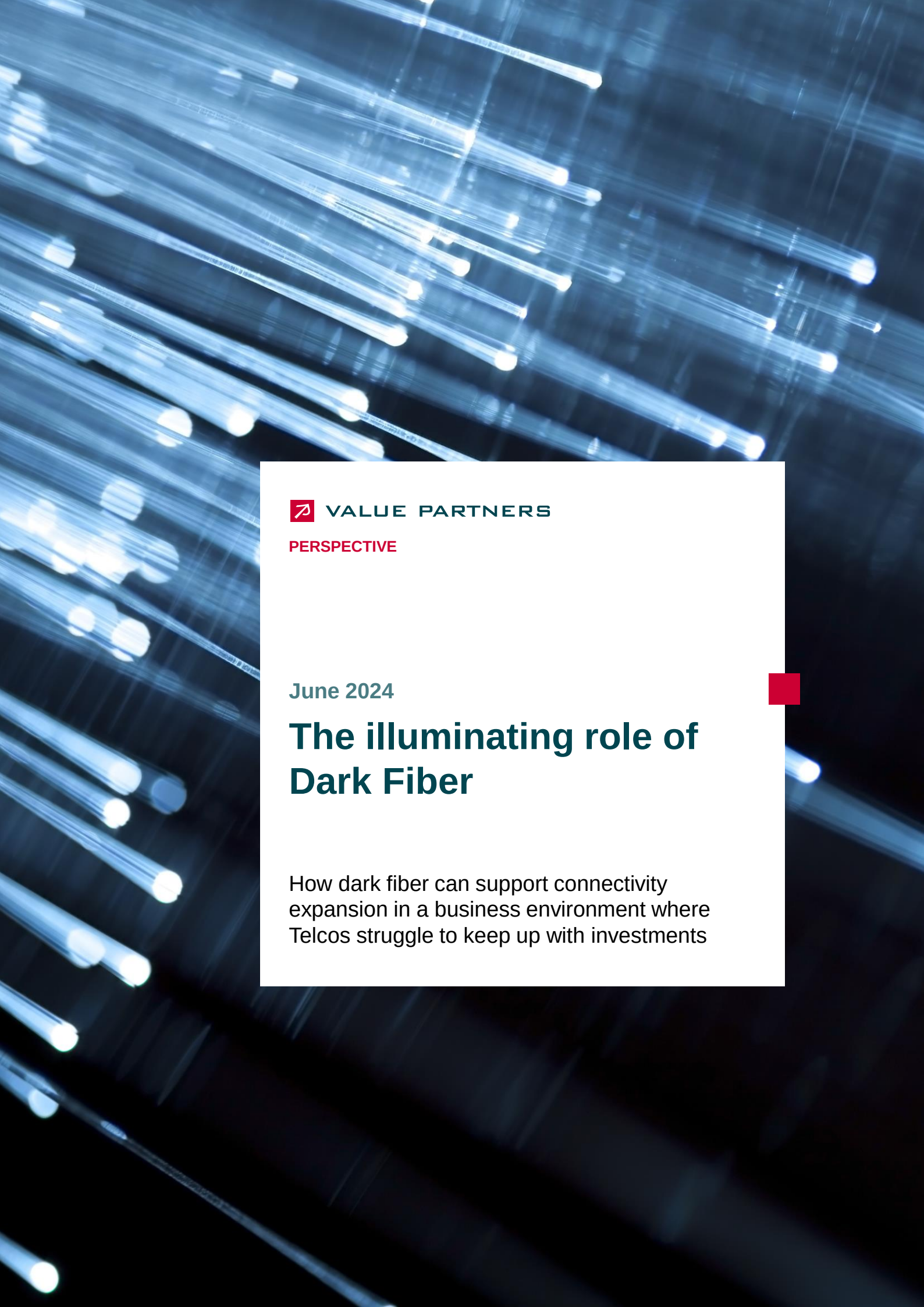


VALUE PARTNERS

PERSPECTIVE

June 2024

The illuminating role of Dark Fiber

How dark fiber can support connectivity expansion in a business environment where Telcos struggle to keep up with investments

Contents

Executive summary

Decades after the beginning of the digital era, internet traffic and global users continue to experience double-digit growth. Governments, businesses and individuals increasingly rely on broadband as an economic and social development catalyst, thus strengthening the need for robust and extensive connections. Dark fiber – surplus fiber laid down in advance by infrastructure companies – partially closes the gap between growing connectivity demand and its fulfillment.

