Office (europa.eu)

In addition, there are important **institutional stakeholders** that interact with end users to deliver social benefits through advanced social ICT services. These stakeholders, **SGIs and services of general economic interest** (SGEIs), are among the largest potential customers of the new broadband network and can act as **'anchor tenants'** to attract citizens to the new broadband network. These include:

- Hospitals;
- Schools;
- Elderly and social housing companies/ associations;
- Police, emergency services, military;
- Utilities;
- Public administration authorities and offices.

These SGIs and SGEIs are often directly or indirectly controlled by the public authority running the project. They should be involved in the project early on to strengthen the business case, reduce investment risk, and ensure that the network is designed to accommodate the socio-economic needs of the territory.

32 There are even examples of utilities building telecommunication service subsidiary. Besides the case of local public-owned utilities acting as broadband deployment vehicles for municipalities and regions, there are some high-profile examples from national utilities. One example is SIRO, launched in 2015 by Irish power utility ESB together with Vodafone, to build a nationwide 100% Fibre-to-the-Building network; the first of its kind in Ireland. The second example is Italian power utility ENEL, which, together with the Italian investment bank Cassa Depositi e Prestiti, built open fibre to deliver ultra-fast broadband across the country, mainly through FTTH.

33 Gigabit Infrastructure Act

INFOBOX 4

Utilities and mobile operators: special types of stakeholders

1. **Utilities** represent a critical stakeholder in many broadband deployment projects as they can take many crucial roles:
    - **Strategic network users:** broadband networks are key in ensuring the provision of mission-critical high-speed broadband communications in the context of utilities (such as in the management of intelligent energy / smart energy grids, intelligent transport safety and transport management systems, among others). As such, utilities can represent a solid customer base, providing network requirement specification (such as in terms of bandwidth, reliability and latency) as well as much needed revenue.
    - **Infrastructure owner:** because digital connectivity is so critical for their operations, many utilities have deployed infrastructure[32] (ducts, poles, masts) over the years that could be reused for the broadband project[33].

Moreover, **utilities** are sometimes partly or fully owned by the regional or local government.

2. **Mobile operators**, although generally privately owned and operating at national level, also need to rely on fibre infrastructure and can therefore be anchor tenants (such as by leasing fibre for their base stations) and infrastructure providers (by sharing their ducts and fibres with other users or cooperating in building backhaul network).

2.7 General State aid considerations

The use of public resources to fund an economic activity in the EU is subject to the EU's State aid rules, whose overarching principle is that **State intervention must limit the risk of crowding out or replacing private investments, of altering commercial investment incentives, and ultimately of distorting competition in the EU**.

Under certain conditions, State interventions can correct market failures. A market failure exists if markets, without intervention, fail to deliver an efficient outcome for society.

In the context of broadband, market failure occurs when private investors lack commercial incentives to invest, despite the societal benefits of broadband deployment outweighing the costs. An example of this market failure is linked to positive externalities, where market participants fail to account for the full benefits of their actions. For example, the availability of advanced broadband networks enables the delivery of advanced services and drives innovation, which offer greater benefits of public interest than immediate returns to the network's investors and subscribers. Such market conditions therefore result in insufficient private investment in broadband networks.

In order to establish that there is a market failure, mapping and public consultations are required to verify the presence of existing or planned private investments in broadband networks, giving clear indications on which areas can be considered as constituting a market failure and therefore justifying public interventions.

Based on the mapping and public consultations, areas can be classified as white, grey or black, depending on the number of infrastructures (not operators) that provide at least 100 Mbps download speed under peak-time conditions (ultrafast networks) which are present or planned in the near future in a given area. For mapping purposes, the near future is intended as the time horizon in which the planned supported project is expected to be completed. Areas are classified as:

- **White**, if there is **no** 'targeted type of network for mapping' present or planned;
- **Grey**, if there is **only one** 'targeted type of network for mapping' present or planned;
- **Black**, if there are **at least two** 'targeted type of network for mapping' present or planned.

Public authorities are allowed and encouraged to intervene in market failure areas subject to certain conditions, including that the intervention demonstrates a **'step change'**.

The qualification of areas as white, grey, or black may be reviewed regularly to verify, for instance, that the private investment plans declared by operators in the public consultation are indeed materialising. If the public authority identifies deviations from the plan which suggest that the project will not materialise, or which give sufficient reasons to doubt that the investment will be completed as declared, the public authority may, at any time during the relevant time horizon, consider including the areas concerned by the investment in a new public consultation with a view to verifying their potential eligibility for State aid intervention.

For example, in the case of an area classified as grey based on investment plans declared by private operators: should those plans not materialise in the announced timeframe, the public authority may request that the area be reclassified. This can, for example, allow minimising the risk of the operator strategically blocking publicly supported deployments.

A proper mapping and public consultation should in fact require that operators demonstrate that planned investments are credible. This could be, for instance, by specifying an investment roadmap throughout a determined time period so that potential deviations from the investment plan can be detected early on.

Public authorities are responsible for assessing the credibility of investments and for deciding whether the investment plans can no longer be considered credible for justified reasons, before considering reclassifying an area in view of a potential public intervention.

Public authorities considering supporting broadband investment projects should familiarise themselves with the EU's State aid rules. Under certain conditions, the use of State funds must be notified to the European Commission for approval. In view of the importance of State aid rules (see chapter 8), it is advisable, at an early planning stage, to start informal discussions with the Commission (pre-notification phase) and consult with the national BCO on the design of State aided projects.

34 Visit www.bconetwork.eu to find out more about the BCO Network, the mandate of BCOs, and the national contact points.

35 See table of references at the end of the Handbook: BCO-SF

INFOBOX 5

The Broadband Competence Offices Network (BCO)

The National Broadband Competence Offices (BCOs) are Member States' single contact points for broadband at national level. Depending on national contexts, BCOs may also be established at regional level. **BCOs provide broadband-related guidance and good practices to broadband project promoters, investors and users** (municipalities, regions, citizens, operators, businesses and any relevant stakeholders), focusing mainly on **technology, funding and regulatory issues**.

As part of the BCO Network[34], BCOs regularly gather together with the European Commission to exchange good practices and receive technical, regulatory and implementation advice in the field of broadband deployment.

The BCO Network is an initiative launched by the European Commission in 2017 to enable the acceleration of broadband investment and deployment in order to reach EU connectivity targets.

The BCO Network has a dedicated Support Facility[35] which plans and animates the Network's capacity-building activities on an annual basis, in coordination with the European Commission Directorates-General for Agriculture and Rural Development; Communications Networks, Content and Technology; Regional and Urban Policy; and Competition.

Investment models

There are different ways for a public authority to become involved in broadband development in its territory:

- It can choose to invest directly and become the owner of the network infrastructure (in this case, the network can be run directly by the public authority owning it or by a market actor through a concession);
- It can support another actor (either a commercial operator or an end-user association) by providing them with financial and/or in-kind support.

The choice of one investment 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 territory.

Note: the investment model should not be confused with the business model, which is described in Chapter 5.

3.1 Four investment models

A fundamental choice that must be made by public authorities is how much to commit and what role to take in relation to the market, the citizens, and the businesses in the region. Four investment models can be identified:

- **Direct investment model** (also known as public design, build and operate (public DBO));
- **Concession model**;
- **Operator subsidy model** (gap funding, in-kind or in another form; also known as private DBO);
- **Community support model**[36].

The four models have been used in different areas across Europe, sometimes in different parts of the network and with different levels of success.

The degree of influence a public authority will have regarding the choice of characteristics of the project, such as the infrastructure itself, the business model or the financing tools, will depend on the investment model chosen, as described next.

36 Please note that the 'EU Guidelines on State aid for broadband networks' use a slightly different classification (see table of references at the end of the Handbook: EU 2022 BB-SA-GL, Annex IV) and distinguish between gap funding and in-kind support, rather than operator subsidy and community support. That classification makes more sense from the standpoint of State aid.

37 See also Article 76 of the CODE on "Regulatory treatment of new very high capacity network elements"

38 See table of references at the end of the Handbook: EU 2012 EPEC

INFOBOX 6

Co-investment and public-private partnerships (PPP)

In general terms, co-investment[37] refers to initiatives in which two or more investors agree to invest together to deploy network infrastructure over which to provide services such as broadband connections. Co-investment may take place in three ways:

- By establishing a **joint-venture**, meaning a new entity jointly owned and controlled by the co-investors for developing and operating network infrastructure. The joint venture sells access at active or passive level to its partners and potentially to third parties, depending on the specific business model chosen.
- By agreeing on **reciprocal access**, whereby co-investors are responsible for developing and operating their own network infrastructure (usually in geographically separate areas) and are given access to the infrastructure of all the agreement partners.
- By agreeing **long-term access**, in which one party is in charge of the construction of the network infrastructure and a contractual agreement establishes how to provide access to new infrastructure and share costs, risks and profits between all the co-investors.

The term co-investment is most often used in conjunction with private partnerships. When public actors and private actors are involved, it is usually referred to as a **Public-Private Partnership** (PPP). The term PPP may be used to designate different forms of collaborations, and PPP projects vary according to their legal structure, the parties involved, as well as other characteristics[38].

A common PPP example in broadband development is a direct investment in which the public authority decides to co-invest with other private companies. In this case, both the public and private partners own the infrastructure deployed, or parts of it, and take similar roles. This approach may be advisable if a private actor already owns key infrastructure in the territory and is willing to make it available to the project.

Examples of PPPs are also projects with elements of direct and concession investment models. Projects using a pure concession model are not really PPP in the sense that the public sector takes the ownership role and the private actor takes the role of a concessionary to build and/or operate the network, although the PPP label is sometimes used in those situations as well. Whatever form the PPP takes, care should be taken in dealing with public financing and State aid aspects.

3.2 The direct investment model

In the direct investment model, the public authority builds and operates a broadband network in the territory. As such, it is sometimes referred to as **public design, build and operate** (public DBO). Although it may take place in collaboration with the market as a PPP, in which the role of building, owning and operating the network is shared with a private actor (see INFOBOX 6), what defines the model is that the public authority is directly involved in the design, deployment, operation and ownership of the network, at least at the passive or physical layer (see section 4.1).

Typically, a special-purpose company, an in-house entity, or a dedicated division within an existing in-house entity, needs to be established with the task of deploying and operating the network, and procuring the necessary works from the market, from civil engineering to project management.

In this model, the public authority or special-purpose company needs a considerable engagement and bears all the financial risks of the operation, possibly jointly with the private partner if a PPP is used. On the other hand, it also retains **full control of the design and service-provisioning process**, placing it in the best position to **determine the shape of the network based on socio-economic priorities**.

The network is to be made available to all market actors under fair and non-discriminatory wholesale access conditions, in accordance with State aid rules. Generally, this is done through the **wholesale-only business model** (at the passive or active layer, see Chapter 0). The revenues raised from leasing fibre or connectivity to the retail service providers can be used to cover part of the investment costs and possibly be reinvested in network expansion.

The direct investment network model is common in the Nordic countries (for example, in Stockholm in Sweden, and Suupohja in rural Finland) and has also been adopted in Austria, France, Spain, Hungary, Latvia and Lithuania, among others.

A **PPP-enabled version of the direct investment model** can be followed, which leverages the presence of a private actor with extensive fibre infrastructure and willingness to collaborate (see INFOBOX 6).

INFOBOX 7

Direct investment examples

There are many examples of direct investment, from national projects to regional and even municipal projects. Nowadays, virtually all **direct investment projects are combined with a wholesale-only business model**.

1. Lithuania's 'Rural Area Information Technology Broadband Network' (RAIN) 3 project is an example of a national direct investment, where the public authorities deploy and manage the network through a fully publicly owned network operator. The project built a new fibre backhaul network, including approximately 180 telecommunication towers as well as cabinets facilitating the connection of both fixed and fixed-wireless access networks. The measure only intends to offer the passive infrastructure and data transmission services. The network will offer open wholesale access to any operators on a non-discriminatory basis and in respect of the principle of technological neutrality. Access will be guaranteed to all the infrastructure deployed. The total investment for the RAIN project is approximately €21.4 million, with the ERDF contributing €11.3 million through the 'Economic Growth' Operational Programme for the 2007-2013 programming period.

2. One example of a regional project using direct investment is exemplified in a 2009 project in the Asturias region in Spain, where a special purpose company (GIT) was established by the municipal authority (using ERDF and national Government AVANZA funds) to build and operate a wholesale-only broadband network. The Asturcon PPP in Spain is implementing and managing the wholesale network itself (€55 million invested) in order to keep control of its roll-out objectives and to manage the network directly. The high level of control has permitted a range of competing private service providers to get involved. Services include 100/100 Mbps connections for businesses and 100/20 Mbps for residential customers.

3. Many municipalities in Sweden (from urban ones, like Stockholm, to the most rural and sparsely populated in the north of the country) have been deploying fibre networks in their territory for over twenty years, and all have used a direct investment model. Some experiments with vertical integration were run in the very beginning, but today all Swedish municipal networks operate a wholesale-only model. There is a very strong collaboration between them and regional alliances to provide single points of contact for operators and other actors wishing to lease dark fibre. The Swedish Local Fibre Alliance represents virtually all of them and has good support material as well as examples available in English. Today, these networks represent approximately 40% of Swedish fibre access networks (80% of households are connected by FTTH/FTTB).

3.3 The concession model

In the concession model, the public authority procures the building and operation of a broadband network in the territory from a private actor, which receives a concession to operate the network over a long period of time, typically 20 to 30 years.

The public authority keeps ownership of the network, while operation and maintenance are taken care of by the concessionary. There is therefore no need for a dedicated company to be established by the public authority, and both the competences required and the financial risks taken are generally limited. As a network owner, the public authority has a large influence on the design and service provisioning process. Network design and deployment priorities need to be detailed in the concession agreement, as well as the conditions of service delivery and network access, to maximise competition and to reach the objectives set out in the broadband plan.

The form of the concession can vary from case to case. Generally, the concessionary commits the investment (often complemented by significant financing by the public authority) and takes all the revenues as well as the financial risks for the whole contract period. At the end of the contract, the network infrastructure ownership remains with the public authority, who may then decide to renew the contract, to sign a contract with another company, or even to change its involvement altogether and adopt a direct investment model or sell the infrastructure.

To guarantee fair and non-discriminatory conditions to all service providers (operator neutrality), the private firm building and operating the network is normally barred from delivering its own services (wholesale-only business model). This is not always the case, however: if no operator-neutral network providers are available, a vertically integrated operator with mandated access to competitors may get the concession. A concern related to competition at a different level, such as the concession procurement, may arise if an operator (typically the incumbent) is the only operator with existing passive infrastructure in an area. If that is the case, the operator will have a substantial advantage in any competitive procurement, so care needs to be used to maximise infrastructure reuse and comply with competition rules.

The concession model has become common in continental Europe, in regional projects as well as in larger national schemes, such as in Italy, where a wholesale-only operator has been assigned the deployment and operation of a publicly owned network in the white areas of all regions for 20 years[39].

39 See table of references at the end of the Handbook: EU 2016 BB-SA-IT

INFOBOX 8

Concession model examples

Examples of the concession investment model can be found in three French projects involving millions of households, implemented by means of a concession contract. A major portion of the equity capital is provided by investment funds complemented by State funds under a national broadband plan. A similar approach was chosen for the Austrian, Bulgarian, Croatian, Polish, Romanian, and Slovak broadband subsidy schemes.

In a broadband deployment project in the Auvergne region in central France, France Telecom has a 10-year contract to operate and extend the existing broadband network budgeted to cost €38.5 million. While principally based on DSL, the network incorporates fibre-optic loops that increase download speeds, and major service providers have been attracted to provide services to customers.

The Grand Est region of France is deploying two FTTH projects using a concession model: 'Rosace'[40] in the former region of Alsace, and 'Losange'[41], a larger project covering the rest of the Grand Est Region. The Losange project will cover with FTTH areas where private operators were not interested in investing. The 35-year concession deal establishes that the private concessionary, which is operating with a wholesale-only business model, provides approximately 85% of the funding needed to finance the deployment. The public funding was covered by the French State, the region and municipalities, and through the ERDF. There was also a significant contribution from the EIB. Once the project is completely deployed, it will cover over one million fibre connections. The concession deal establishes that the private concessionary, which is operating with a wholesale-only business model, provides approximately 85% of the funding needed to finance the deployment. The public funding was covered by the French State, the region and municipalities, as well as the ERDF and a significant contribution from the EIB. Once the project is completely deployed, it will encompass over one million fibre connections.

The Italian government launched a large national project to close the connectivity gap in rural areas[42]. The investment was divided into macro-regional tenders for white areas (see INFOBOX 24) and was carried out using the concession model. The tenders specified that the infrastructure deployed will remain in public ownership and will be made available at wholesale level to all service providers on non-discriminatory terms and under the technical and economic conditions defined by the Italian NRA, AGCOM. This formulation does not mandate a specific business model to be used, although it clearly favours wholesale-only, with tender evaluation criteria (see INFOBOX 24) awarding extra points to tenderers applying a wholesale-only business model.

40 See table of references at the end of the Handbook: ROSACE

41 See table of references at the end of the Handbook: LOSANGE

42 See table of references at the end of the Handbook: INFRATEL BUL, EU 2016 BB-SA-IT

43 See table of references at the end of the Handbook: EU 2022 BB-SA-GL Annex IV)

3.4 The operator subsidy model (gap funding and in-kind support)

In the operator subsidy model, a private actor receives support from the public authority to build or extend its own network. This can be done in two ways:

- By means of a grant, which is by far the most common way. The financial contribution that an operator receives from the public authority is intended to bridge the gap between the deployment cost and a reasonable profit, hence the term **'gap funding'**.
- By means of equity, loans and **in-kind support** (civil works, access to infrastructure, technical support).

Because of the different nature of the aid, gap funding and in-kind support are listed as two separate models in the Broadband Guidelines[43], but from the perspective of the roles taken by the public authority, market actors and the community, they can be treated as two variations of the same model.

In this model, the public authority is only marginally involved with broadband deployment in the region, limiting itself to subsidising one market actor, typically a major telecom operator, to extend or upgrade its own infrastructure. Risks associated with building new infrastructure and

attracting sufficient customers are borne by the recipients of the funding.

One advantage of this model for the public authority is the comparatively simple contractual arrangements and, in consequence, the potential for relatively rapid deployment. Another advantage is offloading risk to the grant recipient since the public authority has no direct involvement in the network deployment. The financial cost for the public authority is typically lower compared to other investment models, but not necessarily by much. For instance, a survey among BCOs found that the aid intensity in rural gap funding projects is typically above 50%, with peaks of up to 90%.

Almost the entirety of operator subsidy interventions takes the form of gap-funding, and most often the beneficiaries are incumbent telecommunications operators and large alternative providers which usually both own the network infrastructure and offer services to end users in a **'vertically integrated' model**. However, wholesale-only operators can also be beneficiaries of subsidies, and other forms of subsidy than gap funding are starting to appear[44].

Because the infrastructure built is fully owned by the subsidised operator, the public authority cannot directly collect any financial returns to be reinvested in future network deployments. In principle, if the operator makes excessive profit from the State-funded project, the public authority must 'claw back' these funds. On the basis of a claw-back mechanism, the public authority may monitor, for example, the costs and revenues of the beneficiary, comparing estimates in the funding gap proposals in the tender versus actual costs and revenues in implementing the measure, and may claw back excessive cost compensation or may share excess profits. The clawed-back amounts would then re-enter the budget of the funding public authority which may freely decide on their further allocation, including reinvesting in broadband development. This takes place very rarely; the point of a claw-back clause is rather to design the measure so that there are no excess profits to claw-back. The absence of a suitable claw-back mechanism may have many undesirable consequences, including over-compensation risks, which would be prohibited under State aid rules, and would more generally also not promote sound financial management (for example, claims from the operator for further funding at each deployment phase, ending in a larger public investment than needed or initially intended).

Other concerns revolve around competition: in general terms, public intervention should avoid reinforcing dominant positions through the careful selection of the appropriate investment and business model that ensures viability of investment over time while delivering the appropriate level of service to users.

If an operator, typically the incumbent, is the only operator with existing passive infrastructure in an area, it will have a substantial advantage in any competitive procurement and public support may lead to the reinforcement of an already dominant position. In such a situation, particular attention must be given to designing a framework that guarantees an effective and non-discriminatory access to the infrastructure for actual and potential competitors and their capacity to replicate the incumbent's offers. An effective way is by guaranteeing the equivalence of input[45] or the equivalence of output[46]. Another way is by combining the operator subsidy investment model with a wholesale-only business model.

Another challenge of tendering public support in a context where only one operator is present (often the incumbent) is the risk that, given the expected absence of competition in the tender, it may artificially inflate its costs to obtain a higher aid amount. In such cases, in addition to establishing an effective claw-back mechanism, it is necessary to foresee an independent expert audit of the bid.

44 See, for example, the RUNE network in Slovenia, which was among the 2019 winners of the European Broadband Awards (See table of references at the end of the Handbook: EU 2019 BBA-RUNE).

45 The provision of services and information to internal and third-party access seekers on the same terms and conditions, including price and quality of service levels, within the same time scales using the same systems and processes, and with the same degree of reliability and performance.

46 The provision to access seekers of wholesale inputs comparable, in terms of functionality and price, to those the Significant Market Power (SMP) operator provides internally to its own downstream businesses, though potentially using different systems and processes.

47 See table of references at the end of the Handbook: GIG STUTTGARD

INFOBOX 9

Operator subsidy examples

The operator subsidy model has been the standard approach in the first wave of public investment in broadband deployment in Europe. Typically, incumbents would receive funding to upgrade their telephony networks to make broadband available to their end-users.

