FIBER IN URBAN AND RURAL AREAS 2025

The state of the Dutch fiber optic industry

FIBER CARRIER ASSOCIATION

COLOFON

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ABOUT THE FCA

FIBER CARRIER ASSOCIATION

The Fiber Carrier Association (FCA) was founded in March 2016 to support and advise fiber network owners based on trends and developments at home and abroad. The FCA speaks to all stakeholders in the fiber chain and thus fulfills the role of catalyst towards (local) government, business and all other stakeholders.

The FCA identifies national trends and developments. Together with participants, partners and knowledge partners, we represent the interests of the fiber industry with an eye for social impact and broader developments in digital infrastructure and the economy.

The FCA in a nutshell:

- The added value of the FCA can be found in market knowledge, knowledge of legislation and the (political) network, also abroad (think embassies and Foreign Affairs).
- The FCA is affiliated with E-LFA.eu, the European Local Fiber Alliance that represents about 1,000 local and regional carriers throughout Europe.
- In addition, activities such as Fiber Trade Day, thematic mini-lectures and the annual report Fiber in Town and Country that you are now reading.
- The FCA has a close collaboration with other industry associations in the digital infrastructure such as the Dutch Data Center Association, CyberVeiligNederland, Digitale Infrastructuur Nederland, Dutch Cloud Community, NBIP, BTG and NLDigital.
- Many parties work closely together. The FCA facilitates the opportunity to meet easily, which sends a powerful message to the industry
- Both board and management have many years of experience and knowledge and are able to separate main and secondary issues well from that background.
- In the area of education and sustainability, there are several programs such as the Fiber Academy to enable employees to keep their knowledge current.

FIBER IN URBAN AND RURAL AREAS

Before you is already the eighth edition of the annual overview report of the Fiber Carrier Association, the industry association of fiber optic operators in the Netherlands. It will probably not have escaped your notice that last year the report was renamed: Fiber in Urban & Rural Area's. The reason for this is simple - "Netherlands on Fiber," as the report was called until 2024, has always been intended as a mission and brief, where the report provided an overview and background to the question "how far along are we with the vitrification of the Netherlands?

In 2024, we could write in this place that we were almost there. Anno 2025, we can finally conclude that we now have about as many fiber connections as there are households: 8.2 million. That includes duplicate connections, and there are still households that do not have fiber. But 'Netherlands on Fiber' is now almost a reality, at least for households. It is important that we continue to pay attention to those households that want fiber, but do not get it because it is not commercially viable. We ask the government not to forget them.

In the first edition of this report, published in 2017, it was still all hands on deck: household fiber deployment had stagnated significantly across the board. As mentioned, that situation is now completely different. But just because households have a fiber connection does not mean they are using it. There are concerns among carriers that customers are moving too slowly to an Internet connection over fiber. This is important, because as long as consumers continue to use copper connections, this will jeopardize European goals to deploy copper networks by 2030. In addition, fiber is a more sustainable alternative in several ways, both in terms of energy consumption and its ability to scale with the needs of end users.

Fiber, of course, is more than just "fiber to the home" (FttH), as fiber connections for households are called. Access networks, metro networks operating in cities or the backhaul connections connecting regions and countries, are also of great importance. As is international connectivity via sea cables, which make it possible to exchange data anywhere in the world, whether in the tip of Argentina or on an archipelago in the Pacific Ocean. Thanks to fiber optic networks, we can continue to communicate, because even mobile (5G) transmission towers or ground stations for Internet via satellites, eventually transport their data over fiber optic connections.

In the area of fiber roll-out of business parks, there is still work to be done. There are also challenges here: the higher interest rates in attracting borrowed capital, more expensive materials, etc. Increasingly, we see companies using FttH subscriptions instead of Fiber to he Office (FttO), but this is often accompanied by a stripped-down service level agreement compared to FttO.

Fiber in Europe

The FCA has chaired the European Local Fibre Alliance since last year. The knowledge present in the Netherlands in the field of the rapid rollout of fiber is very valuable more widely in Europe. This also means that there are opportunities for the Dutch sector in Europe. ELFA is an industry organization, which not only promotes entrepreneurship, but is also active in Brussels. Increasingly, politicians and policy makers in Europe are asking for input and other national industry organizations from Europe are joining ELFA. An important reason for this growth in interest is that by 2030 households in Europe must be able to use 1 Gigabit connections, but significant challenges still exist in several European countries to achieve this goal.

Open access

The FCA is still very much in favor of open access networks, where the operator of the physical network also makes that network available to other providers of services such as Internet and TV. This way, only one network needs to be built while still allowing competition. Some providers nevertheless choose to build closed networks, which for consumers can lead to the incomprehensible situation of having two fiber connections in the meter cupboard.

The FCA continues to advocate better cooperation among fiber carriers. There is still much synergy to be gained as many networks move from construction to management.

I wish you much reading pleasure.

Andrew van der Haar
Director Fiber Carrier Association

COMMUNITY MEMBERS


EXCLUSIVE
NETWORKS

FORE
FREEDOM

Glazen-Maas

GRONINGEN SEAPORTS


HUAWEI

IMMCO INC

Netceed

ODF
open dutch fiber

RELINED
FIBER NETWORK

ST
Schiphol
Telematics

signet
breedband

simac

SpeerIT

STADSRING LEEUWARDEN

TRENT
GLASVEZEL

TrueCom
Building a connected world

TTNoord®

Uniscape

Vertixo

VITRUM NET

MARKET DEVELOPMENTS 2024

If you live or work in an area that has had fiber optics installed in the past year, you may have noticed orange/green/purple conduits sticking out of the sidewalk. Sometimes those (orange) strands remain visible for months. These connections have yet to be completed in homes or commercial properties. But that's a time-consuming process, plagued, moreover, by personnel shortages.

The reason that so many connections have yet to be disconnected is that in recent years fiber has been installed at a record pace. In 2024, 1.13 million FttH fiber connections were completed, according to the Telecom Monitor of the Authority Consumer and Market (ACM). This represents a slight decrease in the number of newly realized FttH connections compared to 2023, when 1.3 million connections were realized. A total of 8.26 million Dutch addresses now have fiber on their doorstep. We deliberately phrase it this way, because we are talking about homes passed, not households that actually have the connection wired in the meter box.

With the achievement of 8.26 million fiber connections, we can also conclude that the great vitrification of the Netherlands is now largely complete when it comes to households. For the first time, there are more fiber connections available than coax connections (8.26 million and 8.18 million respectively). According to CBS, the Netherlands had 8.4 million households at the beginning of 2024. Although new connections can still be realized through so-called overbuilding, where two carriers each build their own network in a zip code area, we can assume that the period of large-scale fiber optic deployment in the Netherlands is now coming to an end. For business parks, this is a different story, about which more later in this report.

Fiber activation among consumers is not keeping up with the rapid pace of rollout. Just over 37% of fiber connections to households were activated in 2024, meaning the connection was being used for an Internet subscription. In 2022, the figure was still about 50%. So the delivery of new connections is ahead of what is called "uptake" in jargon. However, the number of copper and coax internet subscriptions is declining and the number of consumer fiber internet subscriptions is growing. The

contraction in copper is stronger than in coax, probably caused in part by the disappearance of more than 500,000 copper connections. We can assume those have been replaced by fiber connections. At the end of 2024, 120,000 more households had Internet subscriptions via coax than via fiber (3.09 million vs. 3.21 million, respectively).

KPN has the largest share of homes passed with FttH at 50%-55%. Delta Fiber, Open Dutch Fiber and Glaspoort come in second, third and fourth place.

Survey FCA among participants and networks

The FCA examines each year how its own participants are moving with market dynamics. The ACM increasingly uses data from various market participants for its investigation, but part of the market is not (yet) surveyed by the ACM. In practice, not all providers have their own fiber network and/or offer services over third-party networks. Providers are not asked whether they have a (limited) network. With our own research we therefore want to give an even better insight into market developments.

Figure 1. Market Shares. Homes Passed – Fiber Optic (FttH) Q4 2024. (Source: Survey of FCA participants, 2024)

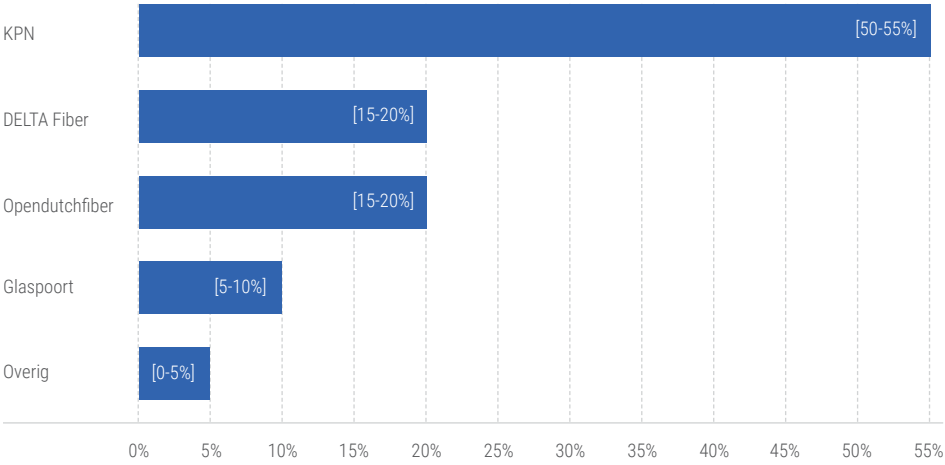


Figure 2. Number of kilometers of existing network of FCA participants, by type
(Source: Survey of FCA participants, 2024)

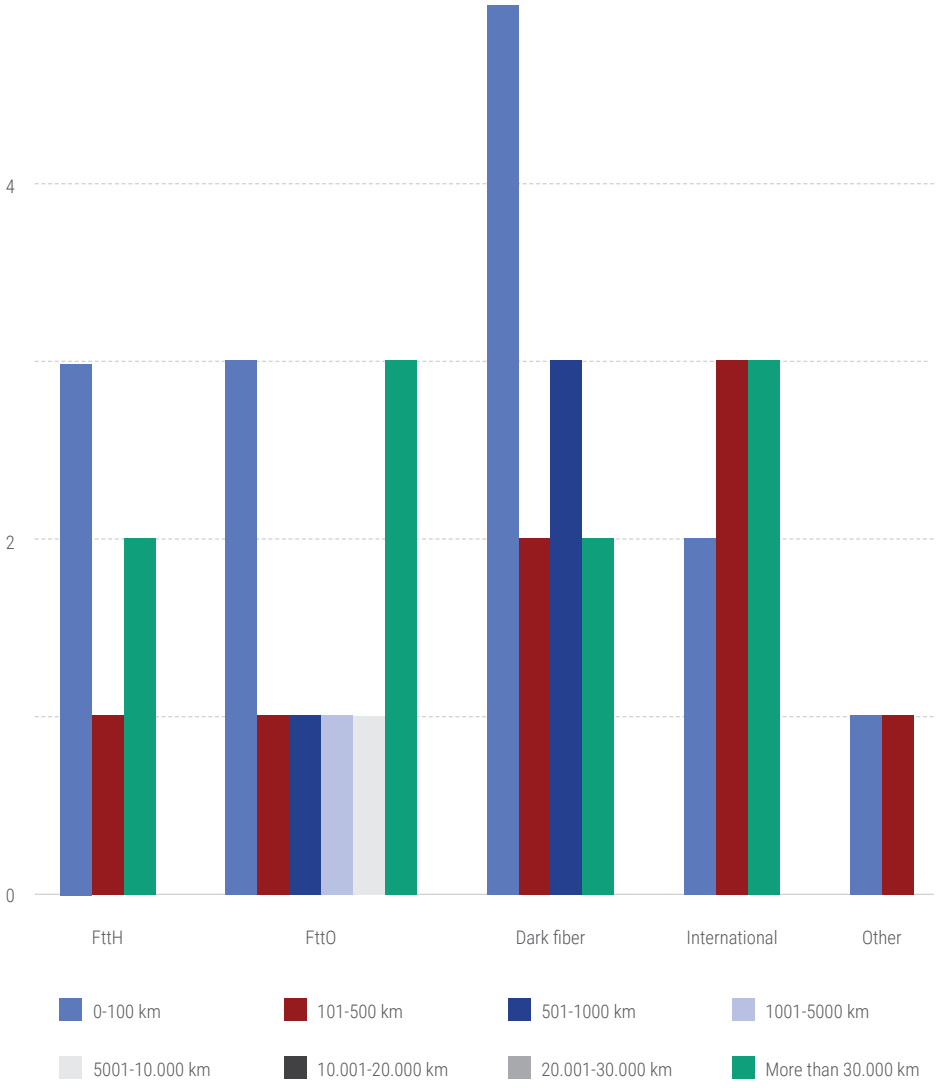


Figure 3. Number of miles to be delivered in 2025 by FCA participants
(Source: Survey of FCA participants, 2024)