Overcapacity, in the form of fiber pairs, can be rented out to telcos and digital businesses in different ways, generating steady cashflows that lower the payback period of the investment. In some cases, dark fiber providers may offer additional services associated with the naked cable, supplying customers with powerful tools to expand their networks quickly and flexibly.

This does not come without risks, since dark fiber services follow a bespoke approach throughout the entire value chain and entering into long-term agreements with the wrong approach can quickly dissipate all benefits. This perspective explores emerging business models and trends in the exploitation of such infrastructures, considering benefits and potential drawbacks for the key actors.

Dark fiber

Unused *surplus* fiber pairs laid down by infrastructure owners and operators in addition to the fiber pairs deployed to control and run their infrastructure

The world is hungry for bandwidth

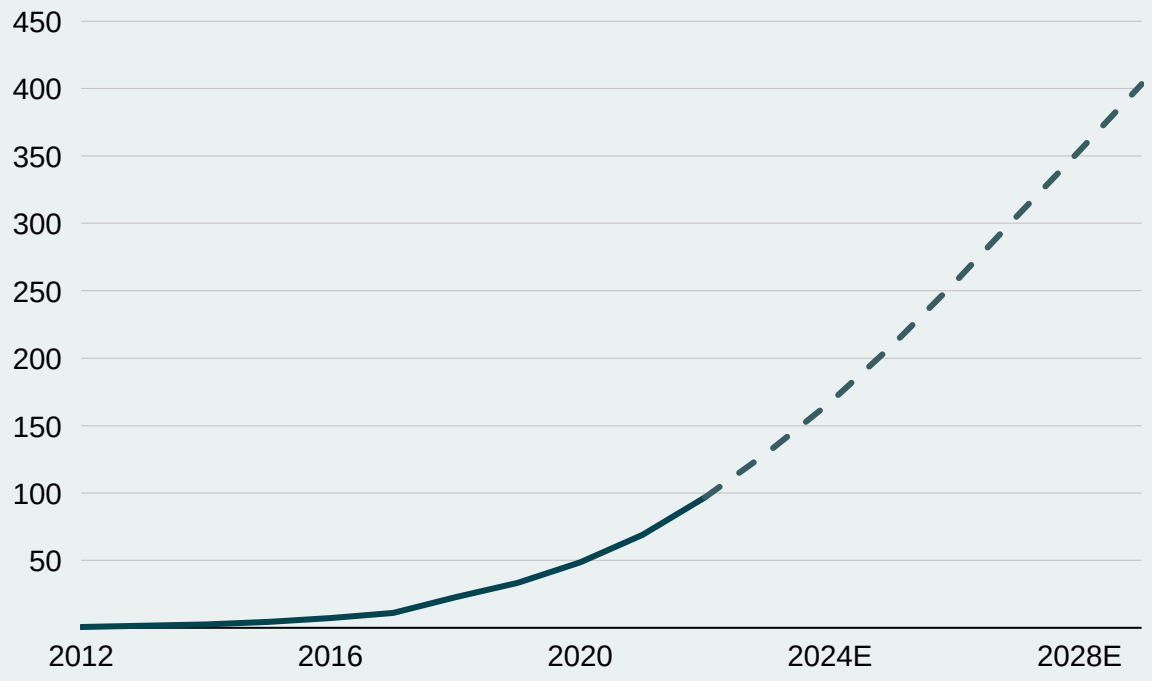
As the full potential of digital technologies unfolds before our eyes, the world is rushing to build data highways wide enough to ensure information keeps flowing unimpeded.

