

Fibre-Optic Network as an Object of Law: Access, Licensing, Cost Allocation and Resilience in the EU Gigabit Strategy

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Abstract. Optical fibre cable is normally considered an engineering artefact, but almost any obstacle to rolling out the cable is a matter of law rather than technology. No existing study, however, reconstructs that framework function by function to show which legal technique carries each obligation and where each technique fails. This paper explores how European law creates the optical fibre network as a subject of law and whether it can provide economically feasible and ecologically sustainable connectivity. The study employs doctrinal, comparative and interpretive analysis of the body of EU instruments for regulating fibre-optic rollout, including, primarily, Regulation (EU) 2024/1309 (Gigabit Infrastructure Act), Directive (EU) 2018/1972 establishing the European Electronic Communications Code, state aid guidelines for broadband networks of 2023 and the resilience frameworks of Directives (EU) 2022/2555 and 2022/2557, taking account of the case law of the Court of Justice and the implementation of the legal instruments in Greece and Cyprus. The study identifies nine regulatory functions and reconstructs them in law: access to physical infrastructure, civil works coordination, permitting, in-building infrastructure, competition and market remedies, resilience, public funding, environmental consent, and copper transition. The study finds that regulation is shifting from telecommunications market regulation to property, administrative and planning law and security law; the critical constraint on roll-out is the time and inconsistency of multi-authority permitting, not the availability of funds; and sustainability emerges rhetorically but not as a substantive duty. The study suggests consolidating the permitting procedure, creating published reference cost models, reengineering conditionality and requiring route diversity for peripheral states. These proposals are aligned explicitly with Sustainable Development Goal 9 on resilient infrastructure, Goal 16 on effective and accountable institutions, and Goal 12 on responsible consumption and production.

Keywords: optical networks, rights of way, Gigabit Infrastructure Act, electronic communications regulation, digital sustainability, critical entity resilience.

INTRODUCTION

Optical fibre is the substrate of the modern economy. Cloud computing, real-time payment systems, remote administration of justice, telemedicine, high-frequency trading, and data flows that make possible sustainability reporting – everything is built upon a strand of

drawn silica whose legal status is rarely examined. The prevailing scholarship on fibre optics belongs to the field of engineering or to the economics of the network industry, with the focus on attenuation, dispersion, the capital cost, and the demand structure. Meanwhile, the legal

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scholarship tends to be focused on the services delivered through fibre optics and not on the fibre itself. As a result, there is a gap: the critical obstacles to gigabit deployment in Europe are not photonic, but juridical.

An optical fibre network is a legal heterostructure. The network is simultaneously a chattel when on the drum, a fixture or accession once blown into the duct, an easement or a servitude in respect of the land the cable traverses, a regulated facility operated by a market-powerful company (Directive (EU) 2018/1972, 2018), critical infrastructure for the purposes of the resilience law (Directive (EU) 2022/2555, 2022; Directive (EU) 2022/2557, 2022), and, in case it comes ashore, an object of the maritime and national security laws (United Nations Convention on the Law of the Sea, 1982). These classifications mean different legal regimes, different competent authorities and different remedies. Deploying fibre optics is, therefore, the process of satisfying property law, administrative and environmental permitting, sectoral access regulation, competition and state aid law, and, increasingly, security law. Nobody in the system has the full picture of the obligations imposed on the deployer.

In response to this fragmentation, the European Union has produced a decade of instruments aimed at reducing the cost of civil works, which accounts for the overwhelming share of fibre network costs (Rendon Schneir & Xiong, 2014). Directive 2014/61/EU of the European Parliament and of the Council on measures to reduce the cost of deploying high-speed electronic communications networks introduced infrastructure sharing and permit coordination (Directive 2014/61/EU, 2014). Directive (EU) 2018/1972 recast the sectoral framework to achieve very high-capacity connectivity (Body of European Regulators for Electronic Communications [BEREC], 2020; Directive (EU) 2018/1972, 2018). Regulation (EU) 2024/1309, the Gigabit Infrastructure Act, replaced the Directive with a directly applicable regime to overcome its predecessor's problem of transposition divergence (Regulation (EU) 2024/1309, 2024). The Digital Decade Policy Programme provided the quantitative targets for assessing these instruments (Decision (EU) 2022/2481, 2022; European Commission, 2026b), while the parallel regimes on cybersecurity and the resilience of critical entities

placed the same physical infrastructure in the framework driven by security considerations (Directive (EU) 2022/2555, 2022; Directive (EU) 2022/2557, 2022).

The investigation is also, and explicitly, an investigation into sustainability. Deployment of fibre-optics technology addresses three of the Sustainable Development Goals of the 2030 Agenda. The SDG that addresses industry, innovation and infrastructure is engaged since gigabit connectivity is exactly what target 9.1 refers to as affordable and reliable infrastructure. SDG 16 on peace, justice and institutions is engaged since the constraint discussed in this paper is a matter of institutions, not finances; the effectiveness and transparency of permitting administration is the key issue at stake here in the light of targets 16.6 and 16.7. Finally, SDG 12 on responsible consumption and production is engaged in copper network retirement, since reusing secondary material and reducing network energy intensity (targets 12.2 and 12.5) will be the environmental element of the transition. The following discussion returns to these three SDGs, explaining the gap between the framework's sustainability rhetoric and its real obligations.