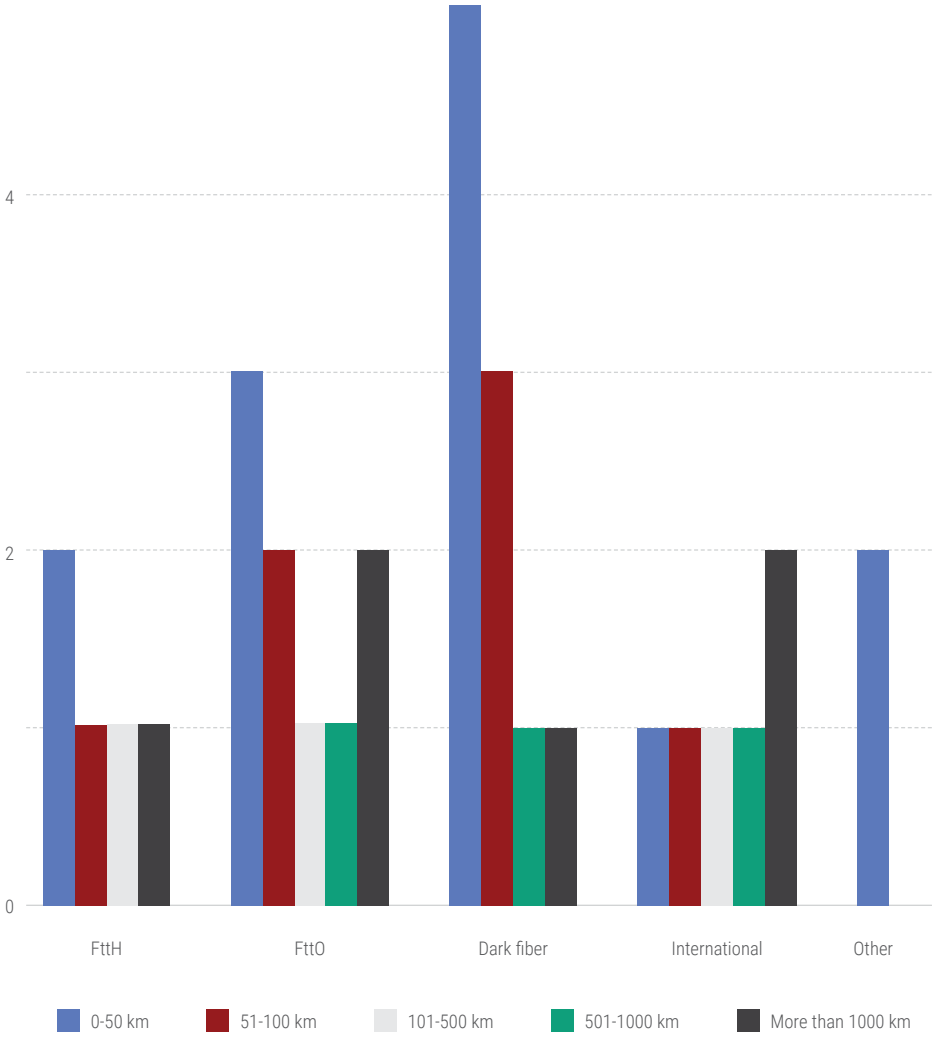
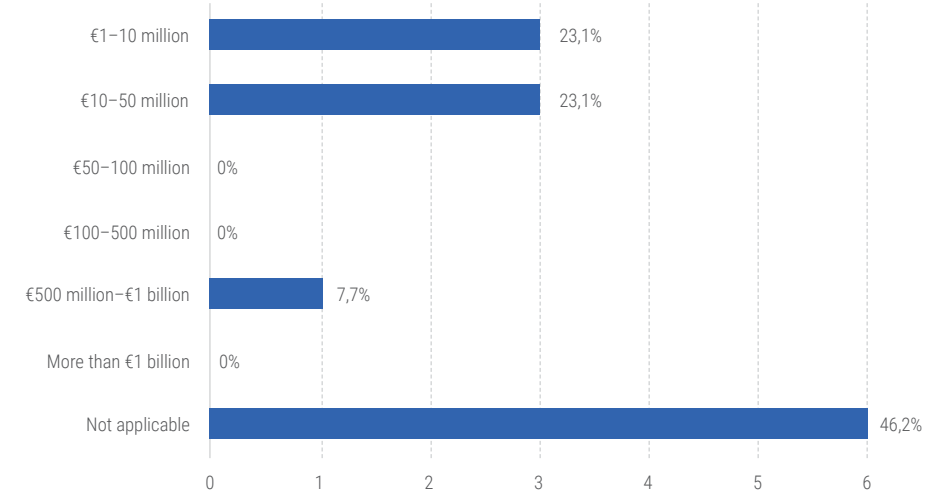
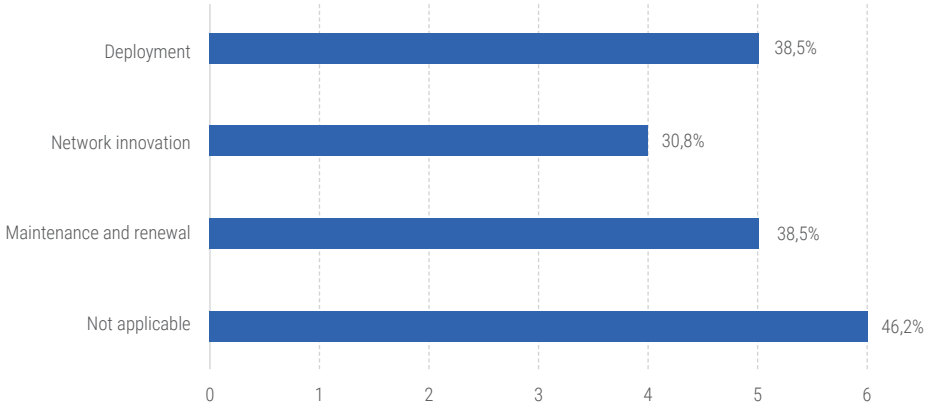


Figure 4. Expected investments in 2025
(Source: Survey of FCA participants, 2024)



Still investing heavily in the sector, among survey participants they are expected to raise between €500 million and up to €1.2 billion in capital by 2025. They are putting this capital to a variety of uses, as shown in the chart above.

Figure 5. Investment spending purpose



Labor market tightness is still a major problem, especially when it comes to technicians. Several survey participants indicated that finding suitable employees for technical work in fiber optic installation, maintenance or repair remains difficult. In particular, employees with the right qualifications and work ethic remain scarce. As one survey respondent put it, “Staff is good to get. Good staff is hard to get.’ Here is still a task for the industry in cooperation with education to promote the influx of qualified employees.

The FCA connects industry and professionals through the Fiber Academy, with a strong commitment to lifelong learning. From novice technicians to seasoned experts, the Fiber Academy enables everyone to gain new knowledge and deepen their experience.

Excavation damage

When constructing or repairing networks, unfortunately damages occur. The WIBON (Wet Informatie uitwisseling Boven en Ondergrondse Netten) provides various tools to manage excavation work. With Klic (Kabels en Leidingen Informatie Centrum), the Land Registry keeps track of applications where work is being carried out and ensures that the applicant receives the information on location and type of connection. This is a publicly accessible database. Specific information is available for a fee.

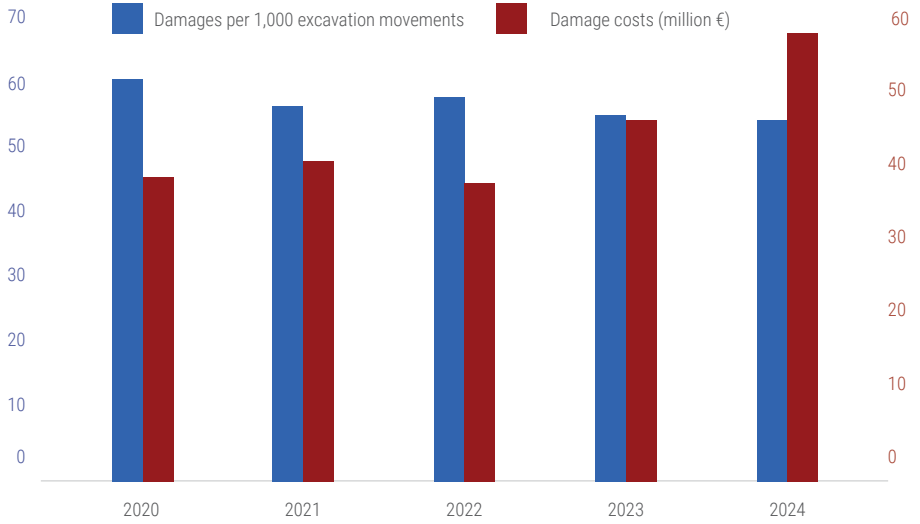
Despite these provisions, excavation damage continues to occur. The soil in the Netherlands is “crowded”: there are many parties who have cables and pipelines in the soil, so there is a risk of damage in many places. Yet improvements are visible, according to the Cable and Pipeline Consultation (KLO), the consultation table where excavation contractors make agreements with each other and exchange knowledge, among other things to prevent excavation damage.

The number of excavation damages has decreased by ten percent over the past five years. In 2020 there were 60 damages per 1,000 excavation movements, in 2024 there were 54. This is according to KLIC figures from the Land Registry. Damage costs rose 47 percent over the same period to €57.6 million in 2024.

The figures show that the number of digging operations is increasing every year: by nearly 20 percent in five years. During that period, the absolute number of claims increased by nearly eight percent, which is proportionately less than the increase in work.

Although in percentage terms the number of damages decreased compared to the absolute number of excavations, in absolute terms the number of damages increased. That is why KLO is working with grid managers, excavation contractors and government agencies to find solutions such as better agreements, laws and regulations and awareness-raising.

Number of damages per 1,000 excavation movements and damage costs (Source: KLO and Kadaster)



Year	Excavation movements (excavation + incident)	Number of damages	Damage costs (mln €)	Damages per 1,000 excavation movements
2020	768.819	46.331	39,1	60,3
2021	812.866	45.682	41,2	56,2
2022	812.517	46.799	38,3	57,6
2023	892.352	48.997	46,4	54,9
2024	921.281	49.913	57,6	54,2

Double construction

In previous editions, we have discussed at length the duplication of networks in municipalities, also known as overbuilding. Last year also showed that double construction is still taking place in various places. This development is viewed differently, with no unambiguous positions being taken by either the industry or the government. For example, KPN states that it is replacing its copper networks with fiber in various places in the Netherlands, even if a fiber network from another provider is already available in that area. Partly for this reason, Delta Fiber announced in 2024 that it was discontinuing the construction of fiber for some 300,000 addresses, largely in Friesland. Municipalities where overbuilding takes place are unhappy about this in some cases because it causes repeated nuisance in public spaces and can lead to digging damage. At the same time, the ACM is positive about the phenomenon of overbuilding because it would give consumers more choice.

Sea Cables

For some time there have been concerns among industry associations about the lack of new plans for sea cables landing in the Netherlands. With the phasing out of TAT-14 and AC-1, the Netherlands has lost its direct connections to the U.S.. Other, European cables, are also being phased out in the coming years. Since the Netherlands has an important data hub function for the rest of Europe and the requested bandwidth will grow strongly in the next 10 years (35% CAGR for this period) it is important that new capacity is realized quickly.

Meanwhile, other European countries are overtaking us, with new connections to, for example, Denmark, the United Kingdom, France and Spain. The FCA sounded the alarm about this back in 2018 and repeated this call many times in various coalitions to politicians and administrators in the Netherlands. Meanwhile, there is a public-private partnership in the form of the Dutch Subsea Cable coalition. In 2024, this coalition was able to report its first success with the IOEMA project, a sea cable that will serve several northern European countries. Because of strong market interest, the Netherlands will have two landfall points for this cable, in Eemshaven and near Rotterdam.

Outlying areas

With the vitrification of Dutch households progressing rapidly, the question is how the so-called “unprofitable” top in the outlying area can keep up with this. Whereas this top was previously estimated at 19,000 households, new figures show that it is 27,500 households that do not have a fixed 100Mbps+ connection. However, it is expected that 15,500 of these households will still be vitrified by market parties up to and including 2028, although this is not

a certainty as market parties can always abandon vitrification.

The approximately 12,000 remaining households will in all likelihood have to do without a fixed 100Mbps+ connection. Minister Beljaarts of Economic Affairs announced in October 2024 that the ball for household vitrification lies primarily with the market. In doing so, he sees opportunities through new types of 5G home Internet subscriptions introduced by various providers in 2024. This is called Fixed Wireless Access. These involve a combination of radio links and 4G or 5G combined with an Internet subscription. Unfortunately, it is also common for these households to have moderate or no mobile coverage, making this solution unsuccessful.

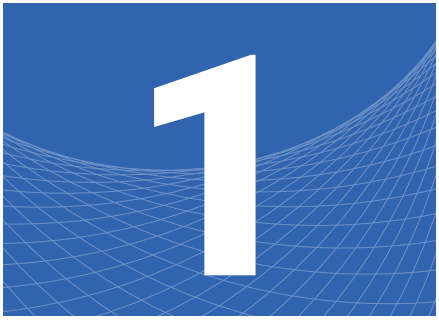
Other options include LEO (Low Earth Orbit) Satellites. Starlink is a well-known of these and can send up to 250 Mbp/s. In the near future, other parties will also come up with an LEO service such as Amazon's Project Cooper, Europe's Iris 2 and TeleSat lightspeed. For unlocking the 12,000 households in unprofitable areas, this could technically be a godsend.