With a 50% CAGR in the period 2017-2023, and a forecasted yearly growth averaging 20% in the period 2023-2029[1], internet traffic figures continue to post robust growth. In fact, **estimated monthly traffic volume for mobile in 2029 is expected to rise twelvefold compared to 2019** (EXHIBIT 1).

This trend is driven by two main factors: a steady increase in users and an uptick in average traffic per user. Indeed, forecasts show that internet users will grow by around 400 M users per year between 2020-25: that's approximately 80% more than in 2005-19, when users grew by 220 M a year (EXHIBIT 2).

EXHIBIT 1

Global internet mobile traffic, Exabytes/ month

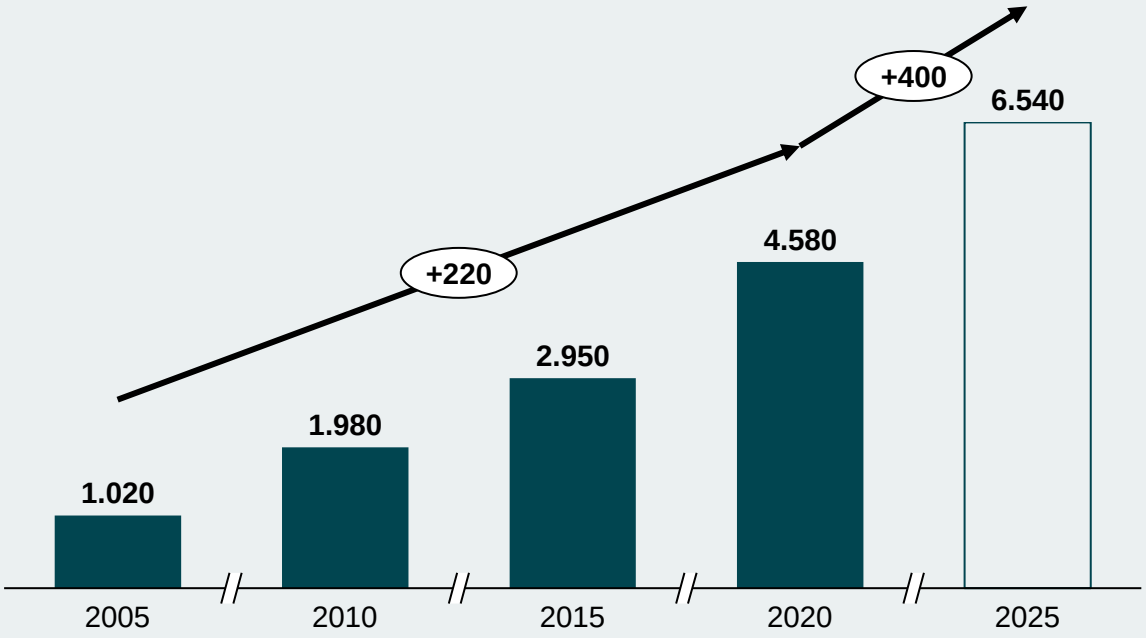


1. Ericsson Mobility Report Data, updated Nov. 2023

The compounded effect of both variables puts a tremendous pressure on backbone networks, which are crucial for reliability, redundancy, and capacity.

The expansion of network infrastructures allows more people to access high-speed internet (resulting in userbase increase) and supports bandwidth-intensive services such as 4K streaming and social media (resulting in per-user traffic increase).

EXHIBIT 2
Global internet users, M



Fiber deployment over time

Initially, telcos monopolized advanced telecommunications technologies, focusing on connectivity in high-demand areas. However, as urban areas saturated, telcos faced diminishing incentives to upgrade connectivity in rural and low-density areas, pushing governments to support network expansion efforts through a mix of subsidies and incentives. As the spread of digital technologies accelerated, other industries benefitted from their deployment too.

Particularly, **telecommunications technologies emerged as a strategic tool for managing key infrastructure** (e.g., power grids and railways), allowing the collection of real-time data for early damage detection, enabling remote operations and network management. This led to a widespread roll-out of optical fiber for operational purposes, which in some cases resulted in excess capacity (i.e., unused fiber) along the infrastructure, sketching the concept of dark fiber itself.