Interesting recent examples are German regional networks, which often partnering with a national operator and sometimes a local utility. These partnerships primarily adopt the classic gap funding model in combination with vertical integration. One such example is in the Stuttgart region[47], where a plan was defined to deploy an FTTH network by defining goals and collaborating with local authorities and operators. The network was built and is operated and owned by the operators, while the federal, state, and municipal governments funded the gap between costs and reasonable profitability.

Projects using the operator subsidy model in combination with the wholesale-only model (see Chapter 5) have recently started to appear. For example, the Irish National Broadband Plan[48] aims to deploy a wholesale-only high-speed broadband network providing covering all premises in the country where there is no existing or planned high-speed broadband network. The project has been partially public financed, and the beneficiary will operate and maintain the broadband network over a 25-year contract.

In Poland, telecommunication operators undertook the implementation of projects for the deployment of NGA networks in underserved areas under a national scheme (the Digital Poland Project Centre[49]) whereby over 50% of the funding was provided by the state using ERDF funds. In this case, the wholesale-only model was defined in the funding scheme itself (top-down).

In Slovenia, gap funding and wholesale-only was achieved in several small projects because several operators there have chosen a wholesale-only business model (bottom-up). Some of the resulting networks have since been acquired by an infrastructure provider owned by the incumbent, thus reaching a hybrid vertical-integration and wholesale-only result.

48 See table of references at the end of the Handbook: IE NBP 2019

49 See table of references at the end of the Handbook: PL CPPC

3.5 The community support model (bottom-up)

In the community support model, broadband investment is undertaken as a private initiative by local residents in a 'bottom-up' approach. Projects employing this model have generally been very successful in driving the take-up rate[50] among the end users and in building financially sustainable cases. The business models used vary from project to project: some rely on a wholesale-only business model while others prefer to procure services from one operator for a number of years. In rare cases, community networks operate as vertically integrated operators.

The role of the public authority in this case is to provide support where needed. This may take the form of co-financing (grant financing), advising, regulating and granting right-of-way (RoW) access to local and regional infrastructure to provide backhaul connections, as well as coordinating with other infrastructure deployments (in-kind support). The public authority can also play the important role of the honest broker that helps in establishing fair conditions for all operators seeking access to the infrastructure, especially when it owns and/or operates a larger network in the municipality or region, where these operators are most likely present.

Note: In this handbook, we treat operator subsidy and community support as two different models because of the very different role the public authority needs to take in the two situations, however:

- From the point of view of State aid, the community support model is equivalent to the **operator subsidy model**;
- In the Broadband Guidelines classification[51], community support falls within either the **gap funding** or **in-kind support models**.

It is recommended that the public authority at regional or national level produces a **guide on how to start a cooperative for broadband deployment**, based on the local circumstances and tools of financial support available, noting that Member States may already have national guides as well as financing programmes or incentive schemes.

A vibrant sector of broadband cooperatives and small private initiatives has sprung up, comprising infrastructure projects in rural areas, notably in the Nordic countries and the Netherlands, as well as networking projects, known as netCommons (initiatives driven in independent and non-commercial spirit[52]), present across Europe. While the former type generally focuses on passive fibre infrastructure, the latter often relies on radio solutions using unlicensed spectrum, such as WiFi, although fibre links and FTTH solutions are becoming more common.

In some cases, community-led networks bring broadband infrastructure and services to the last mile and local area, and connect to municipal or regional networks for backhauling. 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, as seen in some Finnish regions.

In terms of implications for State aid compliance, these projects often represent relatively little State resources and can therefore be exempted from State aid rules if, for example, they are in line with *de minimis* rules or General Block Exemption Regulation (GBER) rules.

50 The percentage of connected households who decide to 'take up' the service, for example to subscribe to a broadband service.

51 See table of references at the end of the Handbook: EU 2022 BB-SA-GL, Annex IV

52 Relevant examples are guifi.net 2017 in Spain, ninux.org, and freifunk.net. For a good overview of this type of network, as well as a guide to getting them started, see NETCOMMONS 2019 in the table of references at the end of the Handbook.

INFOBOX 10

Community broadband examples

Community broadband projects have long been popular in Sweden, where there is an association gathering them and acting as support and representation[53]. The association has links both to the national municipal fibre association, to the Swedish Post and Telecom Authority (PTS) and to the national Federation of Swedish Farmers (LRF). It has over 400 members at the time of writing and receives EAFRD funding.

The project 'Optic fibre to all houses on Gotland', covering an island and region in the Southern Baltic Sea, is an example of a successfully coordinated community broadband project. It achieved complete FTTH deployment to all houses in its mainly rural region as well as its main city, Visby, by connecting the community broadband projects to the regional fibre network built by direct investment by the regional council. Most house owners invested in the project both financially as well as by offering three days of manual labour.

The 100% FTTH infrastructure was deployed in underground trenches through 92 parishes. Each parish has a local node from which a star-net is spread to all houses. At least 85% of residents and 50% of summer house owners on the island have joined the project. The competing telecom actors paid up-front a rent to the parish fibre association to provide services from the local parish node to the houses. The public administration invested €4.3 million, of which €2 million from European Structural and Investment Funds (ESIF). The dominant investment of €12 million was provided by the citizens, who now own the fibre infrastructure through the local fibre associations.

Another example is the 'Michaelston-y-Fedw' village project[54] in Wales, which installed an FTTH network delivering 1 Gbps symmetrical in the village, where the previous average connection speed was 0.5-5 Mbps. The work was carried out by local contractors as well as community volunteers. Although initial interest indicated that approximately 70 properties wanted a connection, over 200 properties in the village and surrounding area have since joined the network, at the time of writing.

With a budget of €300.000, the project saved costs thanks to the voluntary work of the local community to deploy ducting, install chambers, splice bullets, blow fibre, carry out fusion and splicing, and fit out the network hub.

53 Find out more about the Byanätsforum association at www.byanatsforum.se.

54 See table of references at the end of the Handbook: EU 2018 BBA-MyF

3.6 Choosing the investment model

While there is no universal solution, it is important to understand that the choice of investment model impacts key factors including competition, wholesale and retail prices, penetration, take-up and support to competitiveness.

The choice of model should be based on the budgetary and socio-economic context of the area, the ambitions and capacity of the public authority, as well as the development goals for the territory; it is also influenced by the cultural and political environment.

For instance, contexts characterised by populations with low demand for ICT services (due to factors such as an ageing population, low education, low ICT skills, presence of many SMEs/micro enterprises and a poor culture of innovation) may slow down penetration of broadband. To address this, long-term investment models should be chosen to allow enough time for penetration to grow and for the resulting gradual socio-economic impact to take effect. Supporting this is the fact that most of the benefits of broadband infrastructure are amassed by society and the overall economy, so short term investments are unlikely to match the returns of a medium to 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, especially depending on the level of wholesale access supported. On the one hand, a model that involves providing grant funding to meet an operator's commercial gap may achieve short-term results and requires less funding than a direct involvement model. On the other hand, such a model often relies on a vertically integrated operator and may be less pro-competitive than the direct investment model, which generally operates on a wholesale-only

business model. As such, it is less likely to create an engine for sustained future investment.

As a checklist for public authorities, some questions that will need to be answered in choosing an investment model are:

- Given the socio-economic conditions on the ground, what is the best approach to facilitate penetration of high-quality and affordable services?
- What are the concrete benefits in keeping control and ownership of the passive infrastructure and in defining the deployment priorities?
- Would it be better to keep the ownership of the infrastructure and let an operator define and execute the deployment?
- What are the pros and cons of adopting a different investment model to upgrade or expand the network?
- What is the best way to ensure that infrastructure is made available to all actors that can deliver innovation and societal value, beyond telecommunication operators?
- Is there scope to support local bottom-up citizen initiatives?

3.7 State aid considerations

As previously outlined, any use of State funds must comply with State aid rules. In general terms, State funds can be deployed to address an identified market failure, but the intervention must limit as much as possible its impact on private sector incentives to invest and must minimise distortion of competition.

- In the **direct investment model** (where the authority builds the network and operates it, often as wholesale-only, directly or via an in-house company), as the aid is granted directly without a tender, it is important that the public authority justifies its choice of network and technological solutions, and that any entrustment to a third party to design, build or operate the network is allocated through a tender.
- In the **concession model**, private sector entities receive State-awarded rights or rights combined with State funds. Typically, the public authority finances the roll-out of the broadband network, which remains in public ownership, whereas its operation is awarded through a competitive selection procedure to an operator which manages and commercially exploits it.
- In the **operator subsidy model**, the public authority supports the deployment and management of a network by an operator that will then commercially exploit it. The use of public funds turns a project that is not economically viable into one that is viable by filling the gap between the expected revenues and the costs associated to the deployment, management and exploitation of the network, allowing for a reasonable profit.
- In the **community support model**, State funds are generally a smaller part of the investment, and possibly directed at end users rather than private sector operators. Still, for State funding above the *de minimis* threshold, fair competition must be maintained among operators supplying these services.

Regardless of the investment model adopted, State aid rules require that these awards are justified by a market failure (meaning that only the commercially non-viable projects can be State supported) and that competition in the market is protected (for example, by an effective mechanism of wholesale access).

Further details on the State aid rules for broadband investment, and several examples, are provided in Chapter 8.

4

Infrastructure types and technology evolution

Infrastructure types and technology evolution

This chapter helps distinguish the concepts of infrastructure, technology and network design. It provides an overview of the different infrastructure types and provides guidance on planning infrastructure deployment in different areas.

4.1 Layers of a broadband network and the peculiarity of passive infrastructure

In order to understand the roles that public administrations can take, it is helpful to have an overview of the different layers that make up a broadband network (see Figure 3):

- The **passive infrastructure**, which consists of **physical infrastructure** (pipes, masts, ducts, inspection chambers, manholes, cabinets, buildings, entries to buildings, antenna installations, towers and poles) and the **broadband cables** themselves (the transmission medium)[55];
- The **active equipment**, or **'technology'** (transponders, routers and switches, radio base stations, control and management servers);
- The **services** that provide value to the end users (internet, telephony, TV, e-health, etc.).

Of the three network layers in a broadband network, the passive infrastructure layer often represents the bottleneck for broadband development. It is also the layer most suited to intervention by a public administration or public authority.

Similarly to other types of infrastructure (such as roads, power lines and water distribution pipes), passive broadband infrastructure is typically characterised by high capital expenditure (CAPEX), low operational expenditure (OPEX), low economies of scale, and low but stable returns over a long period. Moreover, it is highly local, hard to duplicate and inherently subject

55 The handbook refers to the passive components using the term 'passive infrastructure' or 'physical infrastructure'. Only when the handbook refers to the Broadband Cost Reduction Directive and Gigabit Infrastructure Act (see INFOBOX 23) does the term 'physical infrastructure' refer to the more restricted scope foreseen in this Directive.

to regulation because it most often constitutes a natural monopoly. On the other hand, active equipment, or 'technology', is characterised by high OPEX and economies of scale, and is subject to limited regulation.

Passive infrastructure is a quasi-permanent asset (once the cables are deployed, they have an economic life that can be measured in several decades), whereas active equipment is subject to rapid obsolescence (typically 5-15 years) due to rapid technological development and to electronics aging.

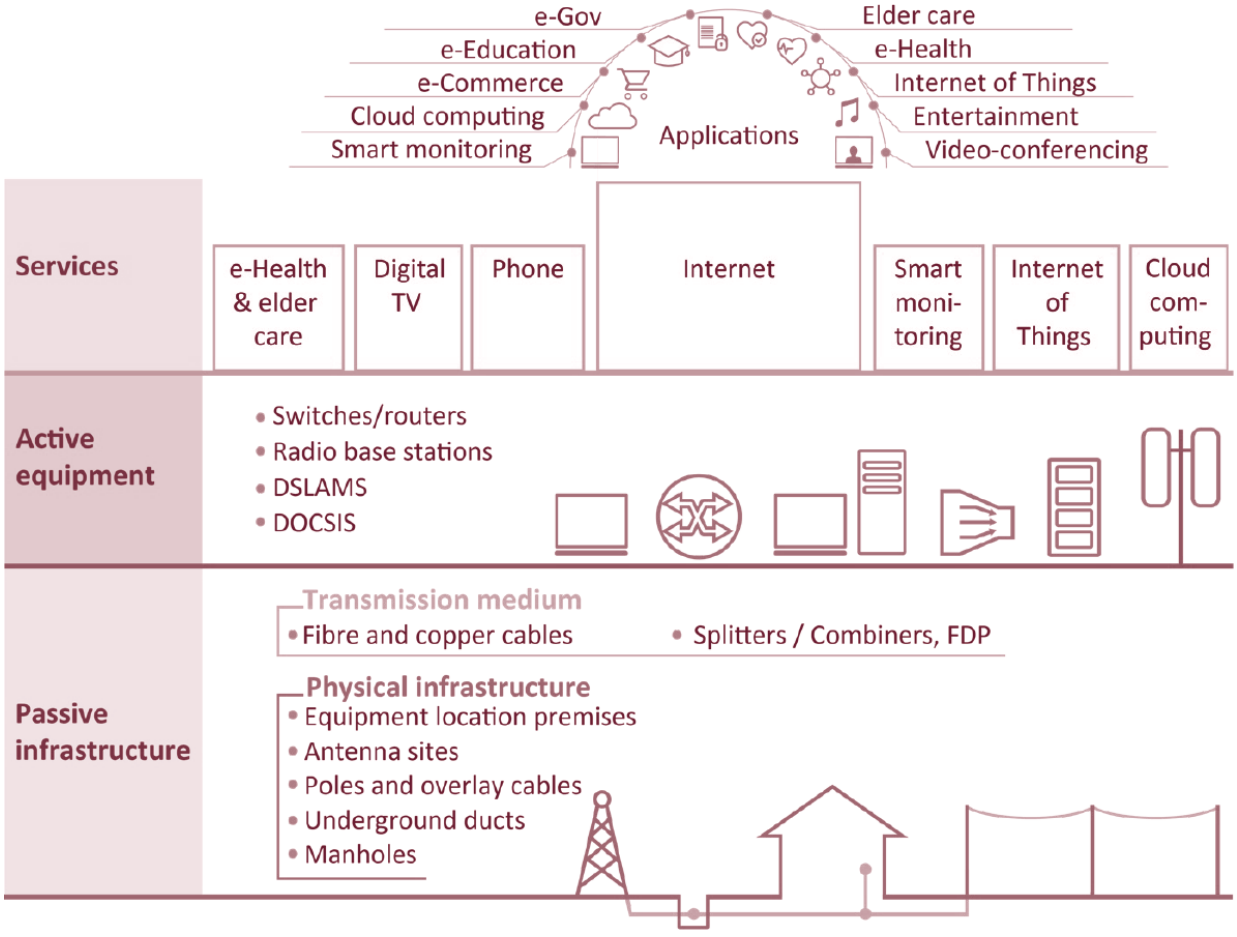


Figure 3 *– Scheme of the three layers of broadband connectivity (passive infrastructure, active equipment, and services offered to end users), as well as applications as services operating over the Internet service (over-the-top or OTT services). The figure expands the 'broadband connection' layer in Figure 2 into a passive infrastructure layer and active equipment layer.*

4.2 Passive infrastructure vs. active equipment (tehnology)

The distinction between infrastructure and technology has important market and business implications, suggesting different roles for public authorities and for market players.

One common source of misunderstanding is the distinction between these closely related concepts[56]:

- **Passive infrastructure**[57] is the **physical transmission medium** over which information is transmitted. The medium can be a twisted pair of copper wires (traditionally used for telephony), coaxial cables (traditionally used for TV distribution in buildings), optical fibres (traditionally used for transmission of very large amounts of data over very long distances), or antenna towers, dishes and sites, if transmission is done wirelessly (for example, for radio and satellite transmission). Infrastructure typically has a lifespan of over 50 years.
- **Technology** is the **active equipment** needed to encode the information into physical signals to be sent over the infrastructure. Active equipment typically has a lifespan of 5-15 years.

Each transmission medium has specific physical properties that define the maximum connection speeds achievable over it. The performance of a broadband connection is the result of how effectively the infrastructure is used by the active equipment.

4.3 Geographical parts of a broadband network (horizontal dimension)

A broadband network can be conceptually separated into three parts:

1. The **backbone** network;
2. The **backhaul** network (also known as 'area network');
3. The **access network** to reach the end users (also known as 'last-mile connections').

The **backbone network** generally consists of a fibre ring or mesh connecting different areas of the region or country. It is where the traffic from all the users in the territory is aggregated and connected to national and international networks.

The **backhaul network** (area network) connects a number of access nodes, aggregating the local traffic further up in the network. This is also often done with a ring of optical fibre cable, although tree topologies (see INFOBOX 14) can be used (this is 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 **access network** (last-mile connections) connects 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 where the first traffic aggregation takes place.

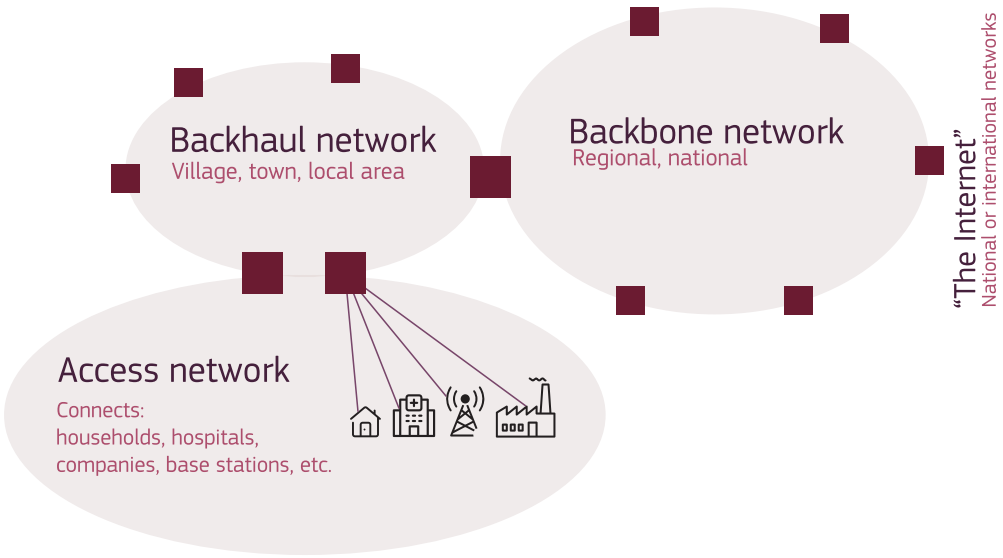


Figure 4 *– The geographical parts of a broadband network*

56 Under State aid rules, a similar distinction is made between 'infrastructure' (see the table of references at the end of this handbook: EU 2022 BB-SA-GL, Broadband Guidelines, paragraph 2.2) and 'broadband infrastructure' (in GBER see EU 2021 GBER and EU 2023 GBER), which is the equivalent of passive infrastructure in this handbook, and 'network', which is the combination of the passive infrastructure and the active equipment (the 'technology', in this handbook).

57 As explained in chapter 1, passive infrastructure includes transmission medium and physical infrastructure to host the medium as well as other facilities or elements associated to electronic communication networks, according to the definition of "associated facilities" in article 2 of the Code (see table of references at the end of this handbook: EU 2018 EECC).

INFOBOX 11

Broadband communications concepts: a metaphor

The capacity of a physical transmission medium (for example a cable or a wireless channel) is the maximum data rate achievable over it and is measured in Mbps or Gbps. This capacity, **C**, is the product of the medium's bandwidth, **B** (measured in MHz or GHz) and the spectral efficiency, **S** (which is measured in b/s/Hz): **C = B x S**.

It may be helpful to visualise a broadband connection as a package delivery service using vans over a road:

- **Information** (the 'files' or IP packets): packages to be delivered by the vans.
- **Transmission medium:** a road over which the vans travel (infrastructure).
- **Bandwidth of the transmission medium:** the width of the road (infrastructure dependent).
- **Spectral efficiency:** the number of packages than can be fit in a van (technology dependent).
- **Capacity of a transmission medium:** number of packages that can be delivered per day, hour or second.

In this metaphor, when a transmission medium is installed, we are building a road. The road will be there for a long time, whereas the vans (the communications systems / technology) will be upgraded every so often, becoming a little more efficient every time.

At the beginning, one may not need to use the full width of the road (the bandwidth of the transmission medium for a broadband network). As traffic demand increases, however, more lanes will be exploited (more of the available bandwidth for a broadband network). Moreover, the efficiency with which we can load the vans, and therefore the number of packages that each van is able to transport (spectral efficiency for a broadband network) will increase with improving technology, but only to a certain degree. As such, it is the bandwidth of the medium that ultimately sets the capacity limit.

Note: in addition to bandwidth, there are other relevant physical parameters, such as attenuation loss, dispersion and signal propagation time, which determine the quality of service attainable on a certain transmission medium.

4.4 Available transmission media for the passive infrastructure

There are five main types of physical transmission medium that can be deployed to deliver broadband services:

1. **Optical fibre** lines: glass fibre cables;
2. **Copper** telephone lines: legacy unshielded twisted pair telephone cables;
3. **Copper coaxial** lines: TV-distribution coaxial cables;
4. Air for **terrestrial wireless** communications ('radio spectrum');
5. Partial vacuum and air for **satellite communications** ('radio spectrum').

Each medium is characterised by its bandwidth, determining the ultimate capacity limit (see INFOBOX 11), as well as other parameters (such as attenuation loss, dispersion and non-linear effects), which determine the transmission reach, meaning the maximum distance over which the signal may be transmitted before it needs to be regenerated by active electronic equipment.

Another relevant parameter is signal propagation time, which is primarily determined by the distance the signal must travel from transmitter to receiver. Signal propagation time affects latency (the time it takes for a signal to reach a receiver and get an answer back). This is generally very low within the medium itself, unless the distance is in the order of tens of thousands of kilometres (as is the case for geostationary satellites).