However, given recent developments in the relationship between the United States and the European Union, the wisdom of using U.S. services for this purpose is highly questionable. Therefore, as this report goes to press, it is unlikely that this path will be pursued and all the more likely that Iris 2 will be adopted as soon as it is available.

The cost of still providing fixed broadband connections has been estimated, in an optimistic scenario, at 50 million euros. However, there are known examples of municipalities with extensive outlying areas where, by cleverly combining excavation work, many households were nevertheless vitrified in those areas. In addition, tens of thousands of households in outlying areas have been vitrified by market parties in recent years.

There are also households that did not participate in the first demand bundles, in the period before massively glazing entire ZIP code areas without demand bundling. They therefore also do not have a fiber connection. Here, state support is also problematic.

FIBERGLASS



The history of fiber optics is closely related to discoveries about the properties of light. For every bit transmitted through fiber optic connections has light as its carrier. Successfully manipulating light is thus the key to lightning-fast Internet connections.

Around 1660, Sir Isaac Newton discovered during a series of experiments that light is made up of different colors. In doing so, he laid the foundation for fiber optic connections, which more than 350 years later form the backbone of the Internet. In the 1960s, Elias Snitzer and Will Hicks discovered that a laser light could travel through a fiber optic without interference from atmosphere and dust particles. The only problem then was that a lot of light leaked out, making the signal unusable for communication purposes. For his part, Sir Charles Kao made a major contribution through his discovery that impurities in the glass led to light leakage and directed research based on which the first usable fiber optic cables were produced.

Rollout of fiber optic connections

In the late 1970s, based on these discoveries, the first fiber optic connections could be put into use. Telecom operators and later governments, research institutions and, for example, railroads began to use fiber optic connections. They did this to save costs, achieve more bandwidth or make business-critical dependencies on technology less prone to failure.

At the beginning of the twenty-first century, the large-scale rollout of fiber optics to households and business parks began in the Netherlands. Thus, fiber optic connections became increasingly commonplace for the business market and consumers. There is still a way to go to provide all buildings with non-residential functions, such as businesses, with fiber optics. But huge strides have been made in recent years, not only in terms of connections realized, but also in terms of innovations to improve the technology.

Techniques and innovation

Optical fibers for data communications can be divided into two groups: multimode (multiwavelength) light guides and singlemode (single-wavelength) light guides. Singlemode involves a signal passing straight through the fiber at one wavelength. This technique is often used for longer distances and is first choice for fiber carriers because of its low signal loss.

Multimode step index reflects light against the outer wall and in a variant of this, the multimode graded index, the refractive index decreases from the core to the outer wall. The light is deflected equally. This variant has the advantage of faster data transmission at shorter distances. To build and expose a network, a combination of techniques is necessary.

Hollow core fiber

For a few years now, hollow core fiber has been available as a technology. This type of fiber is not yet as widely used as, for example, multi core fiber. In the latter variant, multiple fibers are used in a single sleeve. With hollow core fiber, this also happens, but the core of a fiber is airless. This innovation is expected to be used for various applications.

There are two types of hollow core fiber: the Nested Anti-Resonant Nodeless fiber and the Photonic Bandgap fiber.

The advantage of hollow core fiber is that light is less hindered in it to get from point a to b than through a filled glass core. This can provide even lower latency.

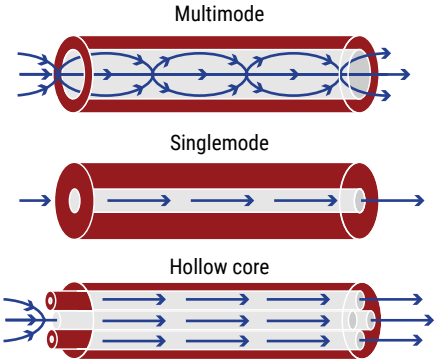
It is also investigating whether the amount of data that can be transmitted per second through a fiber can be increased by “stacking” data in multiple spectrums. This will enable throughputs of petabytes per second. These techniques will likely be the first to be deployed in long-distance core networks.

Meanwhile, research into transmitters and receivers is not standing still either. For example, Alex Alvarado and Vinícius Oliari, both working at Eindhoven University of Technology (TU/e) at the time, together with Erik Agrell of Chalmers University of Technology, have developed a new mathematical model that accurately describes how light signals propagate in fibers when subjected to nonlinear effects. Increased data needs create more demand for low-cost and reliable receivers that can handle a large amount of data traffic in the nonlinear region. Finally, researchers managed to transmit data at a rate of 301 terabits per second through a single, standard fiber optic.

Passive Optical Networks (PON)

Whereas in the past the possibilities of Passive Optical Networks (PON) were

Figure 6. Differences between three fiber types



sometimes questioned, these days this technique is a godsend for more and more fiber carriers when it comes to glassing urban areas (the cores). Through PON, end users are connected to fiber networks. The technique distinguishes itself by splitting the bandwidth of a single fiber for multiple connections and thus end users.

Whereas previously this splitting of bandwidth could impact connection speeds, today this is no longer the case. KPN even showed in 2022 that speeds of 20 Gbps are possible. And is also offering 4 Gbps commercially. Delta Fiber indicates on its website that it can already offer 8 Gbps. The technology has improved greatly in recent years and now offers the same bandwidths and capabilities as point-to-point connections. It is therefore often referred to as GPON (Gigabit PON) and XG PON (10 Gigabit PON). A major advantage of PON is that it brings with it an efficient method of deployment. Less fiberglass is needed, fewer (plastic) tubes need to go into the ground, and energy savings of about 80% can be achieved due to the technology used. It is likely that PON will become the new standard at least in residential areas.

In a common architecture of a PON, fiber is laid from a Point-of-Presence (PoP) of the network owner to a street cabinet. The signal on that fiber is then passively spliced and taken to homes. The distance between the PoP and homes is between 20 and 30 kilometers, depending on the attenuation of the route. Although bandwidth is shared by the end users behind the splitter, in practice one does not notice this thanks to time multiplexing. As with point-to-point connections, multiple service providers can use the PON from the PoP location to offer their services to the end user.

As already touched upon, because of its architecture, PON is an efficient way to glass urban areas. However, as soon as areas are more sparsely populated, PON can be an inefficient way to build. Therefore, point-to-point connections are often still chosen in outlying areas.

In the Netherlands, many (FTTH) fiber optic networks are constructed based

on point-to-point. In this technique, individual fiber optics run from the PoP location to the end user, such as a household, business premises or an institution. Because each end user has their own fiber, they have guaranteed bandwidths, depending on the subscription taken out with an ISP. For business fiber, point-to-point connections are widely used, both from a PoP to an office and between offices. Important reasons for this choice are security considerations and performance guarantees.

Demand for bandwidth continues to grow

A recurring point of discussion about five years ago was whether consumers really need the bandwidths possible with fiber. Is a fiber connection sufficiently attractive compared to xDSL or coax? Does it pay to invest in the construction of new fiber networks?

Even before the corona pandemic, the limitations of the downstream networks that were not glazed in the Netherlands came into view, which meant that during a busy television evening, for example multiple sports games or game show finals, things could become dire on the networks as IP-TV became more prevalent. The events of the past few years have shown that fiber is indeed seen as an added value by consumers and even necessary to meet the growing data hunger. Working from home is now the norm and the number of streaming services continues to grow unabated. In addition, the number of IP service providers continues to grow as well. It is now quite normal in most households for multiple streams to be played on multiple devices while also holding a video meeting or gaming online.

A brief overview of the number of providers. Often they do have their own niche of services.

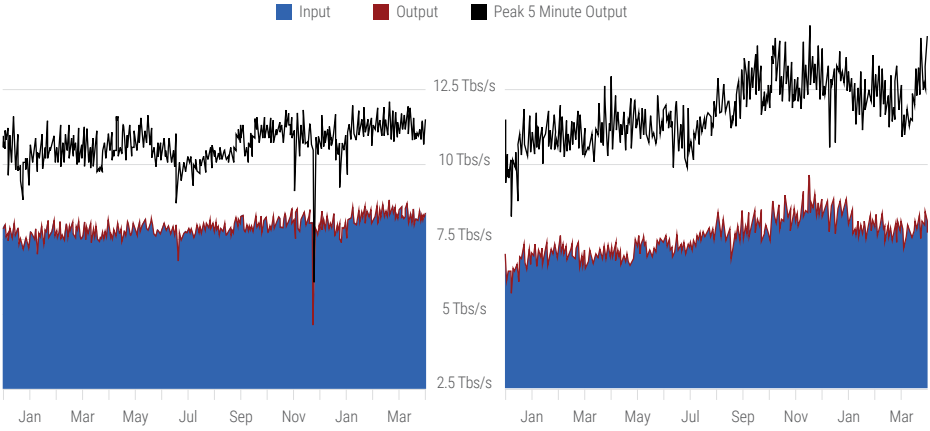
Disney+, Amazon Prime Video, Pathé Home, NLZIET, Apple TV+, Viaplay, Videoland, Max (formerly HBO Max and Discovery+), Ziggo Movies & Series, Cinetree, NPO Plus, SkyShowtime, CineMember, Netflix, Culture Ticket, Film1, Google Play, hayu, IFFR Unleashed, Lumière, meJane, MUBI, Picl, WithLove, Youtube Premium, iTunes and probably more foreign video on demand platforms

The continuing growth in bandwidth and Internet traffic is also reflected in the statistics of the Amsterdam Internet Exchange, or AMS-IX for short. Almost every year, this Internet node achieves new data throughput records, as can be seen on the graphs below. The top graph covers the period December 2022 to April 2024. The

graph below shows December 2023 to April 2025. The peaks and averages of data traffic processed by AMS-IX during these periods are steadily rising every year to ever-increasing heights. This increase is not due solely to consumers, but it does illustrate that the demand for bandwidth and the amount of Internet traffic continues to grow substantially. This trend can also be seen at the European and global level: according to Teleography, global bandwidth grew 23% year on year by 2024, with a CAGR of 35% since 2020 when there was a huge spike due to corona and the lockdowns instituted worldwide.

So the question is not so much whether to build more fiber, but rather how we do it in a way that is sustainable, fast, efficient and transparent.

Figure 7. Yearly traffic statistics, all colocations combined (Source: AMS-IX)



All locations		Amsterdam	
Peak in: 12.017 Tb/s	Peak out: 12.068 Tb/s	Peak in: 13.948 Tb/s	Peak out: 14.073 Tb/s
Average in: 7.906 Tb/s	Average out: 7.913 Tb/s	Average in: 8.709 Tb/s	Average out: 8.764 Tb/s
Current in: 8.311 Tb/s	Current out: 8.348 Tb/s	Current in: 9.001 Tb/s	Current out: 9.101 Tb/s

Open access networks versus closed networks

Open access is a term that refers to how the owner of a network operates it. Namely, he can open up the network to service providers, including Internet providers. In this way, consumers and business users have more freedom of choice in choosing a service provider and competition is encouraged. Opposed to this is a closed network, where the owner also offers the services over that network and in principle does not allow other providers.

In the Netherlands, open access is the de facto standard. However, this is not a given. For example, in 2020 the Authority Consumer and Market (ACM) required KPN and VodafoneZiggo to open their networks to other service providers, but this decision was overturned by the courts. In 2022, talks between the ACM and KPN and Glaspoort led to reduced tariffs for other providers on KPN's and Glaspoort's networks in order to shore up the open access model.

Open access encourages the activation of fiber to households and businesses. The Netherlands has traditionally had a fairly diverse landscape of Internet providers, a significant portion of which did not own their own network. Although the number of Internet providers has now been considerably consolidated, it is still common in the market for providers to use third-party networks. This has helped to ensure that adoption of FttO, for example, is relatively high in the Netherlands.

Abroad, however, the open access model is not so obvious. Often an investor builds a network that is then leased to an operator for a longer period of time. This arrangement is often fixed before construction. The operator must provide customers to make the network lease profitable. The threshold for this is a certain percentage uptake, so there must first be a solid business case. Open access is logically not always part of this, because an operator has more margin if he also offers services himself. This scenario is common in larger countries in Europe, such as Germany.

What is clear is that closed networks make the market less transparent. The construction of the service portfolio on such a network is different than if there were multiple providers. In addition, providers can even, if they have an interest in doing so, frustrate the adoption of fiber by minimizing the advantages of fiber over DSL, for example, so that as much return as possible can still be extracted from the old networks.

The future: AI, quantum networks and fiber security

Fiber is undoubtedly part of the rise of AI in the form of large language models (LLMs) and the burgeoning quantum revolution. The low-threshold application and integration of AI into a variety of applications, as well as industrial applications such as predictive maintenance, mean that the demand for broadband connections continues to grow. Data centers are already seeing an increase in fiber connections between the various AI clusters driven by the increase in data volumes. Often the incidental volumes are not that large, but due to the mass adoption of AI, still creates large volumes of data.