Two key factors contributed to the first wave of dark fiber development: **democratization of telecommunication technologies** and **pressure** from businesses, individuals, and governments **to expand broadband networks for different purposes**.

These opened the opportunity to rent-out surplus telecommunications assets to different actors. In fact, the first spike in dark fiber deployment happened during the dot-com bubble, when digital frenzy drove up demand for fast fiber connections, pushing telcos to rapidly deploy additional capacity. However, large scale exploitation of such assets was hindered by the ambiguity of regulatory frameworks linked to Regulated Asset Base infrastructure investments and the absence of demand aggregators.

A cooldown period followed, where **xDSL technologies enabled the use of existing copper-based phone lines to boost connectivity capabilities while limiting investments in network enhancements**. At the same time, deployment of technologies such as WDM significantly cut the need of additional fiber pairs on backbones, as bandwidth could be split into several wavelengths running on the same physical line, driving a surge in capacity and maximizing asset exploitation.

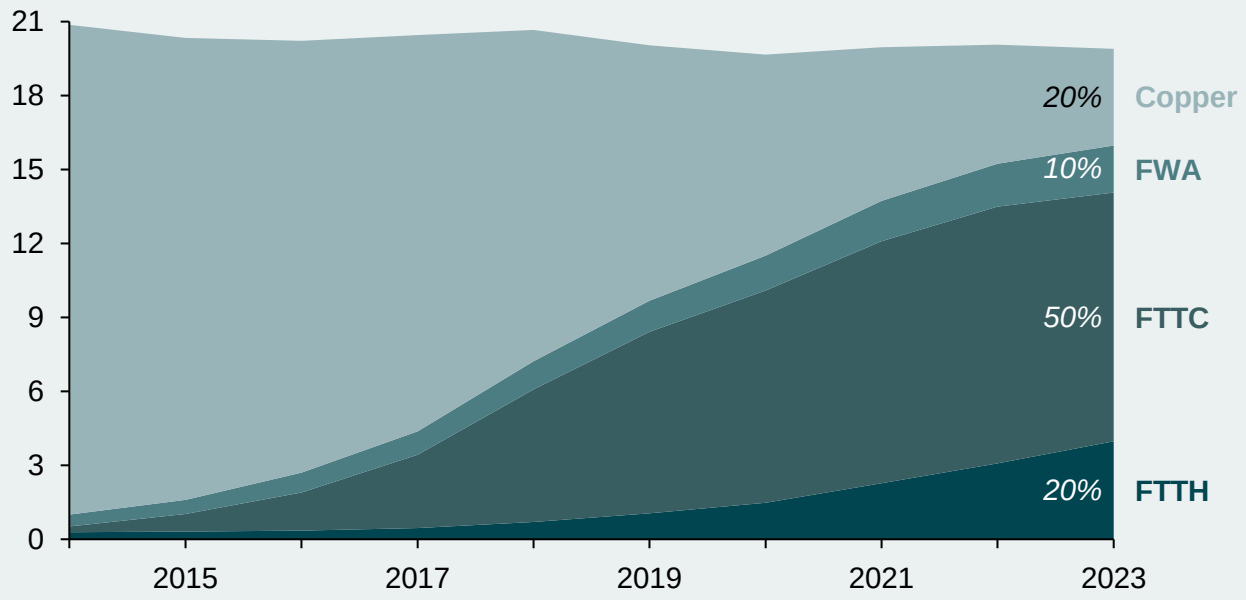
Subsequently, technological progress drove exceptional growth in bandwidth usage, making ADSL and other copper-based technologies obsolete. The ensuing push towards high-capacity technologies and last-mile traffic increase encouraged the expansion of telecommunication networks' span and capacity.

FWA was among the solutions developed for these purposes, allowing customers to obtain high-speed connections through cable-free communication systems transmitting over short distances. However, radio-based solutions such as **FWA failed to reach mass market adoption, having been quickly replaced by more resilient and reliable technologies such as FTTC** (EXHIBIT 3). Indeed, FWA market share in Italy – a country historically suffering from digital divide – has not taken up, reaching only 10% as of June 2023. As a comparison, FTTC and FTTH achieved market shares of 50% and 20%, respectively.