What mainly determines latency in terrestrial communications systems is the delay accumulated for signal processing in the active equipment (signal regeneration), which can add up fast. The shorter the transmission reach, the more regeneration hops a signal has to go through before reaching the receiver, which increases latency. In addition, variations in the processing time in the active equipment make this latency unstable (jitter). Latency and jitter are undesired effects reducing the quality of the digital service, and they generally increase with the number and complexity of electronic processing units encountered along the way.

Finally, depending on how the infrastructure is built, a physical transmission medium may need to be shared among different users. In this situation (referred to as shared medium), the achievable data rates per user is also reduced as the number of users increases. Generally, air is used as a shared medium and cables as dedicated media, but this is not always the case. For instance, an optical fibre access network can be built with dedicated cables to each user (point-to-point, or p2p), or in configurations where end-user fibre lines are aggregated into one fibre connecting to the same equipment at the access node (point-to-multipoint).

This is also the case for coaxial cable networks. Conversely, it is possible to build point-to-point wireless systems for a reduced number of end users and high frequencies. Twisted pair connections (phone lines) do not technically share a medium: every end user is connected by a dedicated phone line to the access node. However, because of the physical proximity of the lines and their unshielded nature, interference across lines occurs, which limits the achievable data rate in a similar way to shared medium connections.

Table 1 shows the two most basic physical properties of different infrastructure types (physical media):

- Available bandwidth;
- Indicative transmission reach, expressed as distance after which the signal attenuates to well below 1% of the initial power.

As can be seen in the table, there is an enormous fundamental difference between copper-based (such as coax and twisted pair) and wireless infrastructure, and fibre. The low power consumption in fibre-based technologies is in part due to the low attenuation loss, allowing for long transmission reach (meaning fewer signal repeaters) and in part to the available bandwidth (meaning much less complexity and computational power needed to transmit signals over the medium).

	Fundamental properties of physical medium		
	Shared medium in last mile	**Available bandwidth**	**Available bandwidth**
Fixed			
Fibre p2p	No	50 000 GHz	80 km
Fibre p2mp	Yes	50 000 GHz	20 – 45 km (32 – 8 users)
Coaxial cable	Yes	1 GHz	0.1 – 3.0 km (high – low speed)
Twisted pair	No	0.05 GHz	0.2 – 2 km (high – low speed)
Wireless			
mm-waves	Yes	1 GHz	1 km, w/o hinders
low- and mid-band waves	Yes	0.05 GHz	few km
Satellite	Yes	10 GHz	--

***Table 1** – Infrastructure types, fundamental physical properties*

58 For examples, see table of references at the end of this handbook: TUCKER 2008 and LI 2020

4.5 Broadband access solutions (infrastructure in the last mile)

In the access part of broadband networks, there are different ways of using and combining the different infrastructure types, giving rise to different access solutions. The different solutions differ on how close fibre is brought to the end user and whether the connection is fixed or wireless. Below are the main options available.

Fibre-to-the-home (FTTH) is, as the name suggests, the solution in which fibre reaches all the way to the end user's living or working space, over which Ethernet p2p or PON technologies can be deployed. In a variation of FTTH, called-to-the-building (FTTB), the fibre medium only reaches the building, and internal cabling is used to connect the single living or working units (see INFOBOX 12). FTTH/FTTB requires high upfront investment (capital expenditure, CAPEX) because of the civil works required to install new ducts and cables, but it is characterised by low operational costs (OPEX) and future-proof physical characteristics.

In addition, the power consumption of fibre-based technologies is much lower (in the order of 10 times lower[58]) than technologies using copper or wireless infrastructure, helping regions and Member States to meet increasingly challenging CO2 emission reduction goals. Two variants of FTTH/FTTB exist (see INFOBOX 14 for topology and technology considerations):

1. a **point-to-point** FTTH/FTTB solution, in which dedicated fibre cables connect each user to the aggregation node, with Ethernet p2p or PON technologies;

2. a **point-to-multipoint** FTTH/FTTB solution, in which the aggregation node connects, via a feeder cable, to a passive signal splitter which in turn is connected to each end user by a dedicated cable, with PON technologies.

An alternative solution is to use the **legacy telephone unshielded copper twisted pair** (the existing telephone lines) for the last mile, over which technologies such as asynchronous digital subscriber line (**ADSL**) and very-high-speed digital subscriber line (**VDSL**) have been successful in providing basic broadband connections over the past two decades or so. This solution has the advantage of copper telephone lines already being present in most households.

For it to be able to carry fast broadband connections, however, it often needs to be upgraded and this is not always possible. If the length of the telephone line is very short (a few hundred metres) and in good condition, VDSL technology can deliver fast broadband today, and **vectoring** technology can further increase the available speed to the order of Gbps, at the cost of increased operational expenditure (OPEX) and reduced unbundling possibilities (unbundling is used to give competing operators physical layer access to end users). To be able to use VDSL and vectoring, fibre often needs to be taken a step closer to the user, generally by installing a new **street cabinet**, halfway between the end user and the access node, or even to a **distribution point** just outside the end user's building. For this reason, VDSL and the vectoring solutions are often referred to as fibre-to-the-cabinet (**FTTC**) or fibre-to-the-distribution-point (**FTTDP**) and the services delivered over that infrastructure are sometimes misleadingly marketed as "fibre broadband", although the end user is still connected by a legacy copper twisted pair cable.

A drawback of xDSL technology is that it is heavily asymmetrical: upload speeds are generally much lower than download speeds. This may hamper services such as cloud computing, video conferencing, teleworking, among others.

Copper-based installations come in three variations:

1. Twisted-pair copper with **fibre in backhauling only**, using ADSL or VDSL (although this will in most cases not be able to deliver 30 Mbps);

2. Twisted-pair copper with **fibre-to-the-street-cabinet** (FTTC), using VDSL, VDSL2 and vectoring;

3. Twisted-pair copper with **fibre-to-the-distribution-point** (FTTDP), using for example G.fast.

Another solution is to use existing **coaxial cables**, typically used for TV distribution within buildings and in some urban areas also connecting buildings to a TV distribution network. This medium has slightly more room to deliver higher broadband speeds than telephone lines. Fast broadband is available on many cable-TV networks, and if infrastructure is properly upgraded and distances kept short (tens of to a few hundred metres), ultra-fast speeds may become possible in the short/medium term. In this case, bandwidth is shared among several users. This means that the available bandwidth for each user will be reduced during peak hours.

In addition, coaxial copper infrastructure is seldom present in 'digital divide' areas, and is generally exempt from unbundling regulation, so only one operator is selling services over the network.

Installations based on coaxial cable infrastructure come in two main variations:

1. Coax with **fibre-to-the-street-cabinet** (FTTC), using DOCSIS 2 technology;

2. Coax with **fibre-to-the-distribution-point** (FTTDP), using DOCSIS 4 technology.

There is also the possibility to use air as a transmission medium to connect households and workplaces. This solution is generally referred to as **fixed wireless access** (FWA). This requires infrastructure for **terrestrial wireless** broadband, mainly consisting of **antenna sites for point-to-multipoint** connections. Wireless solutions have the advantage of not requiring the deployment of last mile infrastructure aside from the antenna sites. Because the bandwidth of wireless systems is shared, however, high achievable data rates require a very dense deployment of fibre-connected antennas. As such, the goals of cost reduction and high data rates are in conflict, and whether a wireless system can be cost-effective in sparsely populated areas depends on a fine calculation, and on the investment horizon (shorter time horizons favour wireless solutions, and longer horizons favour fibre solutions[59]).

Another aspect is whether licenced or unlicenced spectrum is used. To simplify, licenced spectrum is free, but the risk of interference between services makes its use less efficient. There are several technical solutions on the market (5G being the most talked about as of today), most of which require the use of licensed spectrum. From the infrastructure investment point of view, though, it is more relevant to identify three variants:

1. **FWA** using **unlicensed spectrum**, for example using WiFi technology;

2. **FWA** using licensed spectrum in **low or mid-frequency band** and mostly existing antenna sites, for example using **LTE/4G** or **5G** technology;

3. **FWA** using licensed spectrum in the **millimetre wave** band (for example 26, 28 or 60 MHz) and installation of new antenna sites, in combination with, for example, **5G** technology.

Finally, **satellite connections** can also be used to cover large, very sparsely populated areas with a limited total number of users. Satellite connections do not need to use the regional backbone and area networks but require the deployment of end-user equipment. There are two main types of satellite connections.

The first uses **geostationary satellites**, and services based on those have been available for a long time. Issues concerning the quality and affordability of services, especially inherently high signal latency due to the propagation time to and from the satellite (36,000 km), hamper certain applications. This often makes geostationary satellite connectivity a complementary rather than an alternative infrastructure solution, even though in specific circumstances (for example very remote/mountainous areas), this solution may be the only viable option.

The second type uses **low earth orbit (LEO) satellites**, orbiting at much lower altitudes (approximately 1,000 km). These satellite systems are much more challenging to build but allow for lower latency, as well as higher data rates per user. LEO-based services are slowly starting to appear, and the European Union is planning to deploy an EU satellite constellation called IRIS2 (Infrastructure for Resilience, Interconnectivity and Security by Satellite), which will enable secure communication services by 2027[60].

Installations based on satellite infrastructure come in two variations:

4. Satellite receiver and antenna dishes to subscribe to **legacy geostationary satellite services**;

5. Satellite receiver and antenna dishes to subscribe to **new LEO satellite services**.

In the coming years, upgrades in satellite technologies such as 'direct to device' (D2D) satellite service are likely to deliver higher quality of service to end users in a variety of different contexts from agriculture and environmental monitoring, to emergency response and civil protection, among others. This handbook is expected to include an additional chapter on satellite technologies once a sufficient amount of case practice has been built.

59 See table of references at the end of this handbook: LI 2020

60 See table of references at the end of this handbook: EU 2022 IRIS2

	Current commercial technology		Fundamental properties of last-mile physical medium		
	Top commercial technology	Top data rate (down/up)	Shared medium	Available bandwidth	Indicative transmission reach
Fixed					
1. FTTH/ FTTB p2p	10GbE	10/10 Gbps	No	50 000 GHz	80 km
2. FTTH/ FTTB p2mp PON	XGPON	up to 10/2.5 Gbps	Yes	50 000 GHz	20 – 45 km (32 – 8 users)
3. Twisted pair with fibre in the backhaul	ADSL2+	24/3 Mbps	No	0.05 GHz	0.5 – 2 km (high – low speed
4. Twisted pair with FTTC	VDSL2 + vectoring	up to 90/40 Mbps	No	0.05 GHz	0.2 – 0.5 km (high – low speed)
5. Twisted pair with FTTDB	G.fast	up to 500/500 Mbps	No	0.05 GHz	<200 m (high – low speed
6. Coaxial cable with FTTC	DOCSIS 2	up to 40/30 Mbps	Yes	1 GHz	0.5 – 3.0 km (high – low speed)
7. Coaxial cable with FTTDB	DOCSIS 4.0	up to 10/6 Gbps	Yes	1 GHz	<100 m
Wireless					
10. FWA at mm-waves	5G	up to 10/5 Gbps	Yes	1 GHz	Less than 1 km, w/o hinders
9. FWA at mid-low waves	5G, LTE/4G	100/20 Mbps	Yes	0.05 GHz	Few km
8. FWA with unlicenced spectrum	Wi-Fi 5	up to 7/1.3 Gbps	Yes	0.5 GHz	Less than 1 km
11. Satellite (GEO)	Ka-band systems	up to 20/8 Mbps	Yes	10 GHz	N/A (latency inherently high)
12. Satellite (LEO)	Multi-constellation systems	up to 350/25 Mbps	Yes	10 GHz	N/A (latency comparable to copper

Table 2 *–Infrastructure types, fundamental physical properties and supported transmission technologies*

As apparent from Table 2, from the performance standpoint, FTTH/FTTB is the ultimate long-term solution.

A **mix of infrastructures** may be needed in the **short and medium term**, depending on considerations involving population density, digital maturity, socio-economic structure, geography and financial resources. For instance, while FWA in the 700 GHz band may be a good solution to connect a small number of rural households in a context involving, for example, difficult terrain, installing FTTH may be a better solution for a similar case elsewhere, where, for example, the terrain is easier and there are existing ducts, while in a third case, FTTC and VDSL may be the best solutions for, for example, a remote village with few houses concentrated around an existing access point.

Table 3 gives an overview of the advantages and disadvantages of different choices.

Infrastructure and connection solution	Advantages	Disadvantages
1-2. Full fibre (FTTH/FTTB) benchmark	• Future-proof, extremely high level of service, symmetry • Allows for technology requiring very low energy use	• High investment in passive infrastructure
3-5. Copper upgrade (FTTC+VDSL over existing phone lines)	• Relatively low investment needed for passive infrastructure • Least disruptive for the end users	• Low available bandwidth • Data rates limited by distance, potential competition issues for highspeed solutions (vectoring) • Most of the investment needed is in short-term active equipment (lifespan of 5-10 years) • Interim solution – increased requirements in the future will require new infrastructure deployment
6-7. Coaxial cable upgrade (for example FTTC+DOCSIS 3, 4)	• Relatively low investment needed for passive infrastructure • Least disruptive for the end users	• Only one service provider due to lack of technical feasibility of unbundling regulation • Interim solution – increased requirements in the future will require new infrastructure deployment
8-10. Terrestrial wireless (FWA)	• Last mile wire connections not needed • Infrastructure can be used for commercial mobile services as well, subject to certain conditions	• Data rates drop as distances and number of users increase • Weather dependant for some frequency ranges • Interim solution – increased requirements in the future will require new infrastructure deployment
11-12. Satellite wireless	• Backbone and area networks not needed: low investment needed for passive infrastructure • Easy to connect users scattered over a relatively large area (regional, macro-regional or even national) • Connection cost independent of location (good bargain for very isolated premises)	• Relatively low data rates and high latency in today's systems (geostationary), although new LEO systems mostly solve these issues • Weather dependent for some frequency ranges • End-user equipment is costly

***Table 3** –Advantages and disadvantages of different infrastructure choices*

61 For example, see table of references at the end of this handbook: ASAI 2019

INFOBOX 12

FTTH/FTTB vs FTTC+VDSL

The term FTTx is used as a catch-all term to describe any infrastructure that contains fibre in at least some portion of the access network. There is a fundamental difference between FTTH/FTTB and FTTC:

- When fibre reaches an end user's living or working space, we speak of **FTTH**.
- When fibre only reaches the basement of a Multiple Dwelling Unit (MDU) (for example, an apartment building) and from there each household is connected by a dedicated **non-fibre in-building cable** (typically CAT6) owned by the MDU owner or the households, we speak of **fibre-to-the-building** (FTTB). FTTB is classified as a last-mile infrastructure because the fibre/copper handover takes place at the termination point of the service provider.

Solutions especially popular among incumbents with legacy copper infrastructure consist of using fibre to the cabinet, or to reach a distribution point between the cabinet and the end users, from which existing last-mile copper lines are used to deliver the broadband service to the end users, typically using VDSL or G.fast. This approach is referred to as fibre-to-the-cabinet (FTTC) or fibre-to-the-distribution-point (FTTDP). Because the end users are still connected by copper lines, **FTTC+VDSL and FTTDP+G.fast are not fibre access infrastructure**. The FTTH Council has called for a ban to market FTTC+VDSL connections as 'fibre', and some Member States are updating advertising guidelines along those lines[61].

INFOBOX 13

Network infrastructure topologies

The topology of a network describes how the different parts of a network are connected. The most relevant topologies for 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 the case of a fibre cut or other fault, certain parts of the network will be disconnected for long periods of time. 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 given node is connected to two neighbouring nodes (this is sometimes referred to as 'redundancy'), so if a fibre cuts 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 expensive topology.

For the last mile, two main basic topologies exist:

- **Point-to-multipoint (p2mp):** the first aggregation node is connected to a number of end users, partly over a shared medium. In wireless networks, this is the standard situation, with air being the shared medium. In wired networks, it represents the case in which the first aggregation node connects, via a feeder cable, to a passive signal splitter which in turn is connected to each end user by a dedicated cable.
- **Point-to-point (p2p):** each end user is connected to the first aggregation node by a dedicated physical communication link. In wired networks, a cable connects the end user to the first aggregation node. In wireless communications, this can be achieved if the communication beams do not overlap with each other (radio links).

As explained in INFOBOX 14, p2p topologies can be used to deploy both p2p technologies (in which each an end user's physical signal is delivered over a dedicated connection) and p2mp technologies (in which the same physical signal is received by all end users, who then share the bandwidth). The opposite is not possible.

INFOBOX 14

Fibre access: PON vs Ethernet p2p and topology choices

There are two main options when building fibre-based last mile connections:

- Ethernet point-to-point (p2p) technology;
- Passive Optical Network (PON) technology.

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 requiring less physical space and fewer fibre terminations 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. In general, incumbents and large operators tend to prefer PON, while other service providers tend to prefer Ethernet p2p.

The type of topology chosen for the passive infrastructure (see INFOBOX 13), however, has an influence on the degree of choice. Specifically, a p2p infrastructure may be used to deploy both PON and Ethernet p2p, whereas a p2mp infrastructure is only suitable for PON.

4.6 Network robustness

Broadband networks represent a critical infrastructure on which society increasingly relies for everything from economic activity and entertainment, to health, governance, democracy, education, and more. As such, broadband networks need to be robust against both physical and digital attacks and accidents. This involves physical security of crucial premises and network access points, proper deployment techniques to minimise the risk of cable cuts and other disruption, but also intelligent topology design to make networks resilient to potential disruptions.

The ring topology, for instance, has the advantage of being robust because in the event of single fibre cuts or other faults, traffic flowing clockwise can be rerouted in the anti-clockwise direction without disruption. Another way to increase resilience is to make sure that a parallel (additional) infrastructure can be used as backup in the event of failure on the primary infrastructure. For instance, a wireless communication network can be used as backup for a possible failure in a fibre-based broadband network, and satellite links as a further backup solution.

Network robustness has to do with the infrastructure. Another very relevant topic is that of cyber security, which pertains to the digital services being delivered over the network as well as the equipment and infrastructure used to deliver them.

INFOBOX 15

5G opportunities and challenges

The fifth generation of mobile networks, 5G, is a technology that promises to revolutionise mobile communications and which is now at the initial stages of deployment around the world. While previous generations of mobile phone technology were purpose-built for delivering communication services, 5G is driven by use cases such as smart cities, smart grids, smart mobility, e-health, smart agriculture and more, in three application areas:

- Enhanced Mobile Broadband (eMBB);
- Ultra-reliable and Low Latency Communications (URLLC);
- Massive Machine-Type Communications (mMTC).

In broad terms, eMBB is improving the performance of mobile broadband; URLCC is what would allow time-critical applications with extremely high reliability requirements, such as autonomous driving and remote surgery; while mMTC is an enabler of Internet of Things (IoT) by allowing thousands of devices to send data with low time and volume requirements.

The deployment of 5G entails several challenges connected to, for example, frequency awards and coordination, establishment of transport corridors across Member States, use of non-EU countries' technology in critical components, among others. These are themes which are being addressed at national and EU level but go beyond the scope of this handbook, which focuses on fixed broadband access. For further information on this topic please consult the EU Toolbox for 5G Security[62].

Achieving the very high speeds often advertised in connection with 5G mobile services requires high densities of antenna sites and an extensive fibre infrastructure to connect them (fibre backhaul). While in densely populated areas, market conditions exist for mobile operators to build the necessary fibre backhaul, this may not be the case in more rural areas. Here, the presence of a fibre network for the delivery of fixed broadband may become an important enabler of 5G by leasing out fibre connections to mobile operators to use as backhauling. In other words, far from being a replacement for wired broadband infrastructure, 5G will represent a further driver for fibre deployment.

62 EU toolbox for 5G security: https://digital-strategy.ec.europa.eu/en/library/eu-toolbox-5g-security

63 See table of references at the end of this handbook: EUTC 2019

INFOBOX 16

IoT, utilities and network requirements

Internet of Things (IoT) refers to the broad system of connected devices, from sensors to machines and actuators, able to directly communicate with each-other with the goal of automating functions like monitoring, maintenance, etc. Utilities increasingly rely on broadband networks to leverage IoT services critical to the reliable supply of electricity, including real-time monitoring of power distribution and transmission, protective relays, energy management, outage management, smart metering, substation automation. IoT represents a new driver for broadband networks, since its applications set stringent requirements, which the European Utilities Telecom Council broadly defines below[63].

- **Data rate:** as power grids are moving away from a modest number of small, centralised generating stations (<60 in most EU States) to tens or even hundreds of thousands of distributed facilities, data rate requirements will vary between 100 Kbps and 10 Gbps. Artificial Intelligence applications and increased mandatory cybersecurity requirements also increase speed requirements.
- **Latency:** in the most stringent applications (inter-tripping and teleprotection), latency needs to be less than 3 milliseconds, to prevent damage to equipment (fire, explosion) and to isolate fallen conductors before there is a chance for ignition. For most electric utility applications, there is a need to achieve latency of less than 10-20 ms, typically.
- **Jitter:** requirements are application dependent, from a few microseconds to several milliseconds.
- **Packet loss:** should be lower than 0.01%.
- **Availability:** stable 24/7 communications infrastructure is required to guarantee its reliable function. Availability is most important at times of crisis, such as natural disaster, extreme weather, terror attack, strike action or outbreak of a major disease.
- **Reliability:** requirements are extremely high overall (99.9999%). Individual elements of the network can have lower reliability (99.99%) but must be used in combination with other elements which have dissimilar failure mechanisms.
- **Security:** paramount. Utilities are considered 'critical national infrastructure' (CNI) and similar levels of physical and cybersecurity are applied to those found in ports, airports, banking and military installations.