At the same time, rapid advances are being made in quantum technology and its application. QuTech (a collaboration between TU Delft and TNO), together with KPN, SURF and OPNT, has begun testing a quantum network, a new Internet technology. Eurofiber and Juniper also participated in the development and demonstrations of this technology.

Quantum computing is the next revolution in information technology. One of its first applications is encryption and security of data. Whereas now the binary system is used with a 0 or 1 when transmitting data, qubits use the 0 and 1 at the same time. These quantum bits (qubits) are transmitted through optical fibers. Because this operation occurs at multiple locations simultaneously, the optical channel is well suited for this purpose. Security analysts now mainly see the application of a quantum network as a big win for cybersecurity. Security normally causes delays on a network, but with quantum networks this will not be the case because of the optical fibers.

The FCA is involved in the project that focuses on developing a secure Quantum Key Distribution (QKD) connection between Saxion and the Universiteit Twente (UT). Using integrated photonics, unique, non-clonable keys are created, which helps to solve the authentication problem in QKD.

This project not only provides scientific and educational value, but also strengthens cooperation between the two institutions and encourages the development of quantum communication technology for students and companies. Moreover, the results provide a basis for future research on quantum communication.

CONSUMER CONNECTIONS

To appreciate how fast current developments are going, it is good to take a look back. Whereas only 135,000 new connections were realized in 2019, which was considered a good year for fiber deployment at the time, 1.13 million new FTTH connections have been realized by 2024.

It is safe to say that much has changed in a short period of time. Commercial parties have streamlined their processes so that they can build new fiber networks at a rapid pace. KPN, Delta Fiber, OpenDutchFiber and Glaspoort have the largest share of the market and are the most active with construction. There are now over 8 million fiber connections, where at the time of the publication of the first edition of Nederland op Glasvezel in 2017, there were only barely 2.5 million!

This acceleration in the construction of fiber optic connections for consumers does not come out of the blue. In the previous chapter we mentioned the enormous growth in demand for bandwidth and the fact that existing networks based on older technologies are reaching their limits. There is also a domino effect that can perhaps best be described as FOMO (fear of missing out). Now that a few large parties have stepped up a few notches with the construction of fiber, the pressure has increased for other parties in the market to accelerate as well. It provides a competitive advantage to have a network operational in areas that had not yet been vitrified.

The Netherlands has some 8.3 million households. The current count of fiber optic connections includes duplicate connections installed by different providers. It is expected that by 2026 almost all Dutch households will have a fiber connection, with the exception of a small group of households for which it is uneconomic for market parties to fibre them.

Developments in copper, coaxial and fiber optic connections

As in 2023, the number of households using a copper connection (excluding

coax) for Internet also steadily declined in favor of fiber in 2024. Just over 1.5 million households used copper for Internet access, while nearly 3.1 million households used fiber for this purpose. In the same quarter in 2023, this ratio was 1.9 million and 2.7 million, respectively. However, coax (cable) was also dominant in 2024, as there were 3.21 million activated households in the fourth quarter of 2024. This is another area of contraction, but very gradual, with 3.32 million households using coax for Internet access in the fourth quarter of 2023. It seems that the innovation on coax with docsis 3.1 (Data Over Cable Service Interface Specification), among others, currently still provides enough bandwidth for consumers not to switch en masse. In addition, there are many addresses where there is fiber in the street but not yet in the meter box, leaving people reliant on coax for high-speed Internet.

Work is also underway on Docsis 4.0, which technically could make coax last for a long time and should also be able to offer substantial bandwidths. However, upgrading networks will be very costly, perhaps more costly than rolling out fiber, so the question is to what extent this is a cost-effective option for large areas. Ziggo announced in the spring of 2025 its intention to accelerate the rollout of Docsis 4.0.

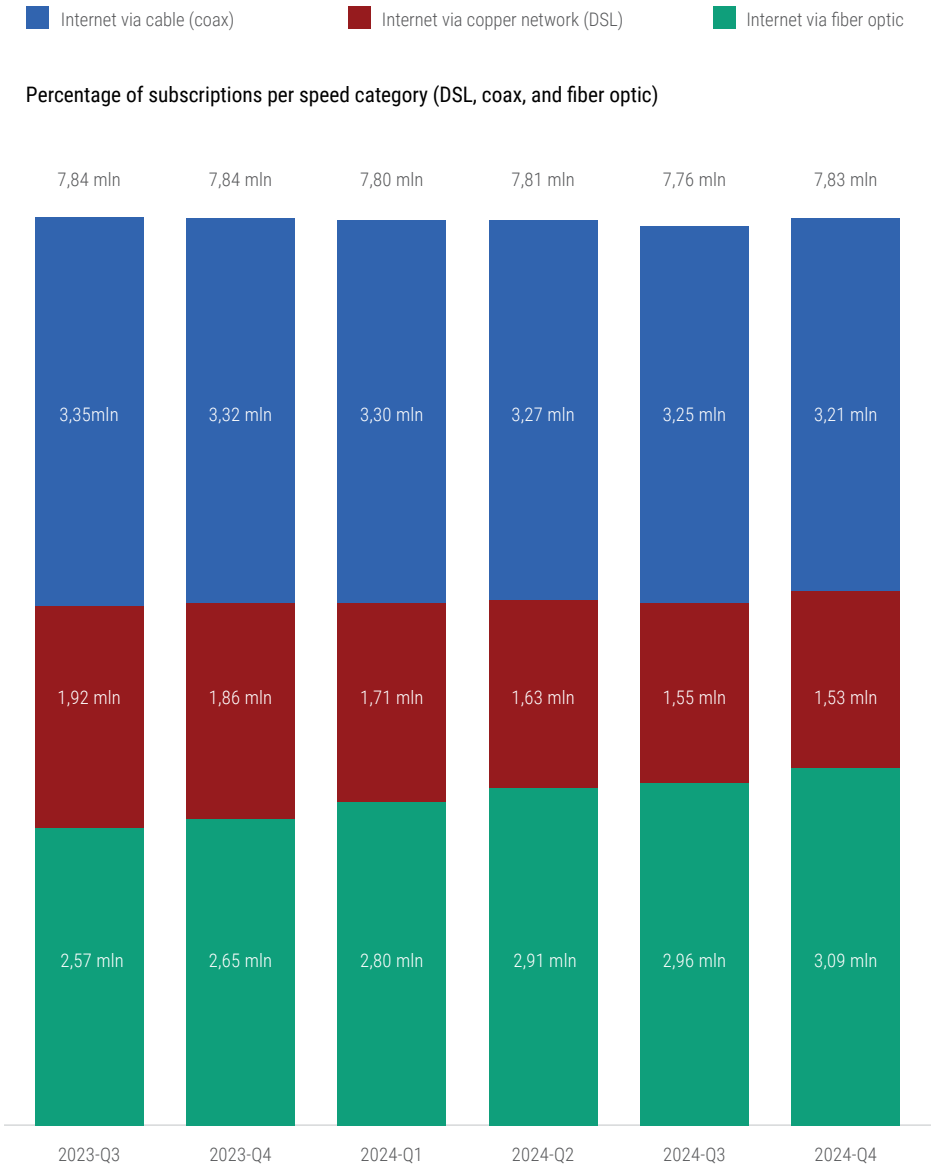
There is still a shift from DSL to fiber and it seems to be accelerating. In one year, some 300,000 DSL subscriptions disappeared (Q4 2023 - Q4 2024). A year earlier, there were 230,000. As already mentioned, the number of coax connections also decreased slightly.

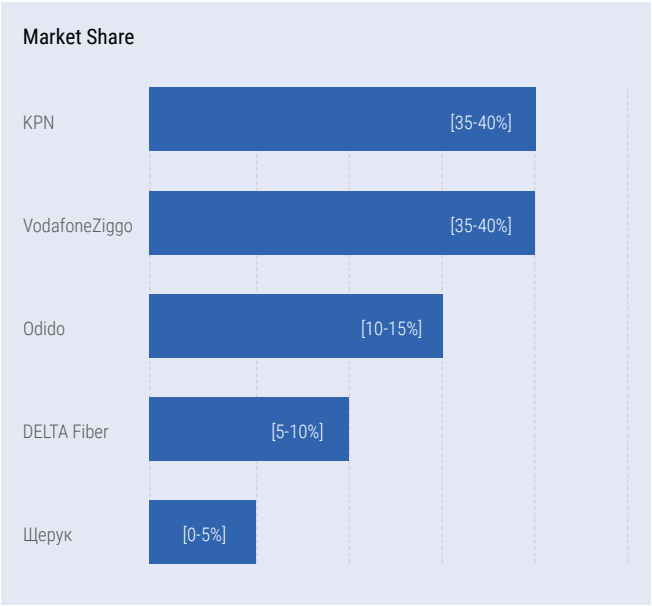
Because of this growth in the number of FttH connections, the steady decline in the number of homes activated on copper and coax, and the growing need for bandwidth, the Internet speeds of subscriptions that consumers take out are increasing rapidly. By the end of 2024, 7.83 million fixed Internet connections were active.

Notable is the rapid growth in the number of 1 Gbps+ subscriptions from 7.3% to 12.8% of total subscriptions in one year. That growth appears to have been mainly at the expense of subscriptions with speeds of 30 Mbps and up to 100 Mbps (shrinking from 17.2% to 12.6% of the total). The number of subscriptions with speeds between 100 Mbps and 1 Gbps remained almost stable at 74% of the total in 2024.

Across the board, the average speeds of Internet subscriptions increased in 2024, with over 86% of Internet subscriptions now having a speed of 100 Mbit/s or more, while in the last quarter of 2022, nearly 40% of subscriptions still had speeds below 100 Mbit/s. Interestingly, 0.6% of all subscriptions still had a speed of less than 30Mbps.

Figure 8. Internet subscription speeds for consumers.
(Source: ACM Telecom Monitor Q4 2024)





Households with internet

7,83 million

▲ 72.726 (▲ -0,94%)
compared to the previous quarter

Households with internet by network type

3,21 mln (▼-35.618) cable (coax)
1,53 mln (▼-20.349) copper (DSL)
3,09 mln (▲ 128.693) fiber optic

Households with internet of 100 Mbps and above

86,8%

Previous quarter: 86,4%

New and departing subscribers

229.378 new subscribers
225.386 departing subscribers

Barriers to switching

Not every household that has a fiber optic connection uses it. There are several reasons for this. Coax may be inferior from a technical point of view in terms of achievable capacity and stability, for example, but it is still sufficient for the needs of millions of consumers. It will remain so for the foreseeable future, even if a steady contraction in the number of subscriptions is visible. While strictly speaking this is not a barrier to switching, it is a major blocker to fiber adoption.

In addition, there is a group of consumers who are quite loyal to their provider. Switching is not an option for them if their provider does not offer services over fiber. There is also a large group that does not feel the need to switch, or wonders if it is worth it when you know what you have with your current provider. Last but not least, there are stories circulating about barriers to switching that simply aren't true. For example, it would not be possible to move your e-mail address with you, but that is not true.

Some major carriers, including KPN, have already announced that they will eventually switch off their copper network once fiber optics is installed to replace it. Consumers will then no longer have a choice and

will be migrated to fiber. The copper networks will be dismantled. This is already happening, as figures from the ACM show, as 500,000 copper connections will have disappeared from the counts by 2024.

Finally, it is notable that in many ZIP code areas where fiber has been installed in the last two years, it has not yet been connected to households in the meter box. There are examples of consumers who took out a subscription a long time ago, but still cannot use fiber optics. This is due to a lack of mechanics and technicians who can do the specialized work.

Core and non-core connections

In previous years, we wrote about the contrast between 'core and non-core' when it comes to fiber optic connections for households. By 'core' we mean built-up areas, by 'non-core' we mean areas and thus households that are not part of a built-up area. In other words, fiber in city and country.

For years, non-core areas lagged behind in terms of connectivity compared to urbanized areas. For example, both copper and coaxial networks were later upgraded to enable higher bandwidths. Even when it came to fiber, non-core areas often came up short. However, this was also the case for highly urbanized areas such as (historic) city centers. For both sparsely populated and very densely populated areas, the installation of fiber was long considered not commercially viable. This had several reasons, including the fact that other technologies were sufficient as alternatives. In addition, a fiber optic network is only profitable at an occupancy rate of at least 35%. In sparsely populated areas, however, that percentage is much higher because more kilometers of cable must be laid in the ground, more man hours must be spent on it and these networks are less efficient because of the small number of connections.

Many of these objections have disappeared like snow in recent years. The market parties competing with each other in the construction of fiber opt for market share. As a result, many addresses that did not qualify for a connection a few years ago are now being vitrified anyway. What remains are some 12,000 addresses that will not (yet) have a 100mbps connection by the end of 2028. These include addresses that have chosen not to have a connection installed yet, addresses that are still being vitrified and addresses for which wired (new) broadband connections are too expensive to install.