As demand for capillary fiber connections grows, it is not only backbones that are interested. In fact, infrastructure-sharing schemes such as dark fiber play a strategic role as coverage enhancers and speed catalysts in the last-mile segments of the network. Such improvements further contribute to economic development, for example by providing connectivity upgrades for isolated industrial districts currently lacking appropriate infrastructure to fully benefit from digitalization. These aspects are driving **a second wave of dark fiber deployment, which now involves extensive private networks belonging to infrastructure operators and private players**.

EXHIBIT 3

Fixed internet lines by technology, M, %, Italy, 2014-23



Source: AGCOM Reports

A new role for dark fiber

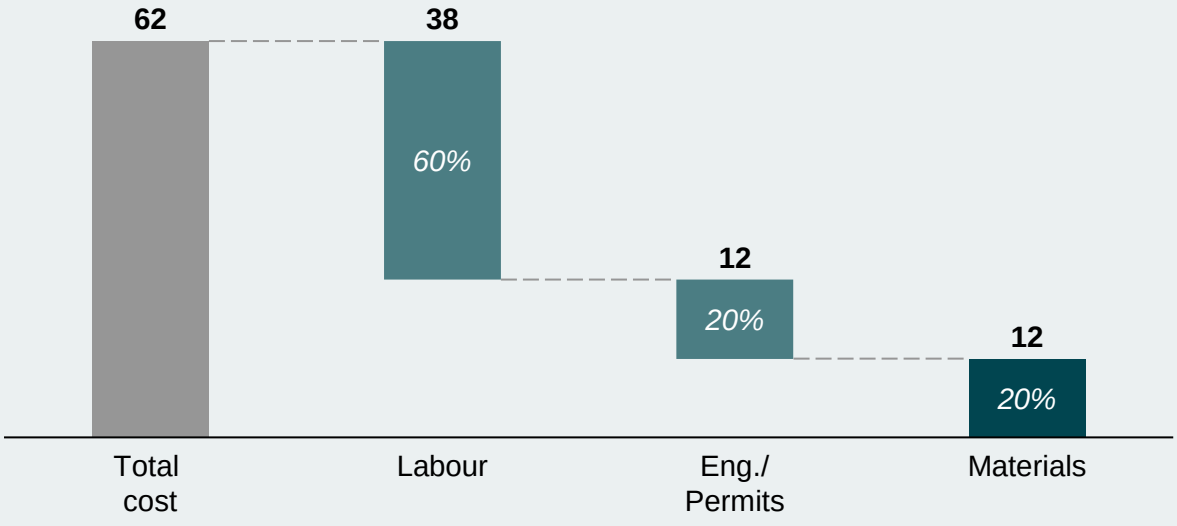
Overcapacity provided by dark fiber can be commercialized to telcos and digital businesses with large connectivity requirements (e.g., datacenters). In the base case, where only the naked cable is rented, the burden for the dark fiber provider (DFP) is minimal since there is no need to "light it up" through transmission equipment.

Case studies from the industry show that fiber cables themselves are estimated to represent less than 10% of the overall installation costs of such infrastructures, on average. Although the figure varies strongly depending on the specific context (cost of labor, trenching type, requirements etc.), material costs in the USA averaged around 20% of total costs (EXHIBIT 4) Indeed, most of the expenses are associated with design, planning, installation costs and other materials, making the deployment of dark fiber an attractive investment. In addition, dark fiber represents the fastest type of connection that can be offered, as fiber pairs are typically leased through indefeasible rights of use (IRUs), leaving customers with the possibility of fine-tuning connectivity performance through the installation of their own equipment.

The win-win benefits are clear. On the one hand, DFPs can reduce the payback periods of their investments and the costs of operating their internal data networks, thus incentivizing the digitalization of their core businesses (virtuous cycle). On the other hand, clients such as telcos and companies aiming to expand their networks can obtain immediate access to new infrastructure. Furthermore, such networks are essential for connecting 5G base stations, due to demanding latency requirements and bandwidth targets that cannot be met with radio bridges.