4.7 State aid implications of infrastructure and technology choices

Two aspects of infrastructure and technology choice are particularly important under State aid rules:

- First, the subsidised infrastructure and technology must address the identified market failure in terms of end users' needs. In designing the intervention, the public authority should establish which end users' needs the current and planned networks are not able to address. The new publicly financed network must address such end users' needs and represent a step change over the existing networks.
- Second, the subsidised network must be able to provide an adequate range of wholesale access products without introducing unjustified limitations. For example, in a fixed backhaul network, ducts should be large enough to cater for a sufficient number of operators.

5

Business models

The business model defines the roles and responsibilities of different actors in the broadband value chain. Depending on which actor takes up each role, different business models can be identified.

This chapter describes the different business models available to public authorities and other market actors. The chapter opens with a brief definition of the three main business roles and goes on to describe the different relevant actors typically active in the broadband market with a special focus on the public authority.

INFOBOX 17

Investment model vs. business model: what is what?

In the context of a broadband investment by a public authority:

- The **investment model** (see Chapter 3) describes the role of the public authority in terms of how it makes the investment: whether the public authority decides to build, own and/or run the network, possibly in collaboration with market actors, or whether and how the investment takes the form of financial support to another market actor (an operator or local community).
- The **business model** describes how the deployed network is being run in terms of business roles and value chain: is the entity operating the infrastructure also delivering services to the end users (a vertically integrated business model) or is it only providing access to independent retail service providers (wholesale-only models)? In that case, is access provided at passive or active layer? Is access provided directly or through an intermediate actor (the network provider)?

While some business models are more commonly used in combination with certain investment models (for example direct investment and wholesale-only at passive layer, concession model and wholesale-only at active layer, operator subsidy and vertical integration), examples of virtually any combination can be found (see Table 4). The optimal choice will depend on each specific case.

5.1 Network layers, business roles and business actors

As previously outlined, a broadband network broadly consists of **passive infrastructure** (ducts, cables, masts, premises) and **active equipment** (transponders, routers and switches, control and management servers). **Services** are delivered over these. The three layers are characterised by different technical and economic features, and three main business roles can be identified:

- The **physical infrastructure provider (PIP)** owns and maintains the passive infrastructure (characterised by long-term investments and limited need for technical knowledge). Several business actors can take on this role: telecom operators, housing associations, local cooperatives, MDU owners, municipalities, regions, national governments, homeowners, or public and private actors with long-term investment plans.
- The **network provider (NP)** operates and typically owns the active equipment (characterised by shorter-term investments and a strong need for technical knowledge) to offer service provider (SP) connectivity to the end users. Depending on the business model, it may often be integrated with either the PIP or SP role, but sometimes the NP role is taken on by a neutral operator (sometimes called communication operator) with experience and knowledge in operating active telecommunication networks.
- The **service provider (SP)** delivers the broadband services and, as such, is characterised by short-term investments and high end-user interaction, and only needs to place equipment in a central location (such as the regional data centre) and interface with the NP's equipment. Several types of business actors can take on the SP role: local operators with or without their own infrastructure in other parts of the territory, national virtual operators, or large national and international operators, such as telecom incumbents.

Note: although we use the terms PIP, NP and SP to define different business roles, the term **operator** designates a business actor operating and selling broadband services. Operators typically take up the SP role, often combined with NP and sometimes even PIP (vertical integration). In certain situations, they may exclusively take the NP or PIP role, particularly in the regulatory context of mandated access.

The **end user** business role may be taken up by private citizens, small or large companies, hospitals, schools or public administrations, among others, who are purchasing services over the broadband network.

A network's **wholesale customers** are entities who lease dark fibre from the PIP, or connectivity from the NP, for their own communication needs. These can be broadband SP, NP, NP+SP, mobile operators, cable operators, banks, large enterprises, the public sector, etc.

5.2 Vertical integration vs. wholesale-only

Depending on which market actors take on which roles (PIP, NP, SP), different business models arise:

- A **vertically integrated** model (typically but not exclusively large telecom operators);
- A **wholesale-only** model.

In the vertically integrated model, one market actor takes on all three roles.

In some cases, for instance if an operator is deemed to have significant market power (SMP), regulation mandates wholesale access to competitors, either at the passive or the active layer, as discussed below. Similarly, if the network has been publicly financed, wholesale access is mandated for compliance with State aid rules. In that case, the network owner designs the network to deliver its own services and gives wholesale access to its competitors.

Note: wholesale access obligations imposed in compliance with State aid rules may be broader than wholesale access regulation imposed under regulatory rules.

If, on the other hand, the roles are separated, and the entity operating the infrastructure is not providing end-user services, we speak of a wholesale-only model.

Network owners running a wholesale-only business model are typically public authorities, cooperatives or private firms operating a publicly owned network, but the model is also increasingly employed by private network owners. A wholesale-only model can take different forms depending on whether the network owner operates at PIP level alone or also at the NP level, and whether a third-party network provider is employed. As such, we can identify three variations of the wholesale-only models[64]:

- Passive-layer wholesale-only;
- Active-layer wholesale-only;
- Mediated wholesale-only.

Note: because the greatest cost in fibre deployment is not the fibre cable itself but rather the civil works to install it, tens or hundreds of parallel fibres are usually deployed. As such, fibre in the backbone network generally tends to be leased to third parties (such as mobile operators, cable operators and service providers, as well as to non-telecom companies including utilities, banks, TV production companies and large corporations, among others), regardless of whether there is competition in last mile connections.

64 In the previous edition of this handbook, these models were referred to as passive-layer open model (PLOM), active-layer open model (ALOM) and three-layer open model (3LOM).

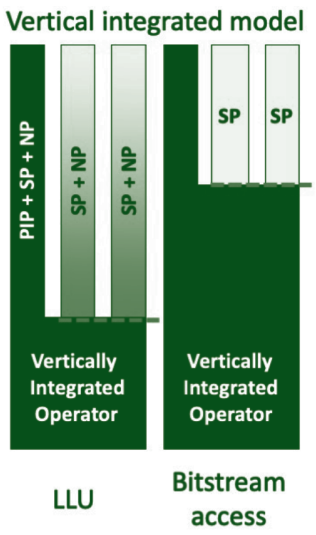


Figure 5 – The vertically integrated business model with network access at passive or active layer.

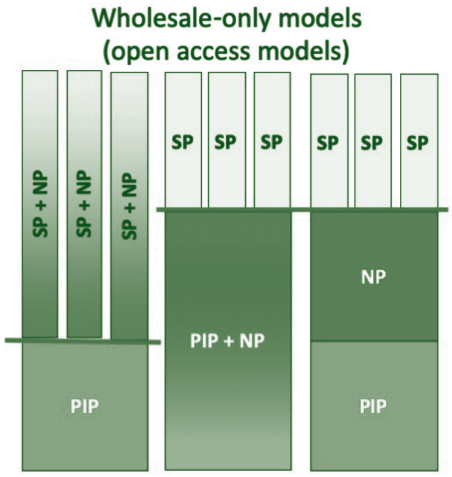


Figure 6 – Three variants of the wholesale-only business model; with passive-layer access, active-layer access and mediated active-layer access.

65 This can be a substantial fee in some markets, such as in Sweden, where this is generally regarded by homeowners as an investment increasing the market value of the property

66 Rare cases do exist in which independent NPs offer connectivity services to SPs, which prefer not to deploy their own equipment in the access nodes.

In Figure 7, the generic value chain for the wholesale-only business model is shown. 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 PIP to deliver services to the end users. To guarantee fair and non-discriminatory conditions to all SPs (**operator neutrality**), the NP is typically barred from delivering its own services.

The end users obtain the services from the SP of their choice and pay a service fee. The service fee generally includes a network fee which is then passed on to the NP (in some cases, it is paid directly to the NP). The PIP may also receive revenue from end users in the form of a single-instance connection charge to the PIP and/or a monthly network fee[65].

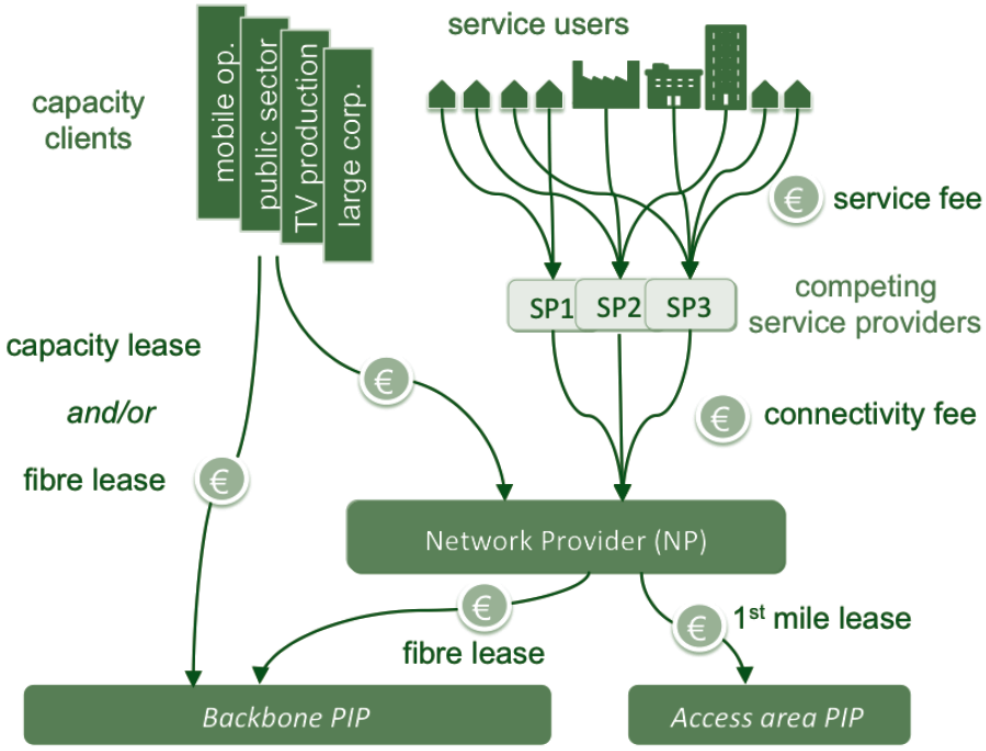


Figure 7 *– The generic value chain for the wholesale-only business model. Note that, in some areas, the same entity takes on both roles.*

The next three sections describe the three wholesale-only models in more detail. The fourth section gives an overview of the vertically integrated model.

5.3 Passive-layer wholesale-only model

In the passive-layer wholesale-only model (referred to as the 'passive-layer open model' (PLOM) in the previous edition of this handbook) an entity builds and operates passive infrastructure to be made available to all market actors under fair and non-discriminatory conditions. This entity can be the public authority, a local cooperative, or a private investor, depending on the investment model chosen.

The entity deploys the passive infrastructure either directly or through civil engineering and network deployment companies.

The PIP operates the passive infrastructure and runs maintenance, while independent operators get direct access to their customers by leasing physical connections from the network owner (PIP). The NP and SP roles are, as such, normally integrated[66].

The PIP receives revenue from operators, who lease dark fibre to deliver their services (or those of 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. The PIP may also receive revenue from the end users in the form of a single-occasion connection charge and/or

monthly network fee (in some cases, included in the monthly rent as an extra housing service, in the same way as a lift or other common area maintenance).

The passive-layer wholesale-only model has the advantage of giving operators maximum freedom and control in the design of their access network. The drawback is that each competing operator needs to deploy active equipment in the access node of each area they want to serve. If the population density is too low, each access node will only aggregate a small number of users, making it economically unviable to have more than one operator in each area. This reduces competition and keeps OPEX and CAPEX costs high.

For these reasons, the passive-layer wholesale-only model is **best suited to relatively large and densely populated areas**. The passive-layer model is typically used by municipal networks in large cities, where the public authority takes the backbone PIP role. A prominent example is the Stockholm fibre network.

5.4 Active-layer wholesale-only model

The solution that many wholesale-only network owners have selected in **more sparsely populated** areas is the active-layer wholesale-only model (referred to as the 'active-layer open model' (ALOM) in the previous edition of this handbook), in which competition between service providers is achieved by offering network openness at the active level, so that network cost (design, active equipment and deployment, as well as operation and maintenance) is low enough to encourage market entry.

In this model, one entity deploys and operates both the passive and active layers (acting as an integrated PIP+NP). This entity places active equipment in all access nodes and builds an **operator-neutral network** over which independent service providers get active-layer access, typically by placing their equipment in a central location, to deliver their services to all end users.

The main difference of this model, compared with the passive-layer wholesale-only model, is that one entity oversees the installation of active equipment in all access nodes. Although this reduces the freedom of operators in designing their own access network, it makes it easier and more economic to deliver services to all end users in the network.

5.5 Mediated wholesale-only model

In the mediated wholesale-only model (referred to as the 'three-layer open model' (3PLOM) in the previous edition of this handbook), the roles of PIP, NP and SP are explicitly separated. In this case, the public authority has the same role as in the passive-layer model, but at the active layer, the NP role is assigned by procurement to an external entity.

This third-party NP acts as a **mediator** by placing active equipment in all access nodes, and builds a wholesale-only, operator-neutral network. Independent service providers get active-layer access, typically by placing their equipment in a central location to deliver their services to all end users.

Service providers perceive the mediated model as very similar to the active-layer model. From the perspective of network owners (PIP), the mediated model requires a similar level of engagement and technical competence as the passive-layer model. The mediated wholesale-only model can therefore be a good option for **smaller networks in sparsely populated areas**.

5.6 Vertically integrated model

Incumbent telecommunications operators and, to a large extent, large alternative operators, usually own the infrastructure and offer services to end users in a vertically integrated model.

If, as is typically the case with an incumbent, the vertical operator 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 (which is called **local loop unbundling** or LLU) or at the active layer (this is generally referred to as **bitstream**).

With bitstream access, competing operators place their network equipment in a data centre where they can interface with the network owner. With LLU, they can place their equipment in the access nodes of the areas they want to serve, provided there is physical space for their equipment. If State aid is involved, the network must be dimensioned to allow effective open access.

Copper upgrade solutions, such as FTTC+VDSL (see INFOBOX 12), may be incompatible with physical LLU in cases where there is a lack of space for competitor operators' equipment in the street cabinets, or if vectoring is used. Virtual unbundling can be used to replace physical unbundling, however, provided certain conditions are respected[67].

67 The circumstances under which virtual unbundling is required under State aid rules are discussed further below. Further discussion of access requirements under State aid rules is provided in Chapter 8.

Regardless of whether network access is provided at the passive (LLU) or active (bitstream) level, a conflict of interest will likely arise from the fact that the network owner is essentially competing with its customers. This can result in competition distortions in retail service markets (at the SP layer). As a result, vertically integrated operators require significant regulatory oversight.

5.7 Choosing the business model

In general, vertically integrated networks have lower business complexity, involving one actor for all network layers, and may also more easily attract investment by larger operators with large existing user bases.

The EECC[68] notes, however, that business models where network owners are limited to the provision of wholesale services can be beneficial to the creation of a thriving wholesale market, with positive effects on retail market competition (competition between SPs).

Another advantage of the wholesale-only business model is its ability to attract financial investors through longer-term asset lives and the relatively low volatility of infrastructure assets.

The EECC notes that certain competition risks arising from the behaviour of undertakings following wholesale-only business models might be lower than for vertically integrated undertakings, provided that the wholesale-only model is genuine and no incentives to discriminate between retail service providers exist. The regulatory response should therefore be commensurately less intrusive while preserving the possibility to introduce obligations in relation to fair and reasonable pricing.

Business model choice may also be limited or influenced by the choice of investment model. Table 4 shows how different business models can be combined with different investment models.

The degree of influence a public authority will be able to have in the definition of the business model will depend on the investment model chosen. Even in the most hands-off model (subsidy model), the choice of business model may be influenced in the procurement terms.

The demographic, cultural and socio-cultural conditions also play a role. In general, a business model which allows for a mutually beneficial situation for all stakeholders (including the end users, the local businesses, the service providers, as well as the incumbent operator) will increase a project's chance of success. Some of the questions that should be asked are:

- How is the population distributed? Outside urban areas, passive-layer wholesale is usually not recommended.
- Is there enough technical competence within the public authority to take on the NP role? Are there sufficient economies of scale? An active-layer wholesale-only model may be optimal.
- Are there market actors interested in taking on the NP role? Consider a mediated version of the wholesale-only model.
- Is the plan to subsidise an operator with a significant amount of infrastructure that is already active as a service provider? Vertical integration may be a good option. Access obligations attached to State aid rules will need to be implemented.
- While wholesale-only models provide good conditions for competition at the service layer, the natural monopoly nature of access networks mean that wholesale prices are not under competitive pressure and may need to be regulated.

68 See table of references at the end of this handbook: EU 2018 EECC

Table 4 *–Different business models can be applied to each investment model; the table includes some examples.*

INVESTMENT MODEL	BUSINESS MODEL			
	WHOLESALE ONLY			VERTICALLY INTEGRATED
	- at passive-layer	- at active-layer	- mediated	
Direct	**PA:** ownership & PIP **Operators:** NP+SP	**PA:** ownership & PIP+NP **Operators:** SP	**PA:** ownership & PIP **Operator-neutral entity:** NP (3-5y) Operators: SP	Generally not used
Concession	Generally not used	**PA:** ownership **Concessionary:** PIP+NP (20-30y) Operators: SP	Generally not used	**PA:** ownership Conc.: PIP+NP+SP (20-30y) **Other operators**: SP or NP+SP (regulation)
Operator subsidy	Generally not used	**Beneficiary:** ownership & PIP+NP **Operators:** SP	Generally not used	**Beneficiary:** ownership & PIP+NP+SP **Other operators:** SP or NP+SP (regulation)
Bottom up	**Beneficiary coop:** ownership **Beneficiary coop or commercial partner:** PIP	**Beneficiary coop:** ownership **Beneficiary coop or commercial partner:** PIP+NP **Operators**: SP	**Beneficiary coop:** ownership & PIP **Operator-neutral entity:** NP (3-5y) **Operators:** SP	**Beneficiary coop:** ownership **Beneficiary coop or commercial partner:** PIP+NP+SP

6

Financing tools

The alternatives available to finance broadband projects, as well as examples of their use, has increased considerably in the past few years, not only through public funds but also private capital, bottom-up, and bank loans and bonds.

This chapter describes the different financing tools available to a public authority or to a local community planning to invest in a broadband project. It explains 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.

6.1 Different tools

A public authority driving a broadband project in its territory can finance it in different ways. Typically, a mix of financing tools is used:

- **Own assets and resources:** public authorities often own key infrastructure assets and sometimes have financial resources available that can be injected into the project (or into the company created to run the project);
- **Loans:** the public authority can obtain loans from EU institutions, national government, and banks; bonds, possibly backed by the government; and loans from private citizens (particularly in bottom-up initiatives);
- **Equity:** the public authority can raise equity funding, whereby an investor provides funding in exchange for becoming a shareholder in the project;
- **Grants:** the public authority may seek non-repayable grants, most notably from national development and EU funds.

- **Tax incentives:** as opposed to grants, tax incentives are generally not subject to competition between projects, but investment-satisfying criteria will be eligible.

While the use of grants has been dominant, combining different tools, possibly for different parts of the project, is seen increasingly positively by financers. The mix of tools depends on the level of risk which the project involves. In general, the lower the risk, the lower the need for grants.

		Types of funding			
		Loan	Equity	Grant	Tax incentives
Funding sources	EU and national government funds	✓	✓	✓	✓
	Financial makets (banks, investment funds)	✓	✓		
	End users (bottom-up financing)	✓	✓	✓	

***Table 5** – Funding options and common financing sources*

6.2 Investing own resources

Public authorities or utilities owned by the local, regional or national government may already own key infrastructure assets, such as ducts, fibre cables, poles, premises to be used for equipment location and data centres, and sites to be used for radio base stations. These physical and financial assets can be invested in the project or the company created to run the project, and can represent a significant part of the equity needed to get the project started and to leverage other types of financing.

Moreover, if the public authority chooses a direct investment model, it generally receives revenue from wholesale dark fibre lease and/or transmission services, as well as infrastructure lease or connectivity fees (or network fees) depending on the business model in place. When part of the deployment is completed and companies, public bodies and end users start using the network, this can become a major financing source and can be used to finance and accelerate network expansion going beyond the first aims of the project.

INFOBOX 18

Municipal networks: built with tax money?

Although people tend to associate broadband investment run or driven by public authorities with taxpayers' money, in some cases, it may be only a minor part of the total financing.

The prime example is the City of Stockholm's fibre project, which is one of the most successful and widely known examples of a broadband network built using the direct investment model. The only public money used by the City of Stockholm was the SEK 50,000 (roughly €5,000) used to register the Stokab company in charge of fibre deployment and operation, in 1994. The rest of the money came from bank loans and revenues from dark fibre leasing (approximately €20 million annually).

The Stokab network, which makes its abundant and capillary fibre available to anyone at fair and non-discriminatory conditions, has one of the most thriving markets for broadband services in the world (Stokab only operates the passive fibre), and today, Stockholm citizens and businesses enjoy among the best broadband services at the lowest prices in the world.

6.3 Debt financing (loans)

As loans constitute debt, they are often referred to as debt financing.

Many projects have secured a large portion of their initial financing through loans with soft or commercial terms. Loans can be provided by EU or national institutions, banks or other investors, for-profit or non-profit institutions, and private citizens. For this to be sustainable, a comprehensive and well-substantiated business plan must be presented.

6.4 Equity financing

Equity financing means that a company gets investment without obligation to pay interest charges, while the investor gets a share of the company driving the project and takes part in the decision-making process. This is opposed to debt financing, which implies interest payment and where the investor has no control over the business, and when the debt is paid, the relationship with the investor is over.

INFOBOX 19

Raising financing from the market

Equity and debt financing are typically provided by institutional investors like national promotional banks and the EIB, as well as other actors[69].