Minister Beljaarts of Economic Affairs recently indicated that for the time

being the government is leaving it to the market to invest in this. Whereas the previous cabinet did not rule out state support, the current cabinet has now done so. The reason is that, according to the minister, the market offers sufficient alternatives, by which he refers mainly to Wireless Fixed Access. At the same time, the Rijksinspectie Digitale Infrastructuur (RDI) is setting the requirement for telecom providers offering 5G that in every municipality 98% of the area must have a good network connection available . If telecom providers indeed adhere to this, it is conceivable that there will still be a group of households that will not have a broadband connection available in 2030, the year in which, according to the EU, all households must have at least a 100Mbps connection.

Services over fiber optics

The three main services taken over fiber connections are Internet, telephony and, for households, television. It is also possible to purchase mobile telephony under the same subscription. This triple play or quad play (this refers to three or four services taken under the same subscription), are still the most frequently chosen and offered.

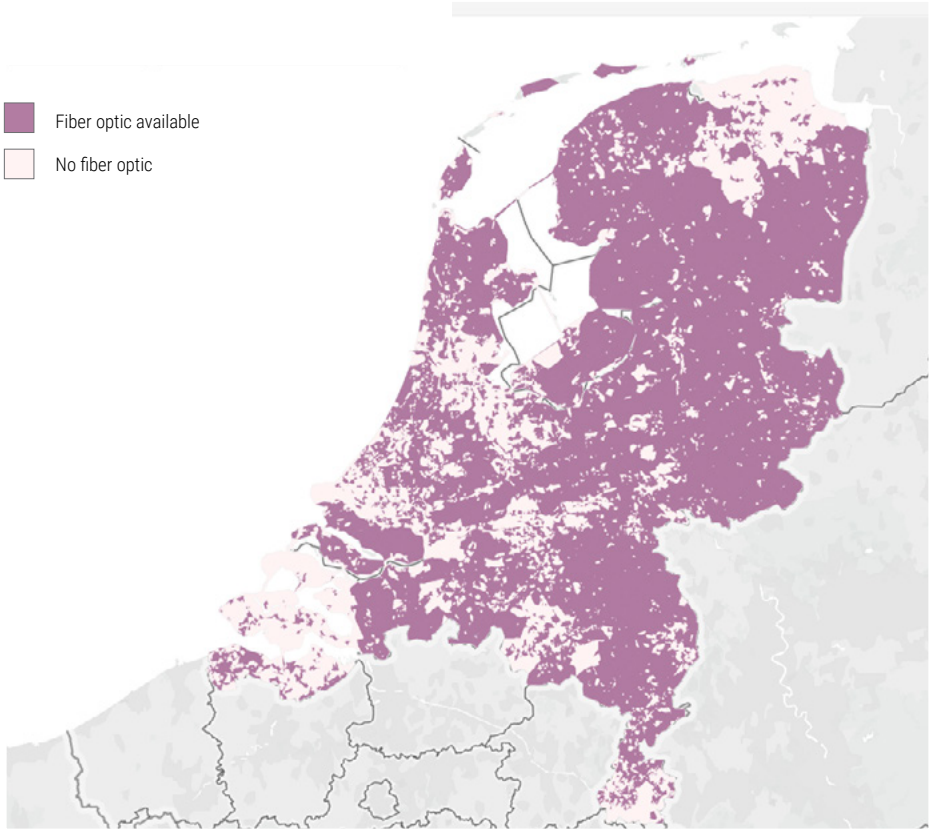
Video services through platforms such as Netflix, Amazon Prime Video, Videoland, Pathé Thuis, Disney+ and other providers are hugely popular. These types of video services are called Over The Top services: they are available independent of the Internet provider. These types of services are still gaining popularity, although the market is now becoming saturated. This requires a future-proof broadband infrastructure. An advantage of fiber optics in this case is that the medium and technology are very reliable, not very sensitive to environmental influences and that energy consumption is low. For now, the existing infrastructure besides fiber is sufficient, but in view of, for example, 5G, fiber is the only option to meet the growing demand for data in the near future. Other services via the IP (Internet) protocol, such as remote care, home automation and energy management will only increase the demand for bandwidth.

Addresses glazed by province

The coverage of fiber optic networks, as the fiber optic map also shows, still varies greatly by region. While some provinces or municipalities are already almost fully glazed, there are also provinces and municipalities where fiber optic connections are not yet a given. Despite the rapid rollout of fiber optics, large parts of the provinces of Zeeland and Groningen and the south of Limburg in particular have yet to roll out fiber optics. Many uncovered areas are also still visible in the Randstad and parts of the Rivierengebied.

Figure 10. Fiber Optic Map of the Netherlands (Source: ACM Telecom Monitor Q4 2024)

The degree of vitrification of the Netherlands, in the lighter areas there is no glass. It is easy to see how certain outlying areas are still devoid of fiber, but that the same is true of city centers such as Amsterdam and Utrecht. However, it is expected that even these areas will be glazed within a few years.



Q3 2023

Especially in the western part of the Netherlands there is still a challenge for further fibre optics. Partly because of the composition of the soil (peat and clay soils) and the fact that there are many historic city centers in this part of the Netherlands, the installation of fiber optics faces the necessary challenges. However, with the acceleration that has taken place in recent years, it is expected that almost all households in these areas will have a fiber optic connection within a few years.

Figure 11. Adressess and homes passed (Source: ACM Telecom Monitor Q4 2024)

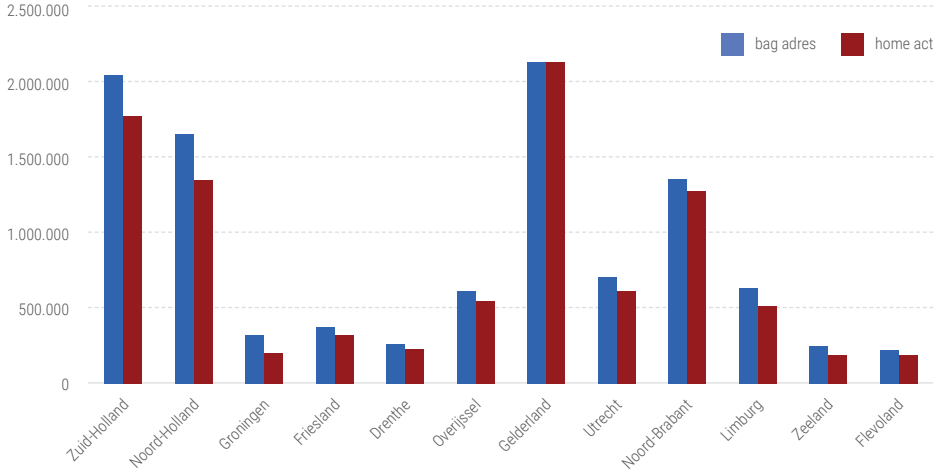
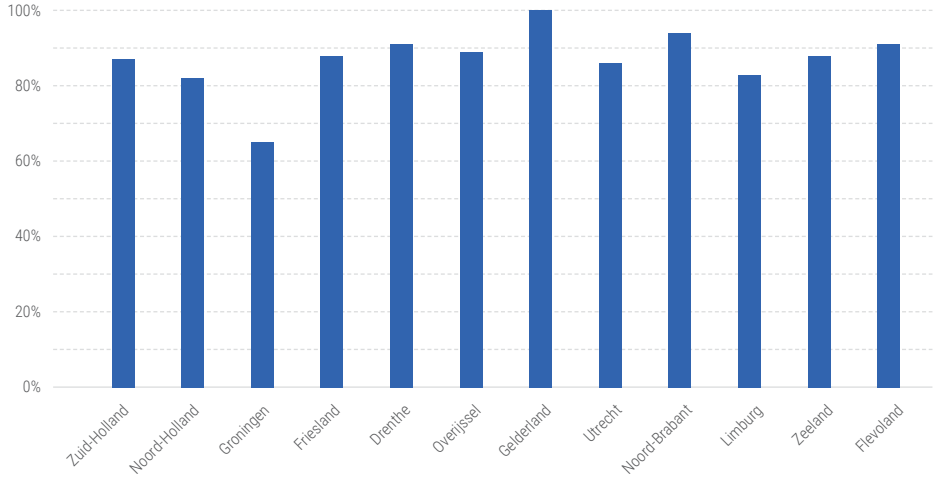


Figure 12. Percentage home passed (Source: ACM Telecom Monitor Q4 2024)



In the overview percentage vs. bag registration you can see how far the provinces are you can see that North Brabant even on several bag addresses must have a duplication, because 104% is connected. Province of Noord holland is lagging far behind and we expect that here the acceleration will come next year.

Maximum achievable speeds

Even when consumers purchase Internet through fiber, they still do not always experience the maximum speeds achievable. That has to do with the standards available for Wi-Fi. The wifi 802.11ac standard does not achieve maximum speeds. Higher speeds in the home, however, are possible with the wifi 6 standard 802.11ax. Wifi 6 can enable higher bandwidths. This will also eventually ensure that speeds of 10 Gbps will actually become achievable for consumers. On Feb. 8, 2024, the Wifi Alliance also announced the Wifi 7 802.11be standard. This should potentially enable speeds of up to 46 Gbps.

Other applications include FTTR: Fiber to the Room. This glues fiber with a virtually invisible fiber along walls and allows easy construction of fiber in homes or offices with 10G Pon to wifi routers or other end devices.

For business connections, 10 Gbps is already possible. Techniques used to achieve these high speeds are XG-PON or XGS-PON. These are successors to the already known GPON (Gigabit-PON). The big difference is that with the XGS-Pon, the upstream Maximum Line Rate is close to 10 Gbps, unlike the GPON and XG-PON where the upstream is at 1.244 Gbit/s (GPON) and 2.488 Gbit/s (XG-PON).

Projects with 25GS-PON were also delivered last year and the first 50G PON solutions are already being implemented. It is not yet known whether this is also expected in the Netherlands within a short time, but it is plausible.

The overview below shows the different characteristics of the type of network. At the time of publication, we did not have an overview of the 25G Pon or 25GS Pon. The big difference is with the S state it can handle synchronous data transmission. With the regular PON it is asynchronous in UP and DOWN load.

Is 5G the replacement for fiber for consumers?

Consumers are increasingly using mobile Internet, even when they could theoretically use a fixed connection. Thanks to falling prices for data bundles and unlimited bundles, competition between fixed and mobile Internet providers has erupted in full force. In time, 5G subscriptions will be possible for home Internet, where the signal is converted to Wi-Fi by a router with a 5G SIM card. This has been possible for 4G for some time and is particularly interesting for addresses that do not have a fixed broadband connection available. As can be read above, this is even an explicit commitment by the government to be able to provide

Specifications	GPON	10G GPON	
		XG-PON	XGS-PON
Wavelength	Downstream: 1480-1500 nm Upstream: 1290-1330 nm	Downstream: 1575-1580 nm Upstream: 1260-1280 nm	Downstream: 1575-1580 nm Upstream: 1260-1280 nm
Center wavelength	Downstream: 1490 nm Downstream: 1310 nm	Downstream: 1577 nm Downstream: 1270 nm	Downstream: 1577 nm Downstream: 1270 nm
Maximum Line Rate	Downstream: 2.488 Gbit/s Upstream: 1.244 Gbit/s	Downstream: 9.953 Gbit/s Upstream: 2.488 Gbit/s	Downstream: 9.953 Gbit/s Upstream: 9.953 Gbit/s
Maximum Physical Transmission Distance	60 km NOTE: The physical reach is defined by split ratio, optical module size and fiber quality.	100 km NOTE: The physical reach is defined by split ratio, optical module size and fiber quality.	100 km NOTE: The physical reach is defined by split ratio, optical module size and fiber quality.
Maximum Split Ratio	1:128	1:256	1:256
	NOTE: The actual split ratio depends on the optical module model and fiber distance.		

broadband Internet to households in rural areas anyway.

The success of 5G requires fiber optics. Mobile devices use much more data through 5G. That means more data transmission per mast, which must be connected to the Internet via a high-capacity fiber connection. The three largest mobile operators with physical infrastructure (KPN, Vodafone/Ziggo, Odido) are busy upgrading their networks. They are also turning off the obsolete 2G and 3G networks. Turning off these networks allows mobile operators to save on the maintenance of these networks. It also frees up the frequency band to offer 5G applications on them.

Although 5G offers very fast Internet, the question is whether it can become a full-fledged alternative to fixed Internet connections. It is likely that subscriptions for fixed Internet via fiber, for example, will remain a lot cheaper than those for 5G could be, as telecom providers need to recoup their network investments. There are also still data limits on consumption. Unlimited bundles often have daily limits anyway or are reduced in speed after a limit is reached. The revenue model for 5G is substantially different from fixed networks such as fiber: whereas fixed networks do not have data limits, mobile networks have them at the core of the revenue model.

While 5G could be an alternative to fiber in terms of speeds and coverage, cost-wise it is not.