EXHIBIT 4

Median cost of underground fiber deployment per meter, USA, 2023, €/ m



Shifting paradigm in dark fiber deployment

Dark fiber deployment allows companies to turn burdensome CAPEX into flexible pay-as-you-go OPEX through leases or rental agreements centered on dark fiber access and utilization. These arrangements fall under **Network as a Service** (NaaS) business models and allow service providers to monetize unused resources, generate additional revenues, and offer capacity under flexible terms to the lessee.

For lessees, a number of benefits stem from this configuration:

- **Cost-effectiveness**: access to high-speed network services without the need for significant capital investment for cable infrastructure
- **Flexibility and scalability**: ability to adapt network services based on changing needs
- **Control and security**: possibility to establish private networks that are not shared with other users, without intermediaries that handle information flowing through the network
- **Maintenance**: lessees can focus on their core business, carrying out O&M activities in their own PoPs while leaving DFPs in charge of managing and maintaining the backbone infrastructure

The service level offered by lessors greatly varies depending on the capabilities of DFPs in the telecommunications field and on their ability – and commitment – to broaden their scope beyond infrastructure-related activities. Three types of actors are typically involved in these arrangements: the lessor, the middleman (optional) and the lessee (EXHIBIT 5).

EXHIBIT 5

Dark fiber value chain

- **Owns and operates the infrastructure** hosting dark fiber cables
- **Exploits its role** as infrastructure operator/ owner to **extend offering**

- **Manages the commercial aspects** of dark fiber operations
- **Bolsters its versatile role** by providing network installation, maintenance and operation

- **Benefits from the use** of dark fiber infrastructure (e.g., for transmitting data)
- **Capitalizes on** the potential provided **by the use of dark fiber**

The flexible structure of these deals allows for the convergence of different roles into the same figure (e.g., a JV with a Telco)

Two key variables must be taken into account to assess know-how, resources required, and economic impact resulting from such agreements: portfolio span and outsourcing level.

Portfolio span defines the number and complexity of services offered in addition to basic dark fiber. It is strongly linked to the level of technological know-how of the DF.

Porfolio Span

Basic fiber	▪ Lease of plain **dark fiber pairs** (with no transmission equipment)
Managed dark fiber	▪ Supply of **ancillary services and products** (e.g., racks, housing spaces, maintenance) to complement and integrate dark fiber offering
Telco-like	▪ Provisioning of **off-site network segments, WDM services** (lit fiber) and other advanced active connectivity solutions

Service level & complexity (- to +)

The **outsourcing level** defines to what extent the DFP is involved in activities concerning installation, maintenance, and commercialization of the dark fiber infrastructure.

Outsourcing (Insourcing) **Level**

	Externalized	**Joint Venture**	**Internalized**
Key principles	▪ **DFP leases the infrastructure** to an external operator that runs it autonomously ▪ DFP receives **a fixed or semi-fixed fee**	▪ DFP runs infrastructure collaborating with an **external partner** with **technical, economic** or **commercial resources** ▪ **Profit-sharing** within JV	▪ **DFP runs** all **operations** (incl. sales, maintenance & upgrades) ▪ Profits from **infrastructure use** and **provision of services**
Pros	▪ **Low know-how** required ▪ Stable revenues	▪ **Limited know-how** required ▪ Moderate flexibility	▪ **Full control** on the business ▪ Maximum flexibility
Cons	▪ **Asymmetric** profits ▪ Rigid structure (typically long-term IRUs)	▪ Difficulty in **finding the right partner** ▪ Difficulty in **balancing** corporate **governance**	▪ **Significant know-how** required ▪ Increased **operational risks**

Examples from the industry

Dark fiber is ultimately a byproduct of technological innovations adopted by infrastructural players. Solutions relying on fiber optics provide significant benefits compared to legacy systems, encouraging companies from different industries to deploy them. However, rail, road and energy grid operators represent the most relevant examples as their infrastructures typically cover vast regions with capillary reach.

These companies exploit fiber technologies to collect real-time data on infrastructure status and enable remote operations on their networks.