Financial markets are other sources of equity financing, and hybrid debt-equity 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. For example:

- 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 investors typically look for an exit between five and seven years once the business is established and they can be replaced by other investors looking for low risk, long-term returns on their investment;
- Infrastructure funds, pension funds and other institutional investors may invest in established infrastructure from the above after three to seven years and seek long-term investment at lower interest rates;
- Private capital and financing from network users (bottom-up financing) is most often done by promoting the last mile as an upgrade of one's property. It can work once the population has reached a good degree of awareness of the broadband potential.

6.5 Grant financing

European, national and regional public funds can generally be used to finance the project, subject to any specific conditions that may be attached to their use. Grants are focused on enabling economic and social improvement. The availability of public funds to finance broadband deployments may vary from Member State to Member State and from region to region, however, a number of EU schemes exist which are available across the EU, even if in most cases the funds are administered by national or regional managing authorities. INFOBOX 20 gives an overview of the major EU funds.

69 See also "InvestEU and a Europe Fit for the Digital Age (europa.eu)" and "Connecting Europe Broadband Fund (CEBF) (eib.org)"

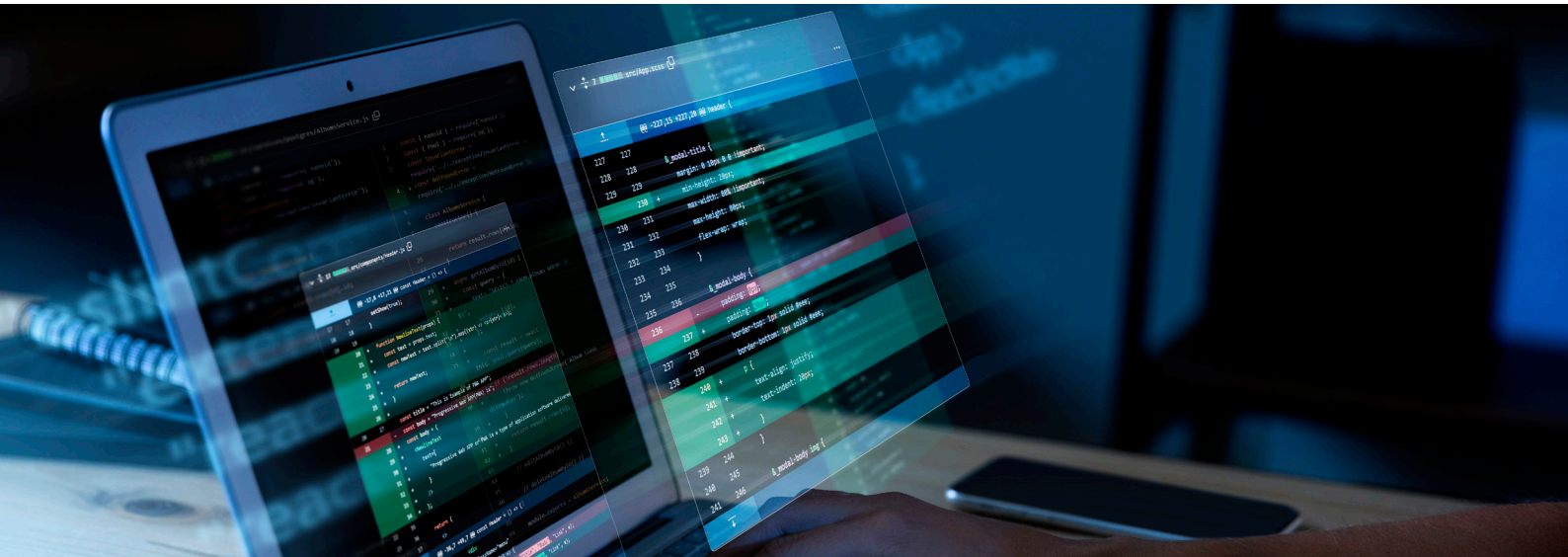
INFOBOX 20

EU funds: choosing the right one

The EU is an increasingly important source of funding, mainly providing grants but also loans and even equity financing. As the volume and types of funding available have grown over the years, so has the number of programmes. These programmes (see a summary in Table 6 - EU funds available to finance broadband projects) have different requirements and conditions, and the possibility of combining different types of EU funding in different parts of broadband projects often exists.

The current programming period started in January 2021 and runs until 2027. The primary sources of broadband investment support come from: The **European Regional Development Fund (ERDF)**: to increase economic, social and territorial cohesion, particularly in less-developed Member States and regions, ERDF support to broadband deployment primarily focuses on addressing market failures, targeting regions where investments are not taking place on a market basis alone;

- The **European Agricultural Fund for Rural Development (EAFRD)**: for broadband projects in certain regions and Member States, depending on how the fund allocation has been designed;
- The digital strand of the **Connecting Europe Facility (CEF Digital)**: funding 5G Corridors (5G deployment along transport paths for connected and automated mobility) and 5G communities (5G systems for socio-economic drivers), as well as projects supporting backbone interconnection of secure and critical digital capacities and global gateways (for example, submarine cables);
- The **Connecting Europe Broadband Fund (CEBF)**: created in the previous programming period, under CEF, this is an equity fund of €555 million (including €160 million from private sources) investing in state-of-the-art networks in predominantly undeserved areas across the EU;
- Mobilising private resources can be done under the **new InvestEU programme,** which will in particular allow the **European Investment Bank (EIB)** and national promotional banks to make use of the EU guarantee and leverage public resources by attracting additional resources from the private sector;
- The **Recovery and Resilience Facility (RRF)**: the key recovery instrument at the heart of **NextGenerationEU**, intended to assist the EU in its recovery from the COVID-19 pandemic. The Facility provides both loans and grants by front-loading financial support for the crucial first years of the recovery. As of January 2023, 21 Member States have included reforms and investments related to connectivity in their Recovery and Resilience Programmes, worth €16.8 billion.



Structural and Investment Funds (ESIF: ERDF)	Connecting Europe Facility (CEF) & Connecting Europe Broadband Fund	Recovery and Resilience Facility (RRF)	EIB & European Fund for Strategic Investments (EFSI)
ERDF: €10 billion on the Digital Decade Objectives of which **€2.36 billion** programme on connectivity 2021-2027**:** Focus on market failures (grey and white areas). Broadband financed under thematic objective 1 (Smarter Europe)	**CEF (CEF2 Digital)** 2021-2027**: €2 billion** over 7 years to support to support connectivity projects including: backbone connectivity for digital global gateways, 5G coverage along transport corridor, backbone networks for pan-European/Edge cloud federations and 5G infrastructure for smart communities, especially in rural areas to support services of general interest. **Connecting Europe Broadband Fund (CEBF)**: expected investments of **€750 million** (currently €500 million)	Total **RRF €502 billion**, in loans and grants, of which about **€130 billion** (26%) are supporting the objectives of the Digital Decade, with about **€16.8 billion** programmed on connectivity.	**EIB loans with EFSI guarantee** 35% of the **€26 billion** budget of InvestEU - which represents **€9.1 billion** – is planned to be invested in digital infrastructure. **€3.1 billion** loans from **EIB** with **EFSI** guarantee are expected to generate more than **€11.7 billion** of total investments into telecoms infrastructure projects

Table 6 *– EU funds available to finance broadband projects*

6.6 Tax incentives

Another form of non-refundable support is tax incentives, typically from the State. Unlike grants, which are either constrained to a total available budget or to financing a limited number of actors in specific project areas, tax incentives are generally not subject to competition between projects, but any investment satisfying criteria will be eligible. In addition, while grants generally involve a direct cash or resource transfer, tax incentives are an indirect transfer in the form of reduced taxation: tax incentives can take the form of tax deferment, tax allowance, reduction in the tax base or tax rate, or even tax exemption. Different national and, in some cases, local governments may offer different forms and degrees of tax incentives.

70 See the table of references at the end of this handbook for the example of Michaelston-y-Fedw (Wales), Category 1 winner of the Broadband Awards 2018: BROADBANDAWARDS-1 2018 and EU 2018 BBA-MyF

INFOBOX 21

Financing bottom-up initiatives

Communities can raise funds to support the development of infrastructure in their areas[70]. This is generally, but not exclusively, suitable to villages or other communities with a strong commitment to bringing broadband to their local areas.

These schemes may consist of selling 'stock' or shares in a community company (equity financing) which either implements and runs the network itself, or commissions this through suppliers. In-kind contributions (effectively corresponding to grants) from citizens (in the form of voluntary digging work and equipment) are also often successfully used, especially in rural areas.

Citizens are sometimes also asked for a commitment to subscribe to next-generation broadband services once the network is operational, as part of the deployment project. This has the benefit of driving early take-up, which significantly strengthens the business case.

INFOBOX 22

Innovative financing for a local wholesale-only private network financed by CEBF

The RUNE project (among the winners of the 2019 European Broadband Awards[71]) aims at deploying a greenfield cross-border wholesale broadband network targeting underserved areas in Slovenia and Croatia. The infrastructure will provide several residents and small businesses with a gigabit broadband infrastructure, using fibre-to-the-home (FTTH) and an active-layer wholesale-only business model. The targeted project area is 14,278 km^2, reaching a total of 3,676 villages and 372,315 potential network points in Slovenia and the Primorsko-Goranska and Istarska counties in Croatia, all of which are not currently covered by FTTH.

The project has been financed by project promoters' own funds. The future infrastructure investment is financed by private funds (both equity and debt). However, part of debt investment was partially de-risked via the European Fund for Strategic Investments (EFSI). The project was supported by the Connected Communities Initiative (CCI)[72] for the preparation of the innovative financing model, while its second phase, infrastructure deployment, is financed by the Connecting Europe Broadband Fund.

71 See the table of references at the end of this handbook: EU 2019 BBA-RUNE

72 The Connected Community Initiative (CCI) was established in 2015 by the European Commission Directorate General for Communication Networks, Content and Technologies (DG CONNECT) as a single donor trust fund implemented by the World Bank. The initiative focuses on facilitating the flow of private and public investments to broadband connectivity projects and assists them in bringing their projects to a level of maturity that would enable funding from various public and private sources.

6.7 State aid considerations

Alternative financing tools can have different implications in terms of State aid rules.

EU programmes directly managed by the Commission, such as CEF, are designed to be consistent with State aid rules: they do not constitute State aid and do not require assessment by the Commission. An example of this would be a project funded with CEF resources when all co-funding is provided by commercial operators. However, when co-funding is provided using national public funds or EU funds under shared management (for example, ERDF or RRF), this co-funding may constitute State aid and may require Commission clearance unless it falls under the GBER or any of the no-aid scenarios described below (such as *de minimis* funding or public funds used as a market economy operator would).

Use of national resources or EU funding controlled by Member States, such as ERDF or EARDF programmes, **or originating in RRF programmes**, is on the contrary considered as State aid and requires Commission clearance (unless it meets the GBER conditions or falls under a no-aid scenario).

If **national-level authorities employ their own assets** to fund a project or fund it alongside private sector operators (for example, taking on equity or debt in a given project), this will typically be considered State aid except if the public authorities invest in a manner that would be acceptable to a **private operator acting in normal market conditions** (the market economy operator principle, MEOP).

In general, when State resources are attributed to private sector operators, regardless of how the authority came into control of those resources, careful assessment of possible State aid implications must be ensured. Further details are provided in Chapter 8.

7

Action plan and execution

While a broadband plan defines the overall goals and strategy for broadband development, the action plan:

- Defines and details the activities needed to implement the strategy;
- Contains estimations of costs and revenue during the different phases of deployment;
- Specifies the roles and responsibilities of different actors, how to engage and coordinate the stakeholders and how to monitor the execution of the project and its outcomes.

This chapter gives an overview of what should be included in an action plan and some guidance on its execution. While an action plan is central for projects run with the direct investment model, most aspects covered in this chapter are important to be examined no matter which investment model is applied, in order to maximise the project's success in terms of closing the connectivity gap, and the project's timeliness and cost effectiveness.

74 See the table of references at the end of this handbook: EU 2014 COSTRED, EU 2018 EECC

7.1 Cost estimates and financial planning

Deployment costs should be estimated in the action plan in order to meet the needs of the possible customer base. The technical solution does not differ from ordinary infrastructure deployment and any installation professional can be consulted on the matter. In order to keep costs down, several measures can be taken, as also indicated in the Broadband Cost Reduction Directive[73].

The action plan should also detail how the different financing tools are going to be used and define the actions to be taken to ensure the needed funds are made available.

If the direct investment model is chosen, the cost estimates and financing planning will form the core of a **business plan** for the project, including SWOT analysis, human resources, a marketing and sales plan and a financial plan.

7.2 Risk assessment and management

The public authority will be faced with different risks depending on the investment model chosen, the accompanying business model, the financing tools employed, and the infrastructure type deployed. It needs to map these risks and have a plan on how to manage them.

One risk is that the business case does not materialise as planned, especially in direct investment projects. For instance, a competing operator may unexpectedly decide to enter the market and offer high-speed services in the territory, either by deploying its own parallel infrastructure, or by requesting access to the infrastructure being deployed by the public authority's project.

This risk can be minimised by establishing an open and constructive dialogue with relevant operators, such as incumbents and strong local operators, in order to understand their long-term intentions and needs and define the project as a mutually beneficial scenario for all relevant stakeholders.

Secondly, while the Broadband Cost Reduction Directive (see INFOBOX 23) obliges the project to give access to the physical infrastructure, a properly designed wholesale-only network with access at network layer may be demonstrated to satisfy the request.

Risks related to operator subsidy models are more related to performances not being satisfactory, or the network having a low degree of future-proofness. Detailed technical specifications, coverage figures and upgradability requirements may be necessary to reduce these risks.

Another risk is that competition may suffer. One way to ease this risk is to mandate wholesale-only, or to properly regulate access and pricing.

74 See the table of references at the end of this handbook: EU 2014 COSTRED

75 See the table of references at the end of this handbook: EU 2020 TOOLBOX

INFOBOX 23

The Gigabit Infrastructure Act

Building on the main features of the Broadband Cost Reduction Directive[74], the Gigabit Infrastructure Act proposal is based on four pillars:

1. Access to physical infrastructure, including transparency on physical infrastructure;
2. Civil works, covering coordination of planned civil works and transparency on planned civil works;
3. Permit granting, including rights of way, addressing applications for permits and timeframe for permit granting;
4. In-building physical infrastructure, covering its deployment, fibre wiring and access. Member States will establish standards and technical specifications and verify compliance to them through national certification mechanisms (for example 'Ultra-fast Broadband Ready' for newly-built buildings).

Furthermore, in order to further boost network deployment across the EU, the Commission has also issued a new recommendation[75] aiming at developing a common connectivity toolbox consisting of best practices on the points described above, and additionally on environmental impact and investment-friendly spectrum assignment. The development of the toolbox included the collection of good practices up to March 2021 and for Member States to share their roadmaps for its implementation (April 2021) from then onwards.

7.3 Network design, key connections and urban planning

Because public authorities may often be the largest users of broadband in the local market, a plan to connect all buildings with fibre should be made (for public administration, public healthcare institutions and hospitals, public schools, etc.). This generally constitutes the core of the network.

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

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

Even when the public authority has not chosen a direct investment model, it should be directly involved in this planning in order to ensure adequate coverage and performance where needed, and to reduce the risk that any parts of the territory and socio-economic fabric go underserved. In addition, because of the significant civil works involved in broadband deployment, it is important that broadband infrastructure is included when new city planning is done.

7.4 Procurement

Procurement will most likely be a central part of any broadband project. Even in the case of the direct investment model, most of the practical activities of network deployment will be outsourced to the market. As such, proper procurement procedures will need to be put in place.

Procurement can take very different shapes in different Member States and for different investment models, and can be delicate to design properly. It is particularly important to ensure that the procurement be designed in such a way as to reach the objectives set out in the broadband plan, and that the strategic choices made can be properly implemented. 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, etc.).

Market awareness is also important, especially among the business actors who appear most suitable for the investment and business model chosen. For instance, an intervention with direct investment or concession models in rural areas will most likely need an operator-neutral NP, if the public authority only wants to provide the passive infrastructure. NPs are a relatively new type of entity, so it is important to run the required market research to locate and reach out to these companies.

The procurement should be built in such a way that the crucial aspects of the "ideal winner" are given proper weight while complying with the principle of non-discrimination. For instance, if competition in the retail service market (i.e. at the SP layer) is an important aspect, measurable criteria and award points should be included accordingly (for example, an operator committing not to sell its own services will be free from 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 the procurement scheme reward this?).

Another relevant issue is tender size: if the lots in the procurement call are too large, it may risk attracting only a limited number of bidders; on the other hand, if the lots are too small, they risk reducing the economies of scale, increasing the relative cost of the project.

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

For further information about the use of the EU electronic tendering procedure, the information system for EU public procurement can be consulted[76].

76 See the table of references at the end of this handbook: EU SIMAP

INFOBOX 24

Tendering a nation-wide FTTH deployment using the concession investment model: the example of Italy

In 2016, the Italian government adopted an investment measure for a nation-wide FTTH project using a concession model[77]. The tender lists detailed awarding criteria for the construction of the passive infrastructure and its operation separate from the economic and qualitative criteria.

For the construction tender, economic criteria included not only the overall cost of the network but also its maintenance costs, and the timing and overall duration of the roll-out of the network (noting that this has direct impact both on costs and on the loss of revenues due to the delay of the commercial exploitation). Furthermore, five separate qualitative criteria were included:

- Household coverage;
- Capability to support download and upload speeds above the minimum speeds mandated;
- Latency - notably suitability for real-time applications;
- Reliability and scalability;
- Reuse of existing infrastructure and use of solutions reducing the environmental impact.

For the maintenance, management and commercial exploitation of the network, the economic criterion focused on the amount of the concession fee and the wholesale price, while the two qualitative criteria were:

- Improvement of the Service Level Agreement (SLA) proposed by the NRA;
- Proposal of a wider set of wholesale-access products going beyond the ones mandated in the tender.

In addition, the business model of the bidder was also taken into account. The awarding authority gave extra points to bidders that were either wholesale-only operators or ensured strict accounting separation their wholesale and retail arms.

In terms of wholesale prices, the Italian NRA, AGCOM, set the maximum applicable price at the regulated price imposed on the SMP operator. The measure also foresees the possibility to use a pay-per-use pricing model in order to incentivise the use of the subsidised infrastructure by reducing up-front investment which could represent a barrier to entry. In a pay-per-use pricing model, the use of the infrastructure is charged on the basis of the number of end users actually using it.

77 See the table of references at the end of this handbook: EU 2016 BB-SA-IT

78 See EU 2015 MONIT in the table of references at the end of this handbook for the general monitoring and evaluation principles for projects financed or co-financed by EU Structural and Investment Funds.

7.5 Monitoring and management of the network

It should be ensured that the project is properly monitored during execution by using milestones and periodic reviews, and that there are tools in place to evaluate its success. The European Commission's guidance document on monitoring and evaluation provides relevant information[78].

In addition, in case of publicly financed networks whose compatibility has been assessed by the Commission according to the Broadband Guidelines, the public authorities must submit a report to the Commission every two years with key information on the aid measures, in accordance with Annex III of the Broadband Guidelines.

Additional broadband infrastructure indicators that can be monitored are:

- **Physical deployment:** proper installation of the necessary network elements (fibre cables, termination electronics, wireless transmitters, satellite ground equipment, etc.);
- **Network activation** or **service availability** on different parts of the network according to schedule;

- **Wholesale access** requests and actual implementation;
- **Service quality**, in terms of download and upload speeds under peak-time conditions, latency, network availability;
- **Failure rate**: service or network downtime as reported by customers or discovered by network staff;
- **Maintenance and repair**, so that scheduled maintenance and repair take place;
- **Service and network take-up**: the number of new end user connections activated (residential and business) and the amount of fibre and/or capacity leased.

The public authority should set out adequate monitoring requirements in the procurement contracts. For instance, the contract with a network provider should specify the target number of service providers signed up, quality parameters, number of households connected, and a target number of active customers (take-up rate).

Monitoring will allow enforcement of the targets agreed upon with suppliers and contractors, for example by setting penalty payments or by linking payment to specific milestones.

In the case of State aid, monitoring is mandated to ensure compliance with compatibility conditions. Monitoring is also a tool that can be relevant in ensuring best value for the public money spent, as it can provide valuable input, for example, to activate claw-back provisions in certain situations to avoid overcompensation. Moreover, proper monitoring should be put in place to verify the development of competition among multiple service providers (and innovation in services) over the network and to verify that wholesale access (capacity, dark fibre or duct) is provided to all service providers on fair terms and without discrimination in terms of time, traffic management or quality of service limitations.

7.6 Identification of potential customers

The action plan should also identify potential customers: not only end users but also future operators and service providers. Mobile evolution (with 5G requiring ever higher data rates to the antenna sites) as well as IoT and smart city applications are expected to drive the need for fibre. When a new infrastructure is in place, this will support new actors entering the local market. If infrastructure can be leased, mobile operators will see a positive business case in delivering services without the need to build their own dedicated infrastructure.

In some areas, a few SPs dominate, controlling a very large market share between them. In these situations, the major SPs will have a large presence and profile. This often sets expectations in the minds of consumers, who may be led to believe 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 could therefore increase service uptake and the success of the network.

It is important that discussions with potential customers and users of the network take place early on, and that as many contracts and agreements as possible are signed before deployment is started. This also gives the chance for SPs and mobile operators to know what is being planned so that they can design their sales activities accordingly.