Auction round for frequencies 3.5 Gigahertz

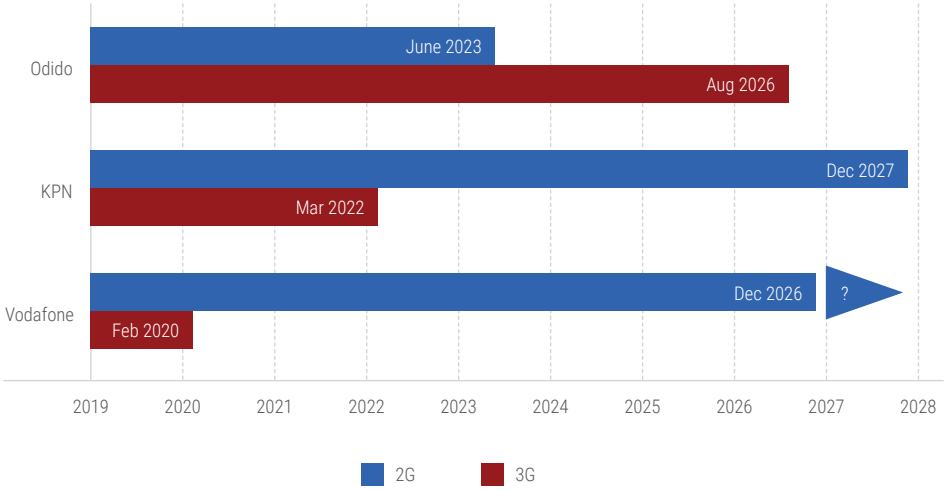
The 3.5 Gigahertz frequency was auctioned in 2024. The frequency auction was conducted by the National Digital Infrastructure Inspectorate (RDI). Odido, KPN and VodafoneZiggo secured frequencies in the 3.5Ghz band.

The 700 MHz frequencies were auctioned in 2020 and are already being used for 5G. The 26 GHz frequencies will be distributed at a later date.

Odido eliminated 2G in 2023. KPN will not do so until the end of 2027 and VodafoneZiggo by the end of 2026. KPN and VodafoneZiggo have already turned off their 3G networks, but Odido will not do so until 2026. 2G in the Netherlands uses the 900MHz and 1800MHz bands. These bands can be used for other purposes after being switched off. Purposes of 2G today include M2M/IoT machine to machine and Internet of things. Examples include communication with the smart home energy meter that has been massively installed in millions of households. But also the life-saving eCall (emergency call) that is mandatory installed in all cars after 2018 and can automatically call 112.

Future Network Services is a program of the National Growth Fund to explore the development and applications of 6G. One of the goals of this program is for the Netherlands to be a leader in the development of 6G. Meanwhile, this initiative has realized a 6G testbed.

Figure 13. Planned phase-out of 2G and/or 3G networks by the three Dutch MNOs (Source: ACM Telecom Monitor Q4 2024)



CHALLENGES NEW CONNECTIONS

Now that fiber is being rolled out on a large scale and the vitrification of the Netherlands is in sight, the question is what challenges remain to get "the Netherlands on Fiber. In practical terms, the government's ambition to achieve a 100Mbps connection at every address is almost achievable, even though it will not always be through a fixed network.

The current challenges in laying fiber are now more organizational and logistical. For example, municipalities are very busy granting permits for the construction of new networks, especially if two or three providers apply at the same time.

Disputes with landowners are also more common. The Telecom Act stipulates that telecom providers may always carry out excavation work if it is intended to carry out work on a (new) network. So landowners must in principle cooperate. But if they obstruct, a project is delayed. This has unpleasant consequences, such as loss of income, higher costs for contractors and higher fees and permit costs. It also harms consumers, as they have to wait longer for a fiber connection.

Another relatively new challenge is that in some zip code areas or municipalities there are three providers operating. That means there are three fiber optic connections hanging in consumers' meters. If coax and copper connections are also present, then a consumer in that area has 5 different networks to choose from. That can't be profitable for the network owners. One wonders if this won't have a long-term negative impact on the providers themselves. In any case, it will do little for consumers.

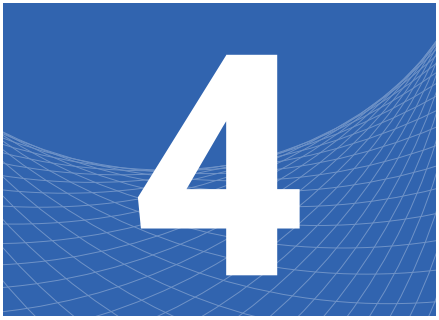
Another area of concern is the "crowded" subsurface in which all those networks, electricity, water, gas and sewer are located. The risk of excavation damage is increasing due to both the scope of the work and the crowded underground. Fortunately,

there is coordination here, including by the knowledge platform CROW. The CROW 500 guideline for soil excavators is a good example to prevent excavation damage.

Unfortunately, despite all precautions, the number of excavation damages has increased in absolute terms, even though they have decreased as a percentage of excavation movements. The damage caused by excavation damage has also increased, something that both the regulator and the industry and stakeholders have expressed dissatisfaction about.

Lastly, certainly not least and related to the above, as in many other sectors, there is a major shortage of technicians and other personnel needed to build fiber optic networks. This includes, for example, fiber optic engineers, mechanics, designers and project managers. Many providers are doing in-company training, but ROCs and HBOs are also developing training programs so that the sector can count on well-trained people who can start work right away. Those who want to know more about this topic can consult our report "Education, education and training in the fiber optic industry.

BUSINESS MARKET



The fiber optic business market consists of SMEs from 2 to 250 employees. According to CBS, these totaled 423,565. companies in the fourth quarter of 2024. The number of self-employed persons without personnel (ZZP) in this quarter was 1,932,130. We exclude this group of entrepreneurs because it is impossible to find out whether they use Internet connections exclusively for business purposes. Sometimes they are in multi-tenant buildings where 1 connection is shared or they work from a home situation. We also leave out the wholesale market, education, research and government.

The business fiber market differs from the consumer market in many ways. There is no mass deployment of fiber, although companies are increasingly using a FttH connection, which entails the necessary risks (see also the column on this subject at the end of this chapter). In addition, the needs of companies are different: some companies need dedicated connections with large capacity, while others are satisfied with a regular business subscription. For example, there are also companies and institutions that do not use the Internet protocol for communication, but WDM or other techniques.

Yet there are also similarities. For example, just like residential neighborhoods, business parks are also glazed, and sometimes multiple networks are present on a single site. But for the most part, that's where the similarities end.

FTTO

Fiber to the Office or corporate Internet services are business Internet services. This type of network is often constructed in a different way than residential networks, allowing the operator to guarantee higher availability. These include reserving network capacity on the network without overbooking. In the past, rates for this type of network in many cases consisted of at least 2 components. The first was the access, the access to the fiber network, with the second component being the service.

Nowadays there are providers operating that offer a comprehensive package, which is common in the consumer market. Here you often see similar offers in terms of Internet upload speeds and download speeds. Many FTTO providers work closely with local ICT partners located near regional business users. The open access network model also allows multiple Internet service providers (ISPs) to offer their services over these networks. Often different areas are connected through a backbone network, or the backbone of national providers is used.

According to ACM, there were 118,343 business fiber connections in Q4 2024, a slight increase from 2023 when there were 117,101 connections. 60,998 business end-users were connected to FttO.

Figure 14. Development of FttO connections and business users (Source: ACM Telecom Monitor Q4 2024)

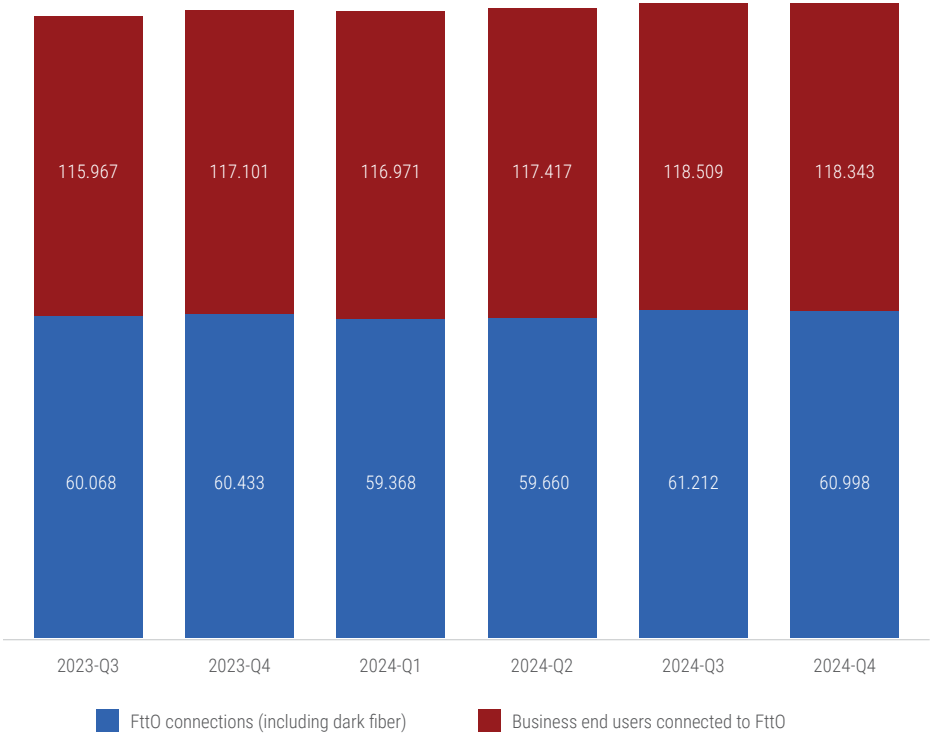
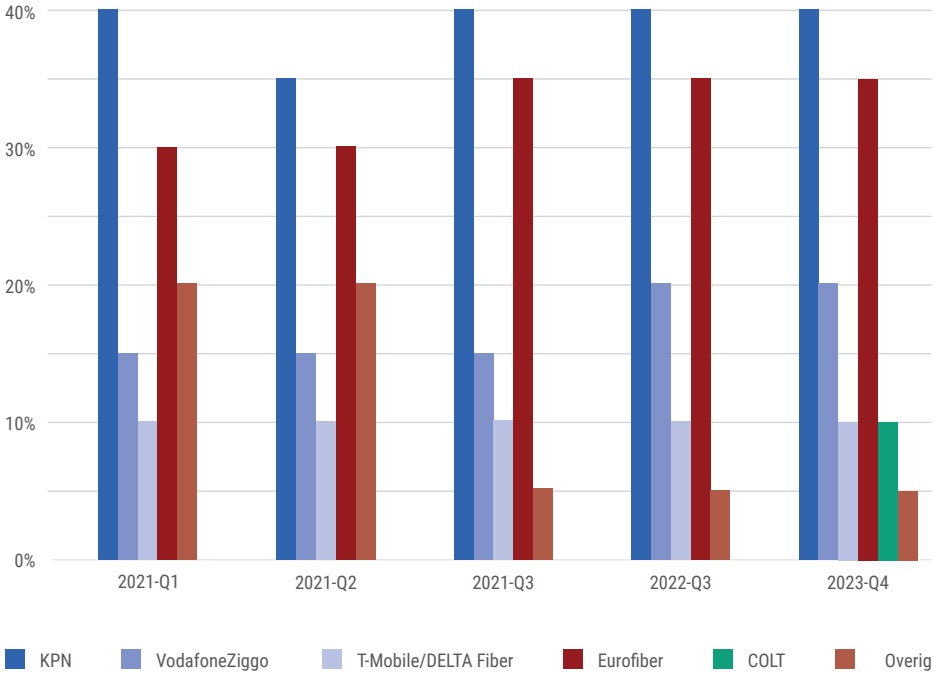


Figure 15. Market share of business fiber optic connections (Source: ACM Telecom Monitor Q4 2024)



	2021-Q1	2021-Q2	2021-Q3	2022-Q3	2023-Q4	2024-Q4
KPN	[35-40%]	[35-40%]	[30-35%]	[35-40%]	[30-35%]	[30-35%]
VodafoneZiggo	[10-15%]	[10-15%]	[10-15%]	[10-15%]	[15-20%]	[10-15%]
T-Mobile/DELTA Fiber	[5-10%]	[5-10%]	[5-10%]	[5-10%]	[5-10%]	[5-10%]
Eurofiber	[25-30%]	[25-30%]	[25-30%]	[30-35%]	[30-35%]	[30-35%]
COLT	-	-	-	-	-	[5-10%]
Other	[15-20%]	[15-20%]	[15-20%]	[0-5%]	[0-5%]	[0-5%]

Business fiber providers

Business fiber connections are generally installed specifically for an individual business location. In some cases, there is demand bundling at a business park, proactive rollout by providers in the past, or a business address can "hitch a ride" on rollout for a consumer network. If an individual connection is to be realized, the distance to the fiber provider's connection network determines the costs (which consist mainly of digging costs). In its market analysis, the ACM gives the following indications for the percentage of business locations in the Netherlands that are within 150 meters of a network:

- All non-KPN connections together achieve a network coverage of 80.2%.
- Although there is much (especially agricultural) activity in the outlying area, we see concentrations of very high-speed connections mainly in and around the cores. In business parks, this is almost exclusively via fiber, since cable is absent here.
- In addition to the regular business fiber optic connections, there is glazing of so-called objects throughout the country. These include all kinds of objects to be controlled and monitored, such as bridges, locks, traffic control installations and electricity network switching stations.