Benefits from fiber optics ultimately impact infrastructure players' performance, thanks to higher efficiency in their operations (e.g., from lower downtimes), cost savings (e.g., early damage detection), and additional revenues from greater asset exploitation (e.g., higher frequency on railways).

Dark fiber deployment can occur in different ways, depending on characteristics of the infrastructure and potential for providing ancillary services (EXHIBIT 6).

EXHIBIT 6

Fiber-optics deployment for infrastructure companies

Railways

- Leverage of **existing cable ducts** to install signals, switches and other network systems
- **Use of technical rooms** and **unused buildings** along the infrastructure **to place transmission equipment**

Roads & highways

- Leverage of **existing conduits** (e.g., lighting) or new installations on roadsides
- Use of the new infrastructure to install **5G radio base stations**

Energy grids

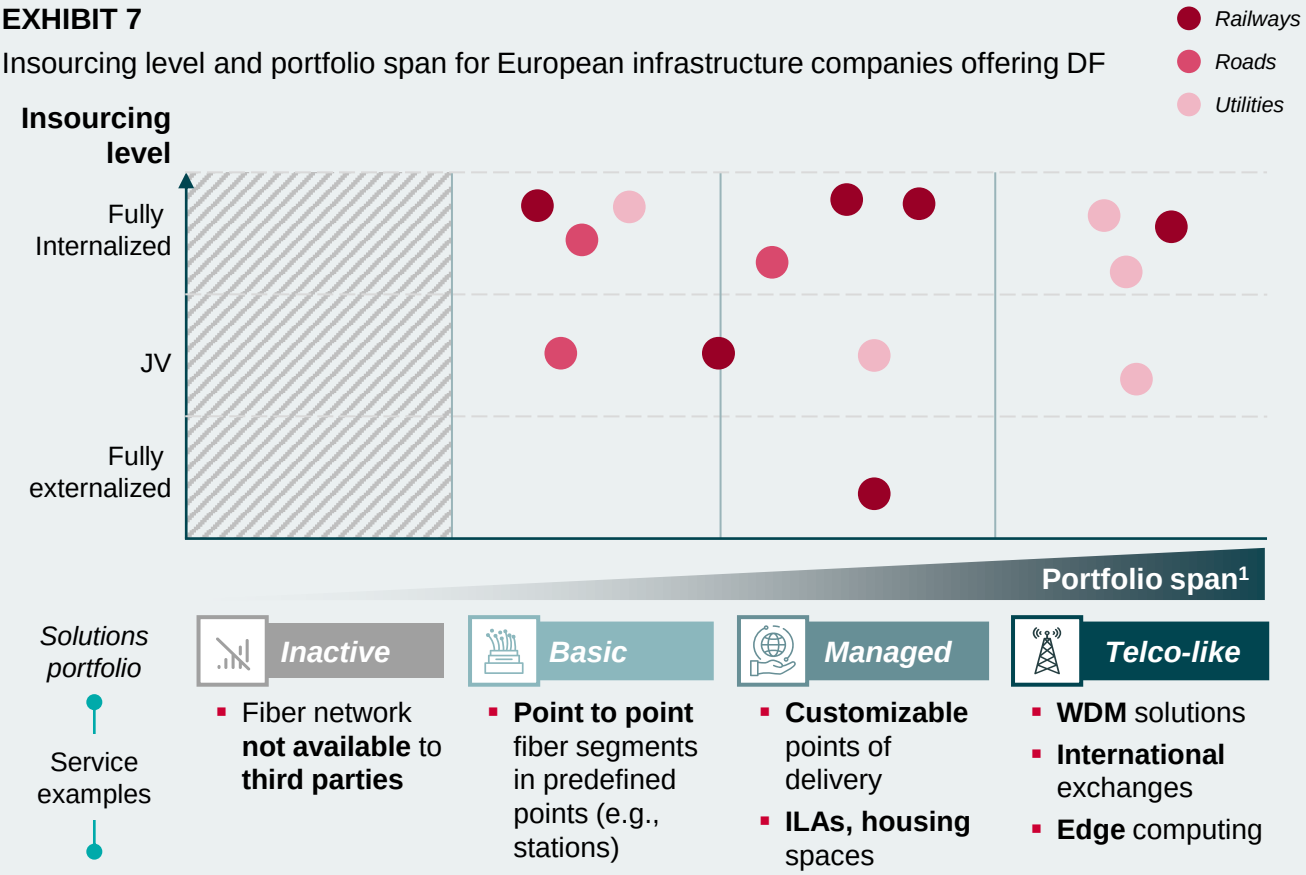
- Use of **shield wires** to lay down fiber pairs along the power lines of the grid
- Leverage of distribution system operators (DSOs) **network capillarity to reach final customers**