7.7 Establishing internal and external coordination and collaboration

Investment in broadband is complex: like any major infrastructure project, it requires coordination of many different activities. It is therefore important to:

- Assign a coordinator for the implementation of 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 IT manager, even if this can be tempting in small local authorities with limited competence and resources. If there are no necessary competences in-house, they should be acquired 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 sewage systems, electricity, district heating, wind power and other infrastructures with which it is possible to share civil works costs (see INFOBOX 23);
- Organise personal interviews and/or workshops with local representatives. The availability of broadband is important for all municipal activities, so all public authority administrative units should be involved.

7.8 The broadband champion

Citizens and businesses are the stakeholders that generate take-up, utilise services for social improvement and deliver economic benefits to the region. In small projects, they are also the most unpredictable stakeholder group. Empirical evidence demonstrates that the strongest community engagement is always found when a project is led and managed from within the community itself. This is best achieved by a 'broadband champion'. Some communities have such a champion already. In others, the champion has to be found. It can be identified as a person who is:

- Already involved in the community, often in another role;
- Respected by the community for that role and their achievements;
- Passionate about maintaining an vital community;
- Frustrated by the lack of broadband and the effect this is having on the community's social and economic life;
- A good communicator;
- In possession of 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 become aware of 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 communities. This is where they add the greatest value and contribute the most to the success of the project.

7.9 Marketing and communication plan

In order to ensure consistency across all stakeholders and to maximise take-up as well as the socio-economic impact and the financial sustainability of the project, a marketing and communication plan is needed, and dedicated resources should be allocated to implement and manage it across the entire programme.

If the intervention is done using the concession or operator subsidy models, the definition and execution of this plan should be done in collaboration with, or be outsourced to, the business partners involved in the project. However, it is important that the public authority remains in control of the overall definition and follow-up of the plan.

The role of marketing the products and services provided over the network is naturally 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;
- Providing an updated map of broadband availability throughout the roll-out of the project;
- Facilitating demand aggregation from businesses, households and other relevant public authorities.

The public authority 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-users;
- 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 cases on a regular basis.

All existing communication channels with the population can be used to execute the marketing and communication plan. This will increase the credibility and confidence in the broadband network as well as in the SPs using it, and will strengthen public authority's role as a community leader.

7.10 Stimulating demand

The public sector has a significant role in stimulating demand as a major purchaser of services for its own use (anchor tenancy), as well as potentially procuring the new network. It can play a major role in encouraging the development of new services and the establishment of infrastructure. In the long term, using infrastructure to drive demand in the digital economy is a natural part of regional development and planning as well as regional growth.

Local communities can play a very important role in driving demand for new services, in some cases by providing part of the financing needed. There are many examples of successful bottom-up initiatives developed on a cooperative 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 may also encourage competition by promoting the role of smaller SPs, who may be able to adopt a new network more easily and may be more willing to do so. This can often accelerate take-up in the early stages, leading to a more sustainable business case.

In certain situations, broadband vouchers can also be used as a form of demand stimulation. It is important to note that, even if State funds are distributed to private individuals, this disbursement may amount to State aid to the extent that it benefits the suppliers of the services that can be procured using the vouchers, especially when a cumulation in the hands of a limited number of providers can be expected. This implies that the measure will typically have to comply with the applicable State aid rules. It should also be noted that the GBER exempts certain forms of vouchers from notification. Several recent State aid decisions also provide helpful examples of notified measures. This matter is further discussed in Chapter 8.

7.11 Decision making

Different investment models imply different levels of involvement and influence on decision making in a project. If the direct or concession model is used, the network infrastructure is fully owned by the public authority and the authority has full control over any decision making.

A good way to take into account the needs of the market is to have a board of 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 always the case when the broadband 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 the community broadband model. The public authority can still monitor activity on the project and refer any undesirable outcome to another enforcing body (for example, involvement of the NRA is recommended in State aid cases).

8

Broadband investment and State aid

This chapter gives an overview of State aid rules applied to broadband investment. It builds on the 2022 Broadband Guidelines and is structured as follows:

1. **Section 8.1:** the general principles of State aid;
2. **Section 8.2:** cases in which a broadband intervention can be considered not to constitute State aid;
3. **Sections 8.3 and 8.4:** cases in which an intervention does constitute State aid, but its compatibility with State aid rules can be self-assessed;
4. **Sections 8.5 to 8.13:** cases in which the intervention constitutes State aid and needs to be notified to the Commission for assessment of its compatibility before proceeding.

8.1 General principles

Any use of public funds to support the development of an economic activity, in this case investment in broadband, needs to comply with the EU's State aid rules.

In the context of a broadband investment project, public funds can be used if the project complies with the State aid rules, which aim to limit as much as possible distortion of competition, for example, by limiting the risk of crowding out private investments by disincentivising, preventing or even discontinuing them.

Under certain conditions, the use of public funds to support broadband investments must be notified to the Commission ahead of granting State aid: ahead of tendering out the project and before signing the contract with the beneficiary.

However, a wide range of uses of State funds do not require notification and their compliance with State aid rules can be self-assessed by the relevant public authorities. This may be because the use of public funds does not amount to State aid and so does not require notification (Section

8.2 discusses the conditions under which this holds), or because they are considered as not having a significant distorting impact on the market, while the benefits largely outweigh any possible distortions of competition (see Section 8.3), or because the intervention is necessary for the provision of an SGEI and its market impact is deemed limited (see Section 8.4).

In all other cases, the measure must be notified to the Commission for the assessment of compatibility with the EU's internal market.

Compatibility with State aid rules can be assessed under various articles of the Treaty on the Functioning of the European Union (TFEU), including:

- 107(3)(c) TFEU: aid for the deployment of broadband networks and for connectivity vouchers schemes;
- 107(2)(a) TFEU: aid for social voucher schemes;
- 106(2) TFEU: aid for SGEIs.

Figure 8 illustrates the different categories of intervention from a State aid perspective.

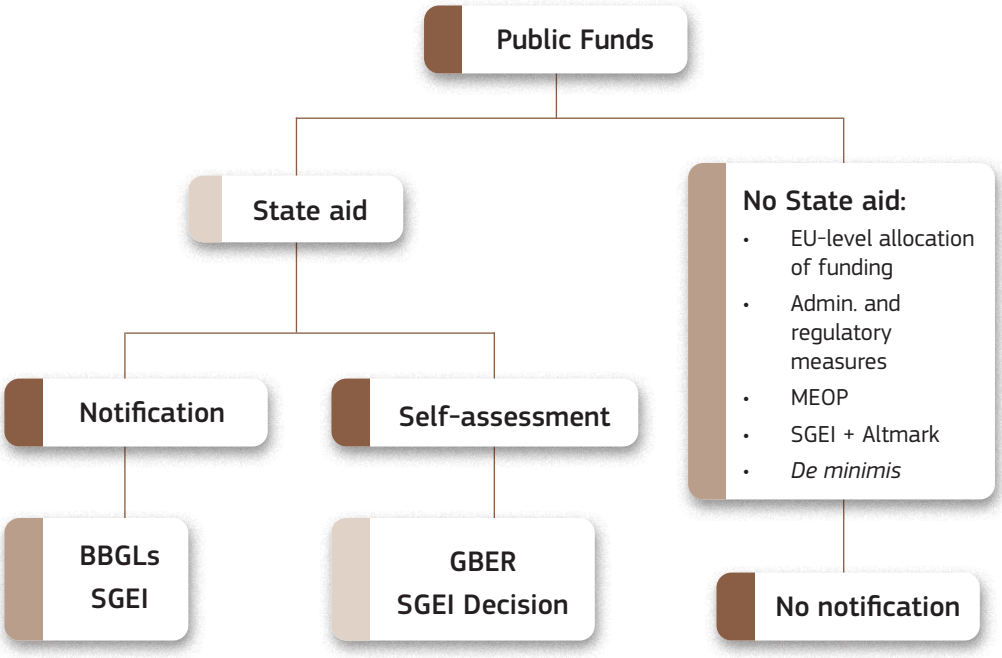


Figure 8 *- The assessment of public funds*

8.2 Public funds that do not amount to State aid

There are various situations where the use of public funds does not constitute State aid. The main ones are:

- EU-level allocation of the funding;
- Administrative and regulatory measures;
- Measures fulfilling the Market Economy Operator Principle (MEOP);
- Measures designed as SGEIs meeting the four Altmark criteria;
- *De minimis.*

Each of the above situations are discussed in more details in the following paragraphs.

EU-level allocation of the funding

In this case, the funds are EU-level resources which are not channelled through public authorities at Member State level: the national authorities have no discretion over the use of the funds nor over the choice of the beneficiaries).

Consistency with principles such as those underlying State aid rules is verified at EU level, not at Member State level.

Administrative and regulatory measures

Public authorities can have an important role in creating conditions to facilitate broadband investments such as by facilitating rights of way, enabling the coordination of civil engineering works, and promoting the sharing of the

infrastructure. Such measures do not constitute State aid to the extent that:

- They are transparent and non-discriminatory;
- They are open to all potential users: they are not limited to the broadband or telecommunication sector (they are open to other utilities, for example, such as infrastructure operators for electricity, gas, water etc.).

Some demand-side measures can also be categorised under administrative measures, particularly when they are non-monetary measures, as these are generally unlikely to have a distortive effect on competition. This is the case for measures aiming to increase the perceived value of broadband access by addressing aspects linked to broadband demand, other than price.

A good practice example of a non-monetary demand-side measure is an awareness campaign from 2018 by the German Ministry of Transport and Digital Infrastructure in collaboration with the Chamber of Commerce and the German Broadband Competence Office (BCO), on the benefits of technology among citizens. Such measures stimulate broadband demand and the development of digital skills, and can be targeted to areas where demand is weakest, such as certain rural areas[79].

Other examples[80] of measures to promote demand include increasing the quality and reach of the available content and services and equipping consumers with the necessary information and tools:

- Promotion of e-government programmes, telemedicine, e-health, distance education, ICT in schools;
- Promotion of local and sectoral digital content, for example in the fields of cultural heritage, tourism, education, local agriculture and food products, etc;
- Government-led information campaigns to increase consumers' awareness;
- Addressing lack of IT skills through specific digital literacy or inclusion programmes;
- Training and assistance to introduce and exploit ICT in SMEs and micro-enterprises[81].

Certain demand-side measures, such as demand aggregation, fall outside the scope of State aid rules as long as the resulting information is made publicly available to all stakeholders in an open, transparent, non-discriminatory way. Examples include[82]:

- Measuring potential demand through the use of surveys or systems of online registration;
- Encourage and involve users in becoming stakeholders of a project through bottom-up models of investment, for example in the form of a cooperative;
- Pre-contractual agreements with households and businesses that can reduce investment risks by increasing predictability.

It is to be noted that demand-side measures in the form of broadband vouchers typically entitle State aid to service providers even if vouchers are to be used by end users. These are discussed in section 8.3, if they are exempted from notification as they fall under the GBER, or in section 8.11, if they must be notified to the Commission for assessment of their compatibility.

Market Economy Operator Principle (MEOP)

Broadly speaking, the Market Economy Operator Principle (MEOP) states that if the conditions associated with the public financing of a particular project would be acceptable to a private investor operating in normal market economy conditions, such use of public funds is not considered State aid. This implies that no advantage is given to any undertaking.

The MEOP analysis for the State's participation must be completed prior to the project but it can be self-assessed. However, past Commission decision practice has made clear that the conformity of a State investment to MEOP must be demonstrated thoroughly and comprehensively, either by means of a significant participation of private investors in conditions at least equal to the State, or the existence of a sound business plan and associated risk-corrected rate of return calculations[83] (see INFOBOX 26). The notification exemption under MEOP only applies to well-substantiated cases[84].

The MEOP framework is quite different from the 'market failure' framework under which State aid is generally understood. For the State to invest as a market investor, it must be the case that the investment is attractive to the private sector. This may pose the question of the motivation for State intervention in the first place. In fact, the Commission has been quite strict in the evaluation of MEOP investments (see INFOBOX 26). In another example, the Commission was not convinced that the conditions for MEOP had been adequately assessed (see INFOBOX 26).

79 See the table of references at the end of this handbook: DE 2018 BBB

80 See the table of references at the end of this handbook: EU 2018 BCO

81 While such measures are generally not State aid, this cannot always be ruled out. Some forms of training aid to firms may be State aid, which may nonetheless be exempted from notification under GBER.

82 See the table of references at the end of this handbook: EU 2018 BCO

83 See the table of references at the end of this handbook: KLIEMANN 2013

84 The MEOP assessment must be carefully documented and reliance on suitable specialist advice is recommended. The public authority should be aware that non-notified investments under MEOP can face legal challenges.

SGEIs meeting the four Altmark criteria

SGEIs are economic activities which deliver outcomes in the public interest that would not be commercially supplied, or would be supplied inadequately or inequitably, without public intervention.

Public authorities have a broad discretion in defining what they regard as SGEIs. The Commission would only question such definitions in case of manifest error, such as public authorities attaching specific public service obligations to an activity which is already provided or can be adequately provided by companies operating under normal commercial conditions.

The Broadband Guidelines[85] have clarified in recital 29 what specific elements the Commission considers when assessing the absence of manifest error in the field of broadband:

- The project is addressed only to areas in which private investors are not in the position to provide adequate broadband services;
- The project deploys a network providing universal and affordable broadband services to all premises in the target area (residential and business);
- The project ensures open wholesale access to the network on a non-discriminatory basis;
- The project is technologically neutral;
- Where the provider of the SGEI is also a vertically integrated operator, the public authorities should implement adequate safeguards (for example, limiting the operation of the network at wholesale-only level, imposing accounting separation, etc.) to avoid any conflict of interest, undue discrimination, and any other hidden indirect advantages.

On compensation for SGEI, which must follow the principles of the SGEI package[86]:

- Any compensation granted should only cover the net costs of rolling out a network in the non-profitable areas, taking into account relevant revenue and a reasonable profit;
- Adequate review and claw-back mechanisms should be put in place to prevent the SGEI provider from obtaining an undue advantage.

Under additional conditions, payment with State funds for the provision of SGEIs can be regarded merely as compensation for discharging those services and therefore are not considered State aid.[87] Such additional conditions have become known as the Altmark criteria[88]. If these are not strictly adhered to, SGEI-related payments will be considered State aid.

The four cumulative Altmark criteria are the following:

- The project is necessary for the provision of services that can be considered as genuine SGEIs for which the public service obligations have been clearly defined;
- The parameters of compensation have been established in advance in an objective and transparent manner;
- There is no compensation paid beyond the net costs of providing the public service and a reasonable profit;
- The SGEI has been either assigned through a public procurement procedure that ensures the provision of the service at the least cost, or the compensation is determined in such a manner as to ensure that it does not exceed what an efficient company would require.

85 See the table of references at the end of this handbook: EU 2022 BB-SA-GL

86 See all the relevant provisions from the SGEI package here: https://competition-policy.ec.europa.eu/state-aid/legislation/sgei_en

87 Payment for the pure recovery of the undertaking's net costs (including a reasonable profit) for the delivery of a SGEI is to be regarded as merely compensatory and not as State aid. Such a payment would be compatible with the internal market without recourse to the public interest exceptions nor the derogation under Article 106(2). Further, as it is not regarded as State aid, a prior assessment by the Commission is not necessary.

88 See the table of references at the end of this handbook: ECJ 2003

INFOBOX 25

The Citynet Amsterdam project, Case C53/2006

The case concerned the construction of an FTTH broadband access network connecting 37,000 households in Amsterdam, which were already served by several competing broadband networks. The Amsterdam municipality invested in the passive layer of the network along with two private investors and five housing corporations. The total equity investment in the project amounted to €18 million.

In December 2006, the Commission initiated a formal investigation as it did not consider that the Dutch authorities had provided sufficient evidence of the MEOP character of the investment and so the Commission was not able to exclude the presence of State aid. In particular, the Commission checked the following four conditions:

- Whether the participating investors were market investors and whether the investments by the private investors had real economic significance;
- Whether the investment by all parties concerned took place at the same time (concomitance);
- Whether the terms and conditions of the investment were identical for all shareholders;
- Whether other agreements or relationships between the public and private investors distorted their valuations of the current investment.

The Commission furthermore made a detailed analysis of the business plan including whether:

a. The underlying assumptions were unduly optimistic;

b. The success of the project was highly sensitive to targets (such as penetration rate) that may have been difficult to materialise;

c. Whether the investors have a track record of successful comparable investments.

Ultimately the Commission was satisfied that any remaining methodological concerns were minor relative to the overall project and that the assumptions and models underlying the projections had been endorsed by the significant private investors and a reputed external auditor.

Having therefore concluded that the public authority had invested in conditions that were in accordance with the MEOP, the Commission concluded that the use of public funds in question did not constitute State aid[89].

89 See the table of references at the end of this handbook: EU 2007 BB-SA-NL

90 See the table of references at the end of this handbook: EU 2012 BB-SA-IT

INFOBOX 26

The Trentino NGN project, Case C53/06

The Trentino NGN project was notified to the Commission in 2012 as a PPP between the Province of Trento and Telecom Italia for the roll-out of an NGN including FTTH in remote areas of the province[90]. This case is an important example where the Commission had doubts that the case constituted a genuine MEOP.

In particular, the Commission doubted whether:

- The evaluation of the in-kind contributions made by Telecom Italia was done on market terms and did not contain any hidden advantage for Telecom Italia. In particular, the doubt concerned the value of the copper network to be switched off;
- There were any hidden advantages from the separate contracts appointing Telecom Italia as supplier of services to Trentino NGN and connectivity services to end users;
- The project was effectively profitable taking the perspective of an investor acting under normal market terms;
- The call option recognised to Telecom Italia did not limit the return on investment of the public authority to a level which a private investor would not have accepted, given the level of risk taken by the public authority as financial investor to the project.

The Commission opened a full investigation of the measure. The public authority eventually withdrew the notification.

INFOBOX 27

SA.37183 (2015 / NN) – France Très Haut Débit scheme, and three other French SGEI measures

For one of the components of the 2016 Très Haut Débit scheme, the Commission verified that the measure complied with the four conditions of the Altmark judgment as well as the relevant provisions of the 2013 Broadband Guidelines[91] illustrating the application of the principles of the SGEI package in the context specific to the provision of a broadband network as an SGEI. The latter included the verification, for the areas concerned, of the absence of credible plans to deploy very high-speed networks and that the operator will ensure:

- Universal connectivity in the areas concerned: more specifically, the infrastructure will be made available to all operators, under objective, transparent and non-discriminatory conditions;
- Non-discriminatory pricing and operational conditions favouring competition: the operator of the modernised network is required to offer tariffs set by the regulator, ensuring the homogeneity of the access conditions;
- A step change: the modernisation allows significantly improved speeds and services;

France had three earlier measures declared free of State aid in conformity with the Altmark criteria: two for basic broadband investments, Pyrénées-Atlantiques (N381/2004) and Limousin (N382/2004), and one for Next-Generation Access (NGA) broadband, Réseau à Très Haut Debit en Hauts-de-Seine (N331/2008).

In these cases, subsidies financing broadband infrastructure in France were not deemed to be State aid because:

- France designed an SGEI and set up specific public service obligations, adequately entrusted to the SGEI provider;
- Specific parameters predefined the amount of compensation in the concession contract;
- There was no risk of overcompensation as the parameters for calculating compensation were precisely defined in the operators' business plans, which were based on the specific data provided by the public authority itself. Another reason why there was no risk of overcompensation was the fact that the public authority had required the operators who were to provide the service to set up a company specifically for that purpose, which would guarantee the neutrality of the service provider concerned; moreover, there were claw-back clauses in case profits were to rise above a given level;
- The needs of the project and what the candidates had to offer were analysed in depth and in detail. Moreover, the procedure chosen enabled the most efficient candidate offering the service at the lowest cost to the community to be selected.

91 See the table of references at the end of this handbook: EU 2013 BB-SA-GLa

The measure falls under the *de minimis* criterion

If the amounts in question are low enough that they cannot be expected to distort competition and/or cross-border trade in the EU, the use of State funds is not State aid within the meaning of Article 107(1) and is allowed under the *de minimis* criterion.

There are two different thresholds – a larger one for SGEI aid and a smaller one that applies in all other cases:

- Up to €500,000 over three years for SGEI (Regulation No 360/2012);
- Up to €200,000 over three years to a single undertaking;
- Loans can be given under the *De Minimis* Regulation if they are at least 50% secured and the loan is no more than €1 million over five years or €500,000 over 10 years.

To assess the compliance with the above thresholds, any aid received within the relevant period under different aid measures must be taken into account. Beneficiaries must keep records of the *de minimis* aid for three years and records must be kept to show that all conditions of the *De Minimis* Regulation are met.

Aid provided under the *De Minimis* Regulation is furthermore required to be transparent. This means that it must be straightforward to calculate precisely what the gross grant equivalent of the aid actually is.

Please note that the above-mentioned rules were set to expire on 31 December 2023. On 15 November 2022, the Commission launched a public consultation on a revised draft regulation which, among others, proposes to revise the *de minimis* threshold[92].

8.3 Aid exempted from notification under GBER

Aid to broadband investments can be provided under the GBER, introduced in 2014 and amended in July 2021 and in June 2023. The GBER exempts certain categories of State aid from prior notification to the Commission since they are considered as not having a significant distorting impact on the market, while the benefits largely outweigh any possible distortions of competition. In that case, the public authority is only required to inform the Commission that it intends to implement a project under GBER. In this way, the Commission will be in the position to check the compliance with the GBER conditions after the fact. In particular, articles 52, 52(b), 52(c) and 52(d) deal with projects for the deployment of fixed broadband networks and their take-up[93], and are discussed below.

Article 52 – Aid for fixed broadband networks

Article 52 concerns projects for the deployment of fixed broadband networks whose budget does not exceed a threshold of €100 million (€150 million for aid in the form of financial instruments) in areas where:

- There is no ultra-fast network (i.e. a network providing more than 100 Mbps download speed under peak-time conditions) present or credibly planned. In these areas, fixed access networks can be deployed to connect households and socio-economic drivers[94];
- There is already one ultra-fast network in place, but there is no network present or credibly planned that can provide more than 300 Mbps download under peak-time conditions. In these areas, only socio-economic drivers can be connected by fixed access networks.