Fiber optics in business parks

The Netherlands has 3800+ business parks. Last year, the FCA conducted research into which business parks are equipped with fiber optics. This is because it turns out to be difficult to find current figures on the vitrification of these areas, while it is indeed taking place. Using the QR code below, you can find some interactive maps of business parks and their vitrification via our website.

Fiber optics and 5G in the business market

As with consumer networks, 5G seems unlikely to completely replace fiber. However, for business purposes, 5G offers numerous interesting applications that are currently being experimented with.

Examples can be found in the port of Antwerp, where, for example, site security is being experimented with through 5G, edge computing and drones. Plans have also been developed to operate unmanned, remotely controlled barges carrying containers, with connectivity provided through 5G. Other examples include inspection of industrial infrastructure with drones through 5G or autonomous, connected vehicles for public transport.

These types of applications are often sensitive, and network availability is of great importance. It is possible for

companies or partnerships of companies to build private 5G networks. This way they keep more control over their wireless connectivity. So far, 37 licenses have been granted in the Netherlands for such networks, mostly to companies in the Rotterdam port area, but also to research institutions.

Business 5G solutions help accelerate or improve business processes. However, the construction of new set-up points requires significantly more fiber, especially because of the expected increase in data transmission over mobile networks. In addition, the future will see an increased need for high-speed access to data sources over both wireless and fixed networks, especially for time-critical applications such as traffic control systems. More workloads are expected to be placed in the edge, for which high-quality connectivity is also a requirement.

5G, combined with fiber, will therefore lead to new solutions and business models. There is much talk of autonomous driving on public roads, but the applications of the Internet of Things (IoT) in smart cities are also getting closer. Fiber optics will play a crucial role here, as the data received by base stations must be transmitted to data centers, linked to various systems and often processed in real time.

FTTH IN BUSINESS PARKS. COST VERSUS RELIABILITY.

A critical look at digital infrastructure

The emergence of FttH (Fiber to the Home) in business parks offers interesting opportunities for companies looking for affordable fiber optic Internet connections. With lower construction costs and an attractive price tag, this seems like a godsend, especially for smaller SMEs and sole proprietors. But the rise of this more economical form of connectivity also carries serious risks for Dutch businesses. Security, stability, continuity and collaboration are at stake.

Advantages of FttH

The low cost of laying FttH makes fiber more accessible with lower subscription costs, especially for small businesses that do not have the resources to invest in often more expensive business solutions such as FttO (Fiber to the Office). For businesses with limited digital needs, FttH can be a great solution. Consider, for example, self-employed workers or small SMEs, where price is often more important than connection stability.

In addition, FttH contributes to the further digitalization of the Netherlands. By offering a wide range of companies access to high-speed Internet, a solid foundation is laid for economic growth and innovation.

The downside of cheap construction

However, the current way in which FttH is being laid creates serious problems. In an effort to keep costs down, the "laying method" is often cut back which, among other things, comes at the expense of quality. For example, cables are placed shallowly - at 30 cm instead of the usual 60 cm. This increases the risk of digging damage. With an average of 75 digging incidents per day in the Netherlands involving data transport cables, it is not inconceivable that one day a company connection could be out of service because it was hit during work.

Technical limitations of FttH

Besides the implications of the construction methodology, FttH for businesses also has technical limitations. Many business networks in the Netherlands are constructed using Point-to-Point technology, where each user has their own fiber connection. FttH, on the other hand, often uses GPON (Gigabit Passive Optical Network), where multiple users share the same fiber. While cost-saving, this can lead to lower performance and limitations in available services.

Another risk of GPON is security. The shared nature of this technology poses risks as data from multiple users is transported over the same fiber. While encryption is an important security measure, there remains a risk of data breaches by technically proficient individuals. For companies working with sensitive data, this is a serious risk that must be considered.

In addition, FttH typically offers fewer opportunities for redundancy. Companies who think that a second FttH connection provides sufficient backup and security often do not realize that both connections run over the same route. This makes them vulnerable to the same trench damage. This emphasizes the importance of physically separate connections, such as those often offered by FttO providers.

Cooperation and regulation: a sustainable solution

A sustainable solution lies in better cooperation within the industry. The Fiber Carrier Association (FCA) strongly supports open-acces models, where multiple parties can use the same infrastructure. This prevents business parks from being flooded with parallel networks, minimizes excavation and contributes to a more efficient use of resources.

Local governments can also play a connecting role. By playing a coordinating role, they can contribute to a future-proof infrastructure. The FCA has initiated a survey to identify areas where fiber is already available at www.fibercarriers.nl/bedrijventerreinen.

Better harmonization of local regulations and supervision are also crucial. Reports of abuses - such as damage to infrastructure, poorly executed excavation work or working conditions that do not meet Dutch standards - must be followed up more quickly by agencies such as the Rijksdienst voor Digitale Infrastructuur (RDI). This increases trust in the sector and prevents further escalations.

Making the right choice

For businesses in business parks, it is essential to make informed choices when it comes to Internet connections. Here are some practical tips:

- **Be well informed:** look not only at speed and cost, but also at SLAs, network architecture and technical capabilities and limitations.
- **Choose tailored:** for sole traders and small SMEs with limited requirements, FttH can be a great choice. Companies with critical processes are better off with a business FttO connection.
- **Invest in redundancy:** choose physically separated connections and consider backup solutions, on top of the physically separated connection.
- **Recognize limitations of mobile networks:** 5G backup may be suitable as an emergency solution, but be aware of data volume and speed limitations.
- **Make socially responsible choices:** choose providers and contractors who adhere to ethical working conditions and environmentally friendly construction practices.

Conclusion

FttH has a role to play in making fiber accessible to small businesses, but the current approach carries too many risks. It creates unnecessary vulnerabilities. Through collaboration, and a more enabling role of local governments, business parks can benefit from both affordability and reliability. This requires better coordination, compliance with agreements. Only by addressing these issues can we ensure a future-proof infrastructure that meets the needs of all entrepreneurs.

INVESTMENTS IN FIBER OPTICS

Whereas several years ago there was substantial investment in fiber optic deployment, this is less the case now. It seems that the peak was reached in the years 2019 - 2021, which the above overview shows well.

Meanwhile, interest rates are substantially higher, which also impacts investments already made. Because the uptake of new connections is not as high, parties that have invested heavily and are facing increased interest rates may start to suffer. In the previous edition of this report, we pointed out that interest rates could affect network consolidation.

The most important possible takeover announced in 2024 was that of Delta's 200,000 connections by Glaspoort, which is part of KPN. However, the ACM expressed concern about this development and required both parties to apply for a license if they wanted to go ahead with the plans. The license for this takeover was applied for in December 2024. A decision is expected in spring 2025.

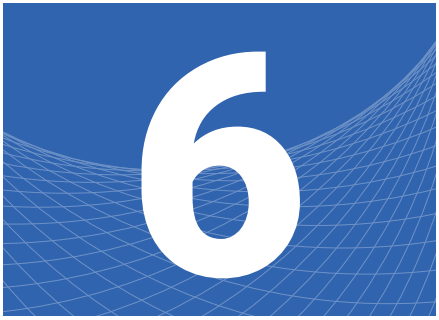
Consequently, the scale of investments like a few years ago are now out of the question. Partly because they are not necessary, and partly because they have become less attractive. Nevertheless, quite a lot of capital still flows into the market every year, for new investments and to refinance existing networks. FCA participants expect to raise up to a billion euros in capital by 2024. FttH market leader KPN announced in late 2023 that it will invest more than 4.5 billion euros, much of which will go to the rollout of fiber.

INCREASE IN INVESTMENT IN FIBER BY PRIVATE PARTIES (2019 - 2021)

In the period 2019-2021, several private parties have made investments in fiber. A clear increase in the number of investments can be seen.

- DELTA Fiber Network (part of DELTA Fiber Nederland) is the umbrella under which DELTA/Zeelandnet, CAIW and Glasvezel Buitenaf are jointly continuing the rollout and management of (fiber) networks in both cores and outlying areas.
- DELTA Fiber Nederland announced in November 2019 that it will invest €100 million in the rollout of fiber in Zeeland.
- Eurofiber acquired Brightfiber Infra in August 2020.
- In September 2020, PPGM acquired a (minority) stake in Eurofiber.
- In September 2020, British investor Ancala took a majority stake in Fore Freedom.
- Eurofiber acquired Levelfour Networks' fiber optic operations in November 2020.
- EQT expressed interest in KPN in November 2020.
- T-Mobile acquired operations of L2Fiber in December 2020.
- In December 2020, Delta Fiber bought out Cogas at CKi. Now 100% is owned by Delta Fiber.
- CEBF invested 30 million in Rodin in December 2020.
    - KPN and ABP started a joint venture called: Glass Gate in March 2021. ABP is putting in 440 million euros. The total investment amounts to 1 billion euros.
    - Delta Fiber Netherlands announced American investment company Stonepeak as a new shareholder in October 2021. As a result, Stonepeak and ETQ now both own 50% of Delta Fiber Netherlands.

CORE NETWORKS



All fixed and mobile access networks consist at their core of fiber connections. These networks, called “core networks” in technical jargon, facilitate interconnectivity between the (sub)networks, Internet exchanges and data centers.

The core networks are therefore of great importance for the digital infrastructure in the Netherlands. These are the so-called arteries that make it possible to provide consumers and businesses with digital services, whether they are delivered from the Netherlands or elsewhere in the world. The following illustration shows that there is a (very) finely meshed core network of fiber throughout the Netherlands. In addition, some core connections cross national borders with Belgium and Germany, so that international data streams can also be established.

The core networks are laid and kept operational by various carriers.

Core networks can be compared to highways: they ensure that data can quickly get from A to B throughout the country. Importantly, this type of network must be relatively easy to expand. It therefore often happens that several carriers are located together in the same route. These are ducts (gutters) that lie on top of each other or next to each other. At various points there are then branch circuits above ground in PoPs or below ground in manholes or handholes. The carriers attach great importance to being able to lay out their network redundantly (duplicated) throughout the Netherlands. This keeps the network up and running in the event of a disaster or maintenance on a route. This often involves using different routes between two points.

Other core networks of KPN and VodafoneZiggo are often used to market their own services. This is different from the above parties who actively offer darkfiber/backhaul services.

There are also core networks that are of a (semi)public nature. These are sometimes originally built to provide municipalities or provinces with a fiber

network so that their facilities can communicate with each other. A good example is TrenT which originated in Enschede and has grown into a large-scale network. The merger with Alliander, which also already owned its own fiber optic network for the purpose of electricity networks, also ensures that business parks, for example, can enjoy excellent coverage.

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Figure 16. Core networks in the Netherlands (Source: Dialogic, The Sate of Telecom 2016)

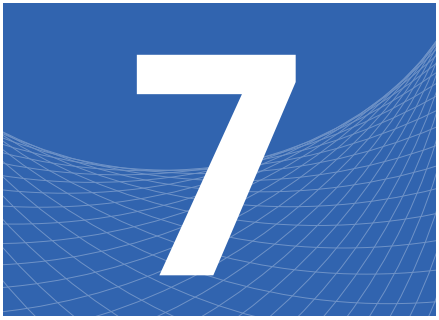
Internet exchanges

Since 2019, we have seen a consolidation in the data center sector. If you want to know more about this topic, please refer to the website of the Dutch Data Center Association (DDA), where several free reports are available on the subject. The Netherlands has over 200 commercial data centers, many of which house multiple tenants and networks.

From these data centers, links are made between different networks. These are the so-called marketplaces or Internet exchanges. Examples are AMS-IX (Amsterdam Internet Exchange), NL-ix (Neutral Internet Exchange) NDIX (Dutch-German Internet Exchange), EFX (Eindhoven Fiber Exchange), FRIX (Frisian Internet Exchange) GN-IX (Groningen Internet Exchange), or relative newcomers such as ERA-IX. Scattered across the country there are also local nodes and exchanges, the Tilburg Fiber Exchange (TiFX) being an example.

In the data center world, many connections are also being built between the various providers. DCspine, now part of Eurofiber Cloud and Infra B.V., for example, is a company that creates links between datacenters, but parties such as Arcadiz can also play a constructive role here. Parties active on the core networks include Relined, Eurofiber, KPN, Ziggo, BT, Colt, euNetworks, Verizon, Lumen, EXA and Zayo. The demand for bandwidths and low latency connections is growing along with it. Where previously a 10 Gbps connection was in high demand, we are now seeing providers with connections of 100 Gbps or higher. The first 400 Gbps networks are already active connecting various cities in Europe such as the FLAP/D (Frankfurt, London, Amsterdam, Paris and Dublin) 5 major European cities where there are many data center concentrations and high speeds are essential.

INTERNATIONAL CONNECTIONS



Just as our physical trade is highly interconnected internationally, so is our digital economy. To facilitate that, in recent decades hundreds of sea cables have been laid worldwide to enable data flows between continents. The Netherlands has traditionally been an important landing spot for these cables, especially from Great Britain and the U.S.