As the panel of European players in EXHIBIT 7 shows, the **provision of dark fiber services does not necessarily follow a common pattern**. For instance, portfolio span considerably differs across players, although some trends emerge within the industries. Particularly, energy grid TSOs/ DSOs are more skewed towards telco-like services, while highway operators are keener on offering a more basic value proposition. Both inclinations are driven by pre-existing know-how in network management and internal capabilities.

With respect to the outsourcing level, **European players tend to position themselves towards a fully internalized model, running all operations and maintaining full control over the dark fiber business**. However, for players operating through JVs it is possible to observe at least three paths through which value is added to the business. In the **first case, the partnership is made with a telco** providing know-how and directly using the infrastructure. The **second is through private investors and PE funds**, mainly to strengthen the capital structure and foster investments. The **last scenario is connecting with peers that already cooperate on different levels** of their business (e.g., between energy operators and distributors).

EXHIBIT 7

Insourcing level and portfolio span for European infrastructure companies offering DF



1. Portfolio span for externalized models and JVs refers to the portfolio span of the JV or outsourcer
Source: Value Partners analysis on 14 infrastructure players from Italy, France, Spain, UK, Germany Sweden and Switzerland

Navigating complexity

Our experience working alongside major infrastructural players and telcos around the world has shown that no single dark fiber deployment model outperforms the others from either the provider, middlemen, or end-user's perspective. **Evolving business models and ancillary services can complicate the overall value proposition** and require experience and know-how for a successful design and implementation.

It is key to assess two fundamental aspects to reach an optimal solution. To start with, players should **evaluate their technological know-how** to better understand the portfolio span they are able to manage, assessing both internal capabilities and potential partnerships. Second, **features and capabilities of the network** determine the attractiveness of dark fiber initiatives, providing opportunities that are linked to geographical footprint (e.g., size and location) and the amount of surplus capacity to be offered.

The design of the business model should consider two additional elements. The first is about tailoring: **whatever the chosen path is, dark fiber service models are typically bespoke arrangements that can be adapted to maximize mutual benefits for all actors**. This includes carefully evaluating the possible ancillary services and products that can complement basic dark fiber access. The second consideration, whose importance grows with the size of the network, is that **more service models can be combined by fragmenting the network in geographical or technological areas**. The last element to consider is organizational. JVs and partnerships provide effective tools for acquiring extrinsic competencies and leveraging knowledge and expertise. However, the natural **rigidity of the infrastructure industry should always be taken into account: leases can span for years or decades, with severe contract penalties and high service levels that impose close cooperation between participants**.

Dark fiber is just one **example of surplus infrastructure leveraging that can open the doors to new business opportunities**. As we navigate through the digital era in a world of increasing competitiveness, the call for widespread efficiency should not be ignored. The risk is sitting on a gold mine – without even knowing it.

Glossary.

DFP	Dark Fiber Provider
DSO	Distribution System Operator
FTTC	Fiber To The Cabinet
FTTH	Fiber To The Home
FWA	Fiber Wireless Access
ILA	Integrated Line Amplifier
IRU	Indefeasible Right of Use
NaaS	Network as a Service
PoP	Point of Presence
Telco	Telecommunications company
TMT	Telecoms, Media, Technology
TSO	Transmission System Operator
WDM	Wavelength Division Multiplexing
xDSL	Digital Subscriber Line

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