There is no possibility of investing in such areas if there is at least one network that can be upgraded to provide 1 Gbps download speed under peak-time conditions. A network is considered to be upgradable to provide 1 Gbps if such an upgrade involves only marginal investments and, in any case, only minor investments in passive infrastructure.

The public authorities must carry out a mapping exercise and a public consultation to determine the types of areas and to establish the existence of market failure that would justify the intervention.

The aid must be allocated based on a competitive selection procedure respecting the principle of technological neutrality and based on the most economically advantageous offer.

The network operator must offer open wholesale access to the subsidised network under fair and non-discriminatory conditions. The duration of the wholesale access obligations is 10 years for active elements and the lifespan of the concerned infrastructure for the passive elements. The type of wholesale obligations is aligned to the ones described in the 2022 Broadband Guidelines (see 8.9) including concerning the wholesale prices which must be based on the regulated prices or pricing principles set by the NRA or on benchmark. The NRA or other competent authorities should be involved in the determination of the access products and associated prices.

92 See the table of references at the end of this handbook: EU 2022 DEMINIMIS

93 Article 52(a) deals with aid for 4G and 5G mobile networks. Article 52(a) is not discussed as this handbook only deals with fixed broadband networks.

94 'Socio-economic drivers' refers to entities which, by their mission, nature or location, can directly or indirectly generate important socio-economic benefits to citizens, business and local communities located in their surrounding territory or in their area of influence, including, among others, public authorities, public or private entities entrusted with the operation of services of general interest or of services of general economic interest as set out in Article 106(2) of the TFEU, and digitally intensive enterprises.

The new network must ensure a step change: it must bring a significant improvement in terms of broadband availability, speed, competition and overall performance. A step change exists if the new network at least triples the download speed compared to the existing networks. In addition, in the case of investments in areas where there is already one ultra-fast network in place, the new network must provide at least 1 Gbps download speed under peak-time conditions. The project must include at least 70% investment in physical infrastructure.

The public authorities must set up a monitoring and claw-back mechanism if the amount of aid granted to the project exceeds €10 million. A proper accounting separation must also be put in place.

Article 52(b) – Aid for projects of common interest in the area of trans-European digital connectivity infrastructure

This article deals with the following types of projects which are exempted from notification under certain conditions (not further detailed here):

- Cross-border sections of a 5G corridor along Trans-European Transport Network (TEN-T) corridors (total cross-border sections in a Member State ≤ 15% of the total length of the 5G corridors in that Member State);
- Cross-border sections of 1 Tbps backbone networks interconnecting certain computing facilities, supercomputing facilities and data infrastructures;
- Cross-border sections of backbone networks interconnecting cloud infrastructures of public administrations or SGEI providers;
- Submarine cables.

For these types of projects, the threshold is €100 million total costs (€150 million for aid in the form of financial instruments).

Article 52(c) – Connectivity vouchers

This article exempts from notification connectivity voucher schemes within the limit of €50 million over a period of 24 months under the following conditions:

- They are used by consumers or SMEs to subscribe to new broadband services or to upgrade the existing subscriptions to a service providing at least 30 Mbps download speed under peak-time conditions. In such case, all operators providing services of at least 30 Mbps download speed under peak-time conditions must be eligible to participate in the voucher scheme;
- They are used only by SMEs to subscribe to a new service or to upgrade the existing subscription to a service providing at least 100 Mbps download speed under peak-time conditions. In such case, all operators providing at least 100 Mbps download speed under peak-time condition must be eligible under the scheme;
- It is not allowed to use connectivity vouchers to switch between operators providing the same speeds, or to upgrade to a new subscription if the beneficiary already has a subscription providing at least 30 Mbps and 100 Mbps download speeds;
- A public consultation lasting at least 30 days must be carried out to present the main characteristics of the scheme and offer the possibility to all stakeholders to comment;
- A market assessment must be carried out in order to identify the service providers active on the market and calculate their market share. If a provider is vertically integrated and has a retail market share larger than 25%, wholesale access obligations must be imposed on such a provider, ensuring that any access seeker can use its network to provide the eligible services under the connectivity voucher scheme;
- Connectivity voucher schemes can have a maximum duration of three years (the validity of vouchers should not go beyond two years);
- Connectivity vouchers cannot cover more than 50% of the eligible costs. These can be a monthly fee, standard set-up costs and necessary terminal equipment. It can also cover in-house wiring and limited deployment in the end users' private properties or in the public property in close proximity, if necessary and ancillary to the provision of the service;
- Vouchers should be technologically neutral and non-discriminatory, and available for the widest possible choice of service providers;
- An online registry, or any alternative location chosen by the Member State, which consists of a list of all available

service providers should be set up in an open and transparent way so that consumers and SMEs can access it to choose their service provider.

Note: GBER cannot be used for broadband voucher schemes with a social character. Such schemes will have to be notified and the Commission will assess their compatibility according to article 107(2)(a) of the TFEU (see 8.11).

Article 52(d) - Aid for backhaul networks

Article 52(d) concerns backhaul network projects whose budget does not exceed a threshold of €100 million (€150 million for aid in the form of financial instruments).

The projects concern the deployment of backhaul networks where there is no backhaul based on fibre or on any other technologies that can provide a similar level of performance and reliability as fibre.

The public authorities must carry out a mapping exercise and a public consultation to establish the existence of a market failure that would justify the intervention.

The subsidised backhaul network must offer open wholesale access under fair and non-discriminatory conditions. The type of wholesale obligations is aligned to the ones described in the Broadband Guidelines (see 8.9). The duration of the wholesale access obligations is 10 years for active elements and the lifespan of the concerned infrastructure for the passive elements. The new backhaul network should cater for all fixed and mobile networks in the target areas and at least 50% of the network capacity should be available for access seekers.

Competitive selection procedures, claw-back and wholesale access prices are the same as described for art. 52 (see above).

8.4 Aid exempted from notification under the SGEI Decision

If the deployment and the operation of a broadband infrastructure is necessary for the provision of an SGEI, State aid for the compensation of such an SGEI up to €15 million per year, on average over the whole duration of the entrustment, may be exempted from notification on the basis of the SGEI Decision[95], provided that the criteria of that Decision are met, namely:

- The SGEI obligation is defined by an entrustment act;
- Compensation is limited to SGEI-related costs plus a reasonable profit;
- A mechanism for monitoring and claw-back of over-compensation is established;
- The Member State discharges certain reporting and transparency obligations, as prescribed by the Decision.

8.5 Broadband Guidelines

The Broadband Guidelines detail the application of Article 107(3)(c) to the deployment or take-up of broadband networks or services, and of Article 107(2)(a) to social vouchers. They indicate under which conditions State aid is deemed compatible with the internal market. Such conditions are known as the 'compatibility conditions':

- The aid must have an incentive effect: private investors have not invested and do not intend to invest;
- The design of the measure does not breach any provision or general principle of EU law;
- The aid is necessary and targets a market failure or important inequalities or cohesion concerns. The existence of a market failure is established through mapping and public consultation;
- The aid is an appropriate policy instrument to meet its objective: the measure ensures a step change, and other less distortive measures, such as administrative or regulatory measures, would not result in the same outcome;
- The aid is proportionate and limited to the minimum necessary: the measure ensures effective wholesale access to the subsidised network and the aid is granted through a competitive selection procedure; the measure respects the principle of technology neutrality, fosters the reuse of existing infrastructure, and provides for an appropriate claw-back mechanism;
- The aid is transparent and the authority meets its reporting and monitoring obligations;
- The positive effects of the measure outweigh its possible negative effects (balancing exercise): the authority must demonstrate, based on a counterfactual analysis, that

95 See the table of references at the end of this handbook: EU 2012 SGEI

the measure has positive effects compared to what would have happened without the aid, and that its negative effects are limited to the minimum necessary.

8.6 Market failure for fixed access networks

One of the most important steps in designing the measure is for the public authority to establish the existence of a market failure, through mapping and public consultation.

The Broadband Guidelines address the concept of market failure for fixed access networks and for backhaul networks.

Two tests must be applied to establish the existence of a market failure in the case of fixed access networks:

First test

No market failure exists if at least one network is in place or is credibly planned providing at least 1 Gbps download and 150 Mbps upload speeds under peak-time conditions. The performance of the networks must be assessed on the basis of what the networks actually provide, not what they can provide, in order to address end users' needs.

Similarly, a market failure does not exist if a network can be upgraded to provide the above-mentioned speeds. A network is considered upgradeable if it can provide the target speeds by simply, for example, changing the active equipment or undergoing marginal investment. The intention is not to overbuild a performing network by another performing network. For instance, in the case of a network based on fibre that does not currently provide the required speeds, it is not possible to overbuild this network because it can be upgraded. The underlining idea is that if upgrading the network requires only marginal investment, operators will likely undergo such marginal investment to address end users' needs, therefore the market failure does not exist.

Whenever the market failure thresholds are assessed, there is a need to assess at least the download speed (unless the existence of the market failure is based on the absence of adequate upload speed), which is always assessed under peak-time conditions. 'Peak-time conditions' refers the conditions under which the network is expected to operate at 'peak time': when the network load is usually at its maximum.

It is also necessary to assess the technologies that have been used to deploy the current networks. This is needed to assess whether the networks are upgradeable to provide 1 Gbps download and 150 Mbps upload speeds under peak-time conditions.

Second test

In order to allow a State aid intervention, it is necessary to assess the likelihood that the market will evolve toward providing 1 Gbps download and 150 Mbps upload speeds without the public intervention. This mainly depends on two factors:

- The competitive pressure in the area, which has a positive impact on the dynamic of evolution of the market toward addressing the market failure: if there are many competitors in the intervention area, this will constitute an incentive to upgrade the network in order to address end users' needs;
- The level of investment needed to upgrade the network, which has a negative impact on the market evolution: there may be situations where there are many networks in the area, but because all of them need significant investment to be upgraded to meet end users' needs, the positive dynamic described above will not take place.

The competitive pressure is assessed based on the number of operators that are present in the intervention area with networks that have been already built or are credibly planned in a relevant time horizon to provide 100 Mbps download speed under peak-time conditions (ultra-fast networks).

The number and relevant type of available networks is used to qualify the areas as:

- **White areas:** areas with no ultra-fast network present or credibly planned for the relevant time horizon;
- **Grey areas:** areas where there is only one ultra-fast network present or credibly planned for the relevant time horizon;
- **Black areas:** areas where there are at least two ultra-fast networks present or credibly planned for the relevant time horizon.

In white and grey areas (with proven step change, as explained in Section 8.7), the public intervention can take place, because there is no positive impact from any competitive pressure: in those areas, either there is no ultra-fast network (white areas) or there is only one ultra-fast network (grey areas).

In black areas, the assessment on whether the public intervention can take place is more nuanced. In this case, the level of investment needed to provide 1 Gbps download and 150 Mbps upload speeds plays an important role in possibly counter-balancing the positive impact of the competition existing in the area (there are at least two ultra-fast networks).

Several possibilities occur:

- When there is no network providing at least 300 Mbps download speed, the intervention can take place. In this case, the amount of investment to address end users' needs (i.e. providing 1 Gbps download speed and 150 Mbps upload) is substantial and therefore it is unlikely that the investment would take place without public funds.
- Where there is at least one network providing more than 500 Mbps download speed, it is likely that the competition will boost network investments towards meeting end users' needs. No intervention is possible in this case.
- In a situation where at least one existing or credibly planned network can provide between 300 Mbps and 500 Mbps download speeds, a more in-depth analysis is needed to conclude whether the networks are likely to evolve toward 1 Gbps download and 150 Mbps upload speeds, or whether the State intervention can take place. In this case, the public authorities should demonstrate to the Commission that all existing operating networks will not evolve in terms of higher speed (market failure), establishing this based on the mapping of the area and on public consultations, verifying the results of mapping and the lack of future investments for the relevant time horizon.

The Broadband Guidelines elaborate on the existence of market failure in the case of backhaul networks. The objective is to avoid situations where backhaul networks become a bottleneck for the access networks. This could be the case where the backhaul network is not capable of handling the expected development of the corresponding fixed and mobile access networks. In this case, an intervention would be considered justified with a view to addressing end users' needs.

In view of the expected increase in the performance at access level, the Broadband Guidelines consider that, at the current stage of technological development, networks based on fibre are best placed to cope with this increase in demand. A market failure may therefore exist where there is no existing or credibly planned backhaul network based on fibre or on other technologies with performances and reliability comparable to or better than fibre.

8.7 Step change

If, based on the market failure assessment described in Section 8.6, the public authority concludes that an intervention can take place, the new network must provide a step change. This means that it must provide substantial additional performance in comparison with the existing ones.

Step change for fixed access networks

In white and grey ultra-fast areas, the new network must at least triple the download speed of the most performing network already deployed (not planned to be deployed) in the intervention area. In addition, the subsidised network must represent a significant new infrastructure investment, not a mere upgrade of active equipment.

In black ultra-fast areas, the new network must fulfil the same conditions as in the case of white and grey areas, additionally providing at least 1 Gbps download and 150 Mbps upload speeds under peak-time conditions.

This means that, in white and grey areas, a step change can be demonstrated even without completely removing the market failure (i.e. without providing at least 1 Gbps download and 150 Mbps upload speeds) while in black areas, the intervention needs to remove the market failure.

The Broadband Guidelines also introduce the concept of mixed white-grey ultra-fast areas. These are areas which are predominantly white but with grey spots amounting to less than 10%. In this situation, subject to the result of a public consultation confirming that overbuilding of the grey spots does not constitute an undue distortion of competition, the overall area can be treated as white, and the subsidised network must at least triple the download speed of the most performing network deployed in the white part of the intervention area, irrespective of the performance of the network deployed in the grey spots. Therefore, in the grey spots, the new network may not triple the speeds of the network deployed there, as it has as reference the speed in the white area.

Irrespective of its performance, the new network must represent a significant new infrastructure investment.

Step change for backhaul networks

In view of the previous consideration about the existence of a market failure for backhaul networks and in view of the expected evolution of the access networks that the backhaul networks serve, a step change exists if, contrary to the existing or planned backhaul networks, the new backhaul network is based on fibre.

8.8 Determining the market failure: mapping and public consultation

The Broadband Guidelines further elaborate on what must be done when mapping and public consultation are carried out to determine market failure.

Mapping

A detailed mapping of the existing and planned networks and their performance is a fundamental step to ensure that broadband investments comply with State aid rules.

The Broadband Guidelines[96] provide a limited number of mandatory criteria for mapping, including:

- The performances must be expressed at least in terms of download speeds and, where relevant for determining market failure and step change, upload speeds that are or will be available to end users under peak-time conditions. When assessing the speeds, any bottleneck that could prevent achievement of those performances must be duly taken into account (for example, if a backhaul network will prevent the provision of the target speed);
- In terms of granularity, mapping must be carried out:
  - For fixed wired networks at address level on the basis of premises passed;
  - For FWA networks at address level on the basis of premises passed or on the basis of a maximum 100m^2 grids.

The Broadband Guidelines further elaborate on the concept of premises passed: a premise is considered passed if, upon request from an end user, the end user can be connected to the network within four weeks from the date of the request, at a price that must not exceed the normal connection fees in the country. The normal price must be determined by the competent national authority. Thus, if an operator reports a premise as passed, it must actually be able to provide the services if requested by the end user.

The Broadband Guidelines also introduce the notion of peak-time conditions (speed is now referred to under peak-time conditions). Peak-time conditions are the conditions experienced by the network during the peak time: when the network's use is at its highest load. According to this notion, if a network is supposed to provide a certain performance, it must provide this performance at peak time.

It is necessary to define the peak-time conditions upfront to have an objective representation of the performance of the networks through mapping, and compare the performance declared by various operators, both for existing networks and planned networks. It also allows to compare the performance of existing and planned networks with the performance of the subsidised network, to ensure it provides an adequate step change. Finally, upfront definition of peak-time conditions allows to check the performance of the subsidised network after the fact.

Annex I of the Broadband Guidelines[97] provide a set of best practices[98] on how to carry out the mapping exercise to support State aid interventions for the deployment of fixed access and mobile access networks. The Annex builds on and complements, for the purposes of State aid, the BEREC Guidelines for Article 22 of the EU CODE for electronic communications on geographical surveys of network deployments.

Irrespective of the mapping methodology used, Member States must make the methodology and the underlying technical criteria used to map the target area publicly available, through public consultation. It is recommended that the NRA is also consulted on the mapping methodology and process.

Irrespective of the methodology chosen, the existence of an appropriate mapping methodology is fundamental for various reasons:

- It is needed to provide an objective representation of the expected performance of the networks. Only by defining the technical criteria in advance will it be possible to have an objective representation of the performance of each network and to compare the performance declared by various operators, on an objective basis;

96 See 'Guidelines on State aid for broadband networks 2023/C 36/01', paragraph 5.2.2.4.1: Detailed mapping and analysis of coverage, and paragraph 5.2.2.4.2: Public consultation: https://eur-lex.europa.eu/legal-content/EN/TXT

97 C(2022) 9343 final ANNEXES 1 to 4

98 Referred to in section 5.2.2.4.1 of the main Guidelines.

- The performance of existing networks must also be compared with the performance of the planned networks (assessment of the existence of a step change). Therefore, the criteria to assess the performance of the existing networks can be checked against the design criteria of the planned networks. Such criteria will be used, among others, by the tendering authority to assess the bids received in an objective and transparent way;
- Finally, the mapping methodology allows to check the performance of the subsidised network after the fact. By assessing the design criteria of the subsidised network, Member States can predict the performance that end users can expect to experience when the network will run under normal conditions (i.e. whether the end users' needs will actually be addressed). This is because the subsidised network could initially provide good performance due to the low level of utilisation, and such performance may then deteriorate as the network use increases. The design criteria of the subsidised network will provide for the possibility to predict the expected behaviour of the network under normal conditions.

Public consultation

In the public consultation, Member States must publish the main characteristics of the planned intervention and the list of target areas. Member States must invite interested parties to comment on the planned State intervention, its design and main characteristics; and to submit substantiated information about the existing or credibly planned networks within the relevant time horizon. The public consultation must last for at least 30 days and must be published at least on a national website.

The Broadband Guidelines clarify that Member States must launch the competitive selection procedure or start the implementation of the project within one year from the start of the public consultation, otherwise a new public consultation is necessary.

The relevant time horizon is defined as the time horizon used to verify the planned private investments and corresponds to the timeframe that the Member State estimates for deploying the planned State-funded network, starting from the moment of publication of the public consultation until the entry into operation of the network. This relevant time horizon cannot be shorter than two years.

The relevant time horizon must take into account all aspects that could impact the duration of the deployment of the new network, such as: the time required for the selection procedure, possible legal actions and challenges, time to obtain rights of ways and permits, availability of civil works capacity, etc. Therefore, whenever the State considers that the deployment of a network will take a certain time, this is the timeframe that should include everything, up to the bringing of the network to the market. If the deployment of the planned State-funded network (until its entry into operation) takes longer than estimated, a new mapping and public consultation are necessary.

The Broadband Guidelines provide a series of best practices that do not constitute mandatory criteria.

One of these best practices concerns the assessment of the credibility of planned private investments. An assessment of the credibility of the private investment plan is necessary to reduce the risk that the State intervention is prevented based on future investment plans that eventually do not materialise, thus having an impact on end users that are not able to benefit from new performing networks.

Member States can request detailed deployment plans with milestones (for example, every six months) demonstrating that the investment will be completed within the declared time horizon and will provide similar performance as the network planned by the State. These commitments can also be recorded in an agreement, against which the Member State can check if the private operator is performing and deploying its network as declared during the public consultation.

Some of the criteria that can be used to assess the credibility of the investment plans may include:

- A project-related business plan factoring in suitable criteria to assess the credibility of the project (appropriate timeframe, proper budget, location of targeted premises, quality of services to be provided, etc.);
- A high-level project plan;
- The size of the company in comparison to the size of the investment;
- The track record of the company for similar projects.

Member States also have the possibility to check how the implementation of the new network takes place, after the fact, by, for example, asking the operators to report regularly on the compliance with the agreed milestones.

If the Member State identifies deviations to the agreed milestones, they may request further information demonstrating the continued credibility of the declared investment. If there are significant doubts as to whether the investment will be completed as declared, the Member State may decide to launch a new mapping and public consultation exercise to verify the potential eligibility under State aid of the areas concerned.

8.9 Wholesale access

As a general principle, wholesale access is needed to increase end users' choice and competition in the area concerned by the public intervention.

The State-funded network must offer effective access under fair and non-discriminatory conditions to all operators who request it. It is important to highlight that wholesale access must be effective; this is why particular attention must be paid in designing the wholesale access obligations to ensure that it is actually useful for access-seekers. The requirement of being effective implies that, in certain circumstances, there may be a need to increase the capacity of existing infrastructure to handle the envisaged future demand and its possible evolution.

In view of the complexity of defining the appropriate wholesale access products, together with their terms, conditions and pricing, it is fundamental to consult the NRA. The NRA should be consulted well in advance to be able to provide the most accurate feedback on this matter, also considering that, in certain cases, it may decide to carry out its own public consultation on the wholesale access obligations to provide a substantiated opinion to the consulting public authority.

It is to be noted that the consultation of the NRA on the overall design of the project is advised even if, contrary to the consultation on the wholesale access obligations, it is not mandatory under the Broadband Guidelines.

Wholesale access products

For fixed access networks, the Broadband Guidelines identify different sets of wholesale access products depending on the competitive situation of the intervention areas.

In white areas, where there is no ultra-fast network, the publicly financed network must provide at least bitstream and access to passive infrastructure, including dark fibre. Furthermore, the public authority is free to decide whether it is more appropriate to mandate the provision of physical unbundling or VULA.