International fiber optic networks over land

Besides sea cables, there is also an extensive network of high-capacity fiber-optic connections from the Netherlands to the rest of (continental) Europe. This network includes connections between the so-called FLAP data hubs (Frankfurt, London, Amsterdam and Paris). Within Europe, these are the largest international data hubs.

Transit nodes for fiber connections between European data centers are therefore in place in the Netherlands at several locations along the country's borders. These are Bad Nieuweschans (Groningen) Hengelo, Enschede, Arnhem, Nijmegen and Venlo, near Antwerp and Maastricht. Due to advancing technologies, throughput speeds have increased tremendously over the past few years. Where previously 100 Gbps was still the norm, 400 Gbps per Wavelength Division Multiplexing (WDM) is now becoming the standard. This also applies to marine cables, by the way, which is one of the reasons old cables can no longer keep up with the times.

Intercontinental connections by sea

Some of these connections have already been phased out or "decommissioned" as it is called: completely cleaned up in recent years. For example, because they have reached the end of their lifespan or because their capacity is no longer adequate. One example is TAT-14, which was the main connection between Europe and the U.S. until the end of 2020. The sea cable had a technical lifetime of 25 years, but was decommissioned after 19 years because it could not keep up with technological developments. While the cable's maximum data

capacity of 9.38Tbit/s may seem very hefty, it should be remembered that connections of 800 Gbit/s to 1 Tbit/s are often already in place between individual data centers, and more and more consumers now have access to 1Gbit/s connections. In that light, 9.38Tbit/s is a narrow funnel to run data traffic between two continents through.

Of course, TAT-14 was not the only connection available, but this example illustrates well how fast developments are also taking place in the field of marine cables. And therefore also how important it remains to keep anticipating them. Because installing sea cables is still a lot more challenging than installing fiber over land. Partly for this reason, part of Africa was cut off from the Internet for a long time because a sea cable near the Ivory Coast was damaged. When such a breach occurs, it is not simply repaired, or a new cable laid. You have to deal not only with depths, tides and weather, but also with highly specialized vessels and crews that are scarce worldwide and usually booked up years in advance. In addition, landing sites must be made suitable and international coordination is required to get a marine cable off the ground.

It is not for nothing that the FCA and other organizations from the digital infrastructure sector in the Netherlands, among others, have been insisting for years that the Netherlands must take a more assertive stance in this regard. And with success.

Sea Cable Coalition

The fact that sea cables land in the Netherlands has been of historical significance for the development of the Netherlands as a global digital hub. Given the efforts, coordination, investments and specialties required for the laying of sea cables, it is desirable that this should be directed. After many pleas for this, the Subsea Cable Coalition is now a fact.

This public-private partnership endeavors to maintain and strengthen the Netherlands' strong position as a digital hub by removing obstacles to the laying of new sea cables. Realizing this is made difficult, for example, by various factors such as regulations. To address these challenges, companies, knowledge institutions and the government have united in the Sea Cable Coalition.

The Coalition emphasizes and promotes the economic and strategic importance of submarine cable connections and actively investigates opportunities to connect to planned marine cable routes, both within Europe and intercontinental. In addition, the Coalition focuses on improving the (permit) processes

surrounding cable landfall in the Netherlands and participates in international collaborations. In addition to the FCA, participants in the coalition include DINL, DDA, Ministry of EZK, AMS-IX, Innovation Quarter and Rijkswaterstaat, carriers such as Relined and LibertyGlobal and Surf.

Innovation Cycle

That there will now be more direction on the laying of new marine cables is very welcome. But are new cables really necessary? It is sometimes suggested to give these older sea cables an upgrade. Fiber optics can of course handle a lot, but at the same time it is also linked to the life cycle of a product.

There is more demand from the market for bandwidth and they are looking at ways to keep operational costs down. This still causes organizations to build new cable systems today. For example, in recent years between the Netherlands and the United Kingdom, the Scylla has come into service. This relatively short connection between London and Amsterdam, which euNetworks owns, uses 96 fiber pairs and can unrepeatedly connect both countries. By comparison, the old connections sometimes had only 6 to 8 fiber pairs. Corning's low loss Ultra G.657 Fibers provide an excellent connection.

Berths

The phasing out of connections like TAT-14 (and also AC-1) mark the end of an era for the time being. For the Netherlands now has no direct connections with the U.S., which does the Dutch position as an international digital hub no good. For years, this sea cable was the pride of the Netherlands. Now we are dependent on using the Havfrue/AEC-2. This connection is a high-tech connection and arrives in Europe via beautiful Blaabjerg (Denmark). From the point of view of data transmission, Blaabjerg is only a stone's throw away from IJmuiden or Eemshaven: the distance is minuscule in terms of speed. It therefore remains extra unfortunate that we have not been able to tie this connection to our country.

Sea cables and geopolitics

With the outbreak of war in Ukraine in late February 2022, it became clear once again that peace in Europe can no longer be taken for granted. And that this also has implications for how we protect our connectivity infrastructure, particularly when it comes to the international sea cables that connect Europe to the rest of the world and vice versa.

For years, occasional reports have surfaced in the news that Russian naval vessels have been mapping sea cables, possibly for the purpose of sabotage.

Given the tensions between the EU, NATO countries and Russia since the outbreak of war, this threat has only increased. Consequently, in 2024, sea cables were very regularly in the news, partly due to some high-profile cable breaks on the Baltic coast. It further highlights how urgent protection of sea cables is.

Marine cables, in short, are fragile. This is still true today, even though we have more and better capabilities to monitor them. However, disruptions would have a huge impact worldwide, making vigilance more necessary than before.

Digital sovereignty and strategic autonomy

Since Donald Trump took office for his second term as U.S. president, dormant geopolitical trends have gained momentum. The current U.S. administration's stated "America First" strategy in just a few months has caused a great deal of geopolitical turmoil, including extreme import tariffs and real and empty threats against friend and foe that touch on national security, defense and strategic autonomy. The wishful thinking in the EU that all will be well with the cooling of the EU-U.S. relationship has been quickly pushed aside by these developments. The EU must stand on its own two feet, including when it comes to digital services and technologies. In this area, dependence on the U.S. is unacceptable in the current geopolitical context.

As the digital chain consists of a range of infrastructure and services, new dependencies continue to surface that were not immediately visible. Although politically the focus at the time of writing this report is mainly on cloud services, it is also useful to wonder about infrastructures such as fiber.

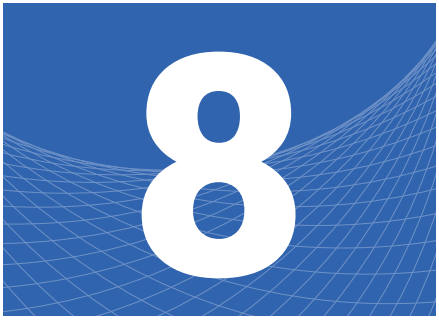
The good news is that infrastructures such as fiber have physical bonding, making the sovereignty issue not directly relevant for consumer and business connections. But when it comes to backbone capacity and transatlantic connections, there are risks. One is that many sea cables in recent years have been built by U.S. tech giants who thus control the entire infrastructure. At that point, the same dependency exists as that around cloud services. So it is also for this reason that the Netherlands and Europe should establish their own connections.

When it comes to the production chain of fiber optics, it can also be observed that in general the same dependencies do not exist as is the case with digital services such as cloud. One of the largest global producers of fiber optic cables, Prysmian Group (which absorbed the once Dutch Draka), is headquartered in Milan, Italy.

When it comes to the raw materials needed for fiber optics, there are also risks of dependency. Fiber optic cables are made with a process that requires quartz, germanium, oxygen, acrylic acid and polymers (petroleum). Germanium is a so-called rare earth metal, 94% of which is produced by China, 4% by Russia and the rest by the U.S. and Japan. Consequently, the EU has put this metal on a proposed list of strategic raw materials. Although oil is also not widely mined in Europe, it is not an immediate strategic risk as rare earths are.

Except for germanium, the same strategic vulnerabilities that exist for cloud services, for example, do not exist for fiber.

CONCLUSION



Now that virtually all households in the Netherlands have or will soon have a fiber connection, it is time to change course. Fiber optic networks are and will remain an absolute prerequisite for well-functioning digital societies and economies. This dependence will only increase in the future. Both in the Netherlands and Europe it is therefore necessary to continue to invest in the rollout of fiber in those places where it is not yet available, be it households or business parks. Certainly from a European perspective, there is still plenty of work to be done. As this edition of this report also shows, in many respects the Netherlands remains the European leader in the rollout of fiber.

That European perspective is rapidly becoming more important in this regard. The Netherlands has much to offer other European countries when it comes to knowledge and expertise in the rollout of fiber optics. But recently the security aspect and questions surrounding digital sovereignty have also become more important. We need to make ourselves resilient against threats that were almost unthinkable just a few years ago. This also means that our networks must be “fused” throughout the chain: from manufacturing to construction, from management to ownership, from application to security.

In the coming period, therefore, the FCA will also focus more on opportunities and threats surrounding fiber. On the one hand, fiber continues to facilitate new technology such as AI. Thus, fiber also drives innovation. At the same time, given the changing world order, it is important to dwell more on the security of networks. Quantum computing and security are undeniably part of this.

At the same time, we remain committed to dossiers that have always been important to the sector, and digital infrastructure more broadly, including intercontinental sea cables. Because while there is visible movement on this file, and stakeholders are doing everything they can to turn the tide for the better, the results are not yet as hoped. This is certainly a task for the FCA, in cooperation with other partners and stakeholders. We are happy to take up that gauntlet.

ALL ACTIVE FIBER CARRIERS IN THE NETHERLANDS

Figure 17. Networks in the Netherlands

FCA member

The following map in Figure 17 and the table below show the most active carriers in the Netherlands.

COMPANY	LOCATION	
AFIBER		
BlueFiber	Zwolle	
Breedband Arnhem	Arnhem	
Breedband Helmond	Helmond	
Breedband Regio Eindhoven	Eindhoven	
Breedband Tilburg	Tilburg	
Brightaccess	Enschede	
Brightfiber (Eurofiber)	Vianen	
Brofiber	Eersel	
BT Nederland	Amsterdam	
Cogas Kabel	Almelo	
Colt Technology Services	Amsterdam	
Community Network Noord Nederland (CNG)	Groningen	
Coöperatie Glasvezelcompagnie Nuenen U.A.	Nuenen	
Coöperatie HSLnet U.A.	Heeze	
Delta Fiber Nederland	Schiedam	
Digiglas	Zuidbroek	
euNetworks	Amsterdam	
Eurofiber	Maarssen	

COMPANY	LOCATION
E-Fiber	Huis ter Heide
e-Quest	Helmond
EXA Infrastructure	
FiberFlevo	Emmeloord
FiberNH	Emmeloord
Fiber Noord	Leek
FiberNow	Krimpen aan den IJssel
Fiber Revolution	Rotterdam
Fore Freedom	Hedel
Glasdraad	Den Haag
Glasnet Buren	Buren
Glasnet Heusden	Heusden
Glasnet Oostplaat	Middelharnis
Glasnet Tiel	Tiel
Glasnet Veghel	Veghel
Glasnet Zoetermeer	Zoetermeer
Glaspoort	Schiphol
Glasvezel Buitenaf	Schiedam
Glasvezel Eindhoven	Eindhoven

COMPANY	LOCATION
Glasvezel Helmond	Helmond
Glasvezel Vught	Vught
Glazen-Maas	Rotterdam
Groningen Seaports	Delfzijl
Interoute Managed Services Netherlands	Schiphol-Rijk
KPN	Den Haag
Kempenglas	Buitengebied de Kempen
Kabeltelevisie Noord-Oost Friesland (Kabelnoord)	Dokkum
Lumen	Amsterdam
NDIX	Enschede
Relined Fiber Network	Vianen
RENDO fiber	Meppel
Schiphol Telematics	Schiphol
SouthernHill	Elsloo
Stadsring Leeuwarden	Leeuwarden
St. Cai Harderwijk	Harderwijk
St. Kabelnet Veendam	Veendam
St. Kabeltelevisie Pijnacker	Pijnacker
St. Regionale Kabeltelevisie Midden-Holland (Rekam)	Gouda

COMPANY	LOCATION	
Stichting Breedband Delft	Delft	FCA
Stichting Glaslokaal	Den Haag	FCA
Stichting Glasvezel Dombosch	Rijswijk (NB)	
Tele2 Nederland	Diemen	
Telemann	Nijmegen	
Teleplaza	Heemskerk	
TelePark	Kesteren	
T-Mobile Netherlands	Den Haag	
TReNT Infrastructuur	Enschede	FCA
Unet	Almere	
Uniscape	Zoetermeer	FCA
Verizon Nederland	Amsterdam	
Vertixo	Arnhem	FCA
ViaGlas	Horst	
VitrumNet	Dordrecht	FCA
Vodafone Libertel	Maastricht	
Zayo	Amsterdam	
Ziggo	Utrecht	

FIBER
CARRIER
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