In grey and black areas, on top of the wholesale access products that are foreseen for white areas, physical unbundling must in principle be provided.

However, there is the possibility to derogate from the obligation to provide physical unbundling in favour of VULA, subject to certain safeguards:

- The reason for derogating must be clearly expressed in the public consultation;
- The public authority must demonstrate that there is no risk of an undue distortion of competition, considering the characteristics of the project and other information such as the existing regulation in place in the country, the business model of the beneficiary (for example, wholesale only or vertical integrated), the size of the project, etc.

It is important to note that a derogation from providing physical unbundling must be approved by the Commission based on the results of the public consultation and the reasoning provided by the Member State.

For backhaul networks, the publicly financed network must grant access to passive infrastructure and provide at least one active service. It is to be noted that, for backhaul networks, the public authority must envisage the deployment of sufficient capacity for the new infrastructure (for example, ducts large enough to cater for deployment of fibre to accommodate the expected needs of all possible operators). Any possible constraint to the provision of effective wholesale access must be removed.

Wholesale access terms and conditions

Active wholesale access (for example, bitstream) must be provided for at least 10 years. The only exception concerns VULA, for which access must be granted for the lifespan of the product for which VULA is a substitution. As VULA is a substitution for unbundling, depending on the type of network that is unbundled, the timeframe for giving access via VULA can change (for example, if unbundling of fibre is concerned, this will be much longer than for unbundling of copper-based networks).

For new passive infrastructure, access must be granted for the lifespan of the network element that has been financed.

Access must also be granted to the existing infrastructure that has been re-used in the project.

Any access obligations must be enforced irrespective of any change in the ownership of the network.

Wholesale access pricing

There are three different approaches to set the prices of wholesale access products:

- Benchmarking: average published wholesale prices that prevail in other comparable, more competitive areas of the Member State;
- The regulated prices already set or approved by the NRA for the markets and services concerned;
- Cost orientation or any methodology mandated in accordance with the sectorial regulatory framework.

Member States are free to decide which approach to use to set the prices. The NRA must always be consulted on the prices of wholesale access products.

It is to be noted that the wholesale products, as well as their terms, conditions and prices, must be included in the tender documents to put the bidders in the condition to know exactly what wholesale access products they will have to provide and at what price. In this way, they can use this information to prepare an informed business plan.

INFOBOX 28

Wholesale access based on reasonable demand

Access based on reasonable demand applies to situations in which the provision of all possible wholesale access products as described above may not be appropriate, as this would result in a disproportionate increase of the cost of the project without bringing significant benefit in terms of additional competition and services.

The derogation from the provision of all mandated wholesale access products must be approved by the Commission in advance for each product for which such derogation is requested.

Such derogation must be clearly justified by the Member State by explaining what the increase in the investment cost is and the reasons why it is considered appropriate to derogate from its provision.

It is for the Commission to eventually approve such derogation and include it in the decision. In this way, all operators participating in the tender know exactly which products they have to provide and at what price.

When the Commission agrees that a derogation from the provision of a certain product is possible, this product will have to be provided only in case of reasonable demand, i.e., in case there is a business plan that shows that there is a need to provide this service and there is no comparable access product already available on the market. The burden of proof is on the access seeker.

In case it is proved that reasonable demand exists, the owner of the subsidised network (the beneficiary) will have to bear the cost of providing the relevant wholesale access service.

INFOBOX 29

Private expansion

As a general remark, a State aid decision assesses an intervention in a specific area. However, the Broadband Guidelines clarify regarding situations where the network extends outside the intervention area using the operator's own financial resources.

Whenever this extension in the adjacent area is done by operators that are not linked to the beneficiary of the aid and are only using the wholesale access to extend outside the intervention area, this is allowed.

If the public authority is of the view that private extension should be allowed for the beneficiary as well, or for an operator linked to the beneficiary, such possibility must be clarified during the public consultation. In this case, the public authority must indicate that private extensions are permitted at a later stage and must provide all the information about the characteristics of the adjacent area where these expansions could take place in order to trigger comments during the public consultation that may point to possible issues.

Furthermore, the expansion can only take place two years after the publicly financed network enters into operation, in the following cases:

- If in the adjacent area there are at least two independent networks providing speeds comparable to those of the publicly financed network;
- If there is at least one network in the adjacent area providing speeds comparable to those of the publicly financed network which entered into operation less than five years before the publicly financed network enters into operation.

In any case, any other risk of significant distortion of competition resulting from the public consultation must be considered and they may result in prohibiting the extensions by the aid beneficiary or by an operator linked to the beneficiary.

8.10 Monitoring and claw-back

Monitoring

Awarding authorities are obliged to closely monitor the implementation of supported broadband projects over their entire duration.

Furthermore, schemes with large aid budgets, or containing novel characteristics, or when significant market, technology or regulatory changes are foreseen, may be subject to an evaluation after the fact[99].

Claw-back

Claw-back refers to the repayment of any excess subsidy that may have been granted to a beneficiary of State aid. To guard against this potential risk, the Broadband Guidelines require that a claw-back mechanism is included in the contract with the successful supplier. However, the claw-back mechanism should not endanger the incentives for operators to participate in a tender and to strive for cost efficiencies when deploying and managing the network. To achieve a good balance between these two objectives, public authorities should only claw-back extra profit above a certain threshold[100].

8.11 Broadband vouchers schemes

A broadband voucher scheme is a monetary demand-side measure whose objective is to address demand deficiencies by reducing the cost of broadband access to end users (consumers and businesses), thus encouraging take-up of broadband services. In situations where prices of broadband services play an important role in take-up, monetary demand-side measures, such as vouchers, can be appropriate in order to lower the cost of access to broadband services by covering part of the monthly subscription fee for a certain period of time, and part of the set-up costs.

Whenever a voucher measure is addressed to consumers who are not carrying out economic activities, the voucher does not amount to State aid to end users. Even in the case where end users carry out an economic activity (for example, vouchers for SMEs), the aid could fall under the scope of the *De Minimis* Regulation, so it would not require a notification to the Commission for approval under State aid rules.

However, broadband vouchers can constitute State aid to operators who will ultimately benefit from the stronger demand created by the broadband vouchers, regardless of whether such broadband vouchers are paid directly to operators or to end users. Typically, such voucher schemes confer a selective advantage, are financed from State resources, and have the potential to both distort competition and affect trade within the internal market. They must therefore be notified to the Commission for approval unless they are connectivity broadband vouchers schemes that fulfil the criteria to fall under the GBER (see 8.3).

There are two types of broadband vouchers schemes: social vouchers schemes and connectivity vouchers schemes.

Social vouchers schemes

Social vouchers schemes fall under Article 107(2)(a) TFEU, which states that "aid having a social character, granted to individual consumers, provided that such aid is granted without discrimination related to the origin of the products concerned" shall be compatible with the internal market.

Accordingly, social vouchers are reserved to individual consumers (businesses are not eligible) that are in a particular situation (for example, consumers that are in a fragile financial situation).

In view of their social nature, such vouchers can only be used to subscribe to new broadband services or to retain existing subscriptions.

Social vouchers can cover up to 100% of the monthly fee, the standard set-up costs, and the end users' terminal equipment.

Social voucher schemes must ensure transparency by setting-up an online registry of all eligible services open for registration to all operators that are able to provide these services.

The public authority must conduct a public consultation inviting comments from stakeholders (operators, consumers association, etc.) to ensure that possible negative effects on competition are properly considered.

Social voucher schemes must be technologically neutral.

Connectivity vouchers schemes

Connectivity vouchers schemes fall under Article 107(3)(c) TFEU. They can address both consumer and business end users and can be used to upgrade current subscriptions or to subscribe to new services but, contrary to the social vouchers, they cannot be used to retain an existing subscription.

The connectivity voucher measures must have an incentive effect, which is reflected by the amount of costs covered. While the eligible costs for connectivity vouchers are the same as the

99 For further details, see paragraph 7.3 and chapter 8 of the Broadband Guidelines.

100 For further details, see paragraph 5.2.4.4.5 of the Broadband Guidelines.

ones for social vouchers (monthly fee, standard set-up costs and end users' terminal equipment), only up to 50% of these costs can be covered by the voucher (contrary to 100% for social vouchers).

In-house wiring and some limited deployment in the end user's private property can also be covered by the voucher, to the extent that this is necessary and ancillary to the provision of the service. This means that they can represent only a minor part of the eligible costs.

Connectivity vouchers must also observe the principle of technological neutrality and transparency: an online registry, like the one described for social vouchers, must be set up and made available to all operators that are able to provide the broadband services eligible under the connectivity vouchers scheme.

In the case of connectivity vouchers, a time limitation applies. The duration of a connectivity voucher scheme cannot be longer than three years, while the duration of each voucher cannot exceed two years.

A fundamental element to assess the compatibility of a connectivity voucher scheme is the market assessment: the public authority must carry out a market assessment that justifies the connectivity voucher scheme. It represents a key element for the Commission to assess the compatibility of the voucher scheme as it outlines the structure of the market, the market share of the operators concerned, the trends in terms of take-up, any regional differences, the deployed technologies, etc. The objective of the market assessment is to assess whether there is the risk of any disproportionate advantage that could be conferred to some operators to the detriment of others. The Broadband Guidelines are not prescriptive in what the market assessment should contain, but it must be an assessment of the market that will put the Commission in the condition to conclude whether the measure will have positive effects that outweigh any possible negative effect.

As an additional safeguard, to foster the use of the connectivity voucher scheme by the widest possible number of operators, if there are operators in the market that have more than 25% market share, they need to make available an equivalent wholesale access product, so that any access seeker can address end users, even if it does not have its own network.

	Social Vouchers	Connectivity vouchers
Target	Consumers in fragile situation	• Consumers • Businesses
Eligible services	• Subscription to a new broadband service • Retaining an existing broadband service subscription	• Subscription to a new broadband service • Upgrade of an existing broadband service subscription (retaining the existing subscription is not eligible)
Eligible costs	Eligible costs may include 100% of: • The monthly subscription fee • The standard set-up fee • The necessary terminal equipment and deployments to access the eligible broadband service • In-house wiring and limited deployment in the consumers' private property or in public property	Eligible costs may include 50% of: • The monthly subscription fee • The standard set-up fee • The necessary terminal equipment and deployments to access the eligible broadband service • In-house wiring and limited deployment in the consumers' private property or in public property
Technology neutrality	End users must be able to use connectivity vouchers to procure eligible broadband services from any provider that offers them, irrespective of the underlying technology.	End users must be able to use connectivity vouchers to procure eligible broadband services from any provider that offers them, irrespective of the underlying technology.
Equal treatment	Public authorities must: • Set up an online registry of all eligible service providers, or • Implement an equivalent alternative method	Public authorities must: • Set up an online registry of all eligible service providers, or • Implement an equivalent alternative method.
Public consultation	The public authority must carry out a public consultation of at least 30 days on the main characteristics of the scheme.	The public authority must carry out a public consultation of at least 30 days on the main characteristics of the scheme.
Duration	No predefined limit	• The duration of a connectivity voucher scheme cannot 'in principle' exceed three years, • The vouchers for individual end users cannot exceed two years (validity).
Market Assessment		The public authority must: • Carry out a market assessment to determine the need for a connectivity voucher scheme by benchmarking the intervention area(s) against other areas of the member state or the EU • Identify the eligible providers • Collect information about the market shares of the eligible providers to ensure that the measure does not give a disproportionate advantage to some providers, possibly reinforcing (local) market dominance.
Wholesale access		If the eligible provider is vertically integrated and its retail market share exceeds 25%, it must grant wholesale access that supports the eligible retail services subject to: • Open, transparent and non-discriminatory conditions • Prices that are set based on the methodology that is also used for wholesale access to subsidised networks.

***Table 7** – Comparison between social voucher schemes and connectivity voucher schemes*

INFOBOX 30

Italy - social voucher scheme SA.57495; Greece – student voucher scheme SA.57357, 2020

The Italian measure consisted of a €200 million voucher scheme to support access to broadband services by low-income families in Italy. The Greek measure consisted of a €20 million voucher scheme to support access to broadband services by students in Greece.

In the Italian case, the vouchers can be used to purchase broadband services with download speeds of at least 30 Mbps, and for the necessary equipment, such as a tablet or a personal computer, to be able to exploit the broadband services.

In both cases, the Commission found that the schemes are mainly aimed at families or private individuals, whilst at the same time amounting to State aid in favour of operators, who will be able to offer such services over existing broadband infrastructures and, in the Italian case, also the necessary equipment.

The Commission therefore assessed the measures under State aid rules, in particular Article 107(2)(a) TFEU, which allows Member States to grant aid having a social character to individual consumers, subject to certain specific conditions:

- It must address individual consumers;
- It must have a social character;
- It must not discriminate the products or the services on the basis of their origin.

The Commission found that the measures will be technologically neutral and that there will be no undue discrimination based on the origin of the operators or of the products. Furthermore, the Member States will take steps to avoid undue distortion of competition and will monitor to ensure that the scheme will not be used to merely replace existing subscriptions of NGA broadband services.

8.12 Overview of the key procedural steps for State aid projects

A public authority wishing to fund a broadband project through State aid must take the following steps:

- **Mapping exercise:** to identify which geographic areas will be covered by the support measure, the performance of the existing and planned networks in the intervention areas, and the technologies used;
- **Public consultation:** to verify the existence of credible private investment plans in the intervention areas and to give adequate publicity to the main characteristics of the measure by publishing the relevant information of the project and inviting comments. Note that there are often two public consultations: the first public consultation aims to verify the intervention area by seeking information on credible investment plans, and to provide a broad description of the project. The second public consultation is launched at a later stage, often immediately before the notification to the Commission, and is meant to provide a final update on the intervention area as well as a more detailed description of the characteristics of the projects that, in particular for complex projects, are likely to change in time;
- **Competitive selection process:** to be conducted in line with the spirit and principles of the EU Public Procurement Directive on the basis of the economically most advantageous offer, including qualitative award criteria, such as performance of the network (including its security), the geographical coverage of the project, how future-proof the technological approach is, the climate and environmental performance of the network, etc. The qualitative criteria will then be weighed against the

requested aid amount. The tender documents must include information on the wholesale access products as well as their pricing, terms and conditions;

- **Technological neutrality:** the tender should not favour or exclude any particular technology or network platform both in the selection of beneficiaries and in the provision of wholesale access;
- **Use of existing infrastructure**: bidders should be encouraged to have recourse to any available existing infrastructure to avoid unnecessary and wasteful use of State resources. Bidders should be encouraged to provide all relevant information on their existing infrastructure to other bidders. That information should be provided in time to be taken into account when preparing the bids (when appropriate, the provision of that information could be mandated to participate in the selection procedure);
- **Wholesale access:** third parties' effective wholesale access to a subsidised broadband infrastructure is an indispensable component of any State measure supporting broadband. Subsidised companies should provide at least the wholesale access products mandated by the Broadband Guidelines or the GBER. Such wholesale products may go beyond what is mandated by NRAs under sectoral regulation to the operators who have SMP, since the aid beneficiary is not just using its own resources but also taxpayers' money to deploy the network;
- **Wholesale access pricing:** prices can be based on benchmark, regulated prices or any other methodology in accordance with the sectorial regulatory framework;
- **Monitoring and claw-back mechanisms:** close monitoring of implementation and profitability. Design and implement a claw-back mechanism (for example, for sharing unanticipated profits) if the aid amount of the project is above €10 million;
- **Reporting:** every two years, the State aid granting authority should report key information on the aid projects to the Commission (in addition to the yearly general reporting). This information is detailed in Annex III of the Broadband Guidelines;
- ***Ex post* (after the fact) evaluation plan:** certain schemes are subject to an evaluation. Given its objectives and in order to avoid putting a disproportionate burden on Member States and on smaller aid projects, this only applies for aid schemes with large Sate aid budgets (i.e. €150 million per year or €750 million overall), containing novel characteristics, or when significant market, technology or regulatory changes are envisaged;
- **Transparency:** this is a transversal requirement that permeates all the steps above. Chapter 7 of the Broadband Guidelines details the information that Member States must publish in the Commission's transparency award module or on a comprehensive State aid website at national or regional level.

8.13 Non-Altmark SGEI compatible with 106(2) TFEU

If an SGEI does not meet the Altmark conditions, its funding with State resources is considered State aid and needs to be assessed for compatibility under article 106(2)[101]. The same above conditions for the definition of a genuine SGEI in the broadband sector would apply.

The assessment of an SGEI measure under Altmark and under 106(2) differs in that the second and fourth conditions of Altmark are not necessarily required for compatibility under 106(2). The fourth, which deals with cost efficiency, is often the main distinguishing feature. If the compensation for the SGEI is not shown to be limited to the costs of a typical well-run undertaking, the cumulative Altmark criteria are not met and the Commission will consider the measure to be State aid.

101 The Commission assesses those measures in the light of a set of documents referred to as the "Service of General Economic Interest package" (or SGEI package): the Commission Communication on the application of the EU State aid rules to compensation granted for the provision of services of general economic interest (OJ C 8, 11.1.2012, p. 4), the Commission Decision of 20 December 2011 on the application of Article 106(2) of the Treaty on the Functioning of the European Union to State aid in the form of public service compensation granted to certain undertakings entrusted with the operation of services of general economic interest (OJ L 7, 11.1.2012, p. 3.), the Commission Communication on a European Union framework for State aid in the form of public service compensation (2011) (OJ C 8, 11.1.2012, p. 15) and the Commission Regulation of 25 April 2012 on the application of Articles 107 and 108 of the Treaty on the Functioning of the European Union to *de minimis* aid granted to undertakings providing services of general economic interest (OJ L 114, 26.4.2012, p. 8.).

Acronyms, abbreviations and terminology

This is a list of acronyms, abbreviations and terms used in this handbook.

ADSL	Asymmetric Digital Subscriber Line, a last mile technology operating over copper phone lines
AON	Active Optical Network, a technology for FTTH/FTTB (also known as Ethernet point-to-point)
BCO	Broadband Competence Office
BEREC	Body of European Regulators for Electronic Communications
Bitstream	A mechanism to provide network access at the active layer; the term originated in the context of DSL technology, especially, to refer to access to vertically integrated network, but is used in the broader context of broadband networks
CAPEX	Capital expenditure
CEBF	Connecting Europe Broadband Fund
CEF	Connecting Europe Facility
DAE	Digital Agenda for Europe
DBO	Design, build and operate
DOCSIS	Data Over Cable System Interface Specification – a cable TV network solution
DSL	Digital Subscriber Line
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EECC	European Electronic Communications Code
EFSI	European Fund for Strategic Investments
EIB	European Investment Bank
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
FTTH	Fibre-to-the-home, a last mile infrastructure
FTTB	Fibre-to-the-building (typically an MDU), a last-mile infrastructure
FTTC	Fibre-to-the-cabinet (from which the last-mile connection starts), a local area infrastructure
GPON	Gigabit Passive Optical Network – a shared-access technology for FTTH/FTTB (ITU-T G.984)
HPC	High-performance computing
HDTV	High-definition television
IRU	Indefeasible right of use
ICT	Information and communication technology
IoT	Internet of Things, the concept by which objects of different types (from home appliances to street furniture, from smart-city sensors to personal body networks) are connected
ISP	Internet service provider, for example an SP delivering internet service

LLU	Local loop unbundling, the process of providing unbundled access to network infrastructure (passive-layer access)
LTE	Long-Term Evolution
MDU	Multi-dwelling unit – an apartment block
MNO	Mobile network operator
Municipality	In this handbook: generic term referring to a local administration (city, town, commune)
NBP	National Broadband Plan
NGN/NGA	Next-generation access/network: it refers to access broadband networks supporting speeds of least 30 Mbps (see 2020 connectivity goals)
NP	Network Provider, operates the active equipment and delivers SP's services to the end users
NRA	National Regulatory Authority
NUTS	Nomenclature of Territorial Units for Statistics
Operator	Generic term for a company operating and selling broadband services of some kind; in the handbook, this is often used to refer to an SP, or a combined NP+SP
OPEX	Operational expenditure
OTT	Over-the-top
PA	Public authority (the municipality, region or Member State carrying out the broadband investment)
PIP	Physical infrastructure provider, owns and operates the passive infrastructure
PON	Passive optical network, a shared-access technology for FTTH/FTTB
PPP	Public-private partnership
PSTN	Public Switched Telephone Network
QoS	Quality of Service, the set of technical parameters defining the quality of a broadband service
Region	In this guide: generic term to refer to a regional public authority (a region, county, province, department, etc.)
RoW	Right of Way
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprises
SMP	Significant market power
VDSL	Very high-bitrate Digital Subscriber Line
SP	Service Provider, sells services (for example internet, TV, telephony, etc.) to the end user
Take-up rate	The percentage of connected households who decide to take up the service, for example, to subscribe to a broadband service
VHC	Very high-capacity connectivity: in practice, gigabit speeds (see 2025 connectivity goals); it is a subset of NGN/NGA
VHCA	VHC Access: it refers to the access part (last mile) of broadband networks supporting VHC speeds to the end user
VHCN	VHC Network: it refers to broadband networks supporting VHC speeds
xDSL	Digital Subscriber Line of any type
Unbundled access	The provision of network access at passive layers (for example fibre or copper), often in the context of regulated access to vertically integrated networks
Undertaking	An entity (public or private) that performs economic activity, defined as offering goods and services in the market, equivalent in this handbook to 'business actor'

References

Below is a list of useful references.

The general format followed is AUTHOR YEAR, or AUTHOR YEAR TOPIC-CODE, depending on the type of reference. In case one piece of information ("XXX") is presented in several relevant documents and medium types, the different references are listed as different versions of reference "XXX", for example, XXXa, XXXb, XXXc.

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