LITERATURE REVIEW

Three bodies of literature are relevant to *the* problem. None of them addresses the problem as it stands. The first body is economics of access regulation, concerned with the effect of mandating access to the incumbent's network on the incentive to invest in a new one. The classic discussion has established the case for access to bottleneck facilities (Laffont & Tirole, 2000), while recent work has redefined the question for next-generation networks, noting that the ladder of investment that justifies the unbundling of the copper does not translate easily to fibre (Cave, 2010). There are models showing that access pricing of the legacy network influences the timing of transition to the new one (Bourreau et al., 2012), and models that show that co-investment arrangements can resolve the tension between access and investment incentives when there is uncertainty (Bourreau et al., 2018). There are also empirical findings about the effect of the design of access remedies on fibre deployment in Europe (Briglauer et al., 2018), and empirical results

from the unbundling experience in the UK demonstrating that the competition benefits of access regulation are both actual and limited (Nardotto et al., 2015). This literature is crucial, but it regards the legal framework as a parameter rather than an object of analysis.

The second body of literature deals with the macroeconomic value of connectivity. Cross-country estimates show a relationship between broadband penetration and the growth effect (Czernich et al., 2011; Koutroumpis, 2009), following earlier studies on telecommunications infrastructure and development (Röller & Waverman, 2001). Economic geography literature has pointed out that the internet's physical layer is geographically concentrated and that differences in access reflect the geography of the existing infrastructure corridors (Grubestic & Murray, 2002; Malecki, 2002). The studies on the diffusion of digital technologies among the populations of enterprises in national economies highlight that the productivity gain from connectivity depends on the absorptive capacity of the firm, while the economic effect of artificial intelligence in the small open economy highlights the concentration of the returns to the advanced digital capability in the location of reliable high-capacity connectivity (Challoumis & Eriotis, 2025). This body of literature establishes the importance of fibre; it doesn't explain why it is difficult to build.

The third body of literature is legal and institutional. The infrastructure theory asserts that the social value of the shared physical resource is systematically underestimated and that this creates a normative rationale for the access mandate and public provision (Frischmann, 2012). The doctrinal studies on submarine cables have demonstrated the protection gap between the freedom to lay cables and its practical enforceability (Burnett et al., 2014; Davenport, 2012). Audit findings on public support for fibre deployment identify permitting and administrative fragmentation, and not capital scarcity, as the recurring problem (European Court of Auditors, 2018). What is missing is the functional reconstruction of the framework, identifying which legal technique carries each obligation and where each legal technique fails.

Research questions and contribution

The article answers four research questions. First, how does European law construct the optical fibre network as an object of rights and duties, and which legal techniques make it possible? Second, where is the binding constraint on deployment once the framework is reconstructed function by function? Third, how does the framework allocate cost, risk and delay between infrastructure holders, deployers, public authorities and landowners? Fourth, what does the framework lack, especially concerning the sustainability and the peculiar exposure of small, peripheral and island jurisdictions, like Cyprus, that depend on a few submarine landings for international connectivity?

There are three contributions. First, it provides a functional map of European fibre law that can be used as an analytical tool rather than a description. Second, it identifies the permitting variance, rather than capital cost or access price, as the constraint on deployment, explaining the diagnosis as a function of the framework's structure. Third, it advances a reform agenda that employs exclusively legal techniques the framework already includes, thus making the proposals cheap in terms of administration relative to their effect. The analysis touches on a broader issue of regulatory design as a condition on the productive circulation of capital in the economy, since the speed of return of the invested funds to productive use depends on procedural certainty as much as on the nominal cost (Challoumis, 2021).

The remainder of the article is structured as follows. The second part describes the methodology, the corpus and the coding framework along with the logic behind the case selection for the comparative component. The third part provides the reconstruction of the nine regulatory functions, the functional map and the friction analysis in tabular form and highlights two cross-cutting findings. The fourth part draws seven implications for regulatory design and outlines the scope of the argument. The conclusion formulates the reform agenda and the empirical research programme that would allow testing rather than inferring the central hypothesis.

METHODS

The research is qualitative and doctrinal, supplemented with comparative and interpretive components. It does not test any statistical hypothesis. The object of inquiry is a normative system, and the proper method of inquiry is systematic reconstruction and evaluation of its coherence, burden allocation and policy-fitting. The methodology adheres to the traditions of European regulatory analysis, in which primary and secondary legislation, judicial interpretation and regulatory soft law are read together.

Corpus

The main corpus consists of the binding instruments of the European Union in force as of the date of writing. They include the core – Regulation (EU) 2024/1309 (Regulation (EU) 2024/1309, 2024) and Directive (EU) 2018/1972 (Directive (EU) 2018/1972, 2018) – read against the background of the repealed Directive 2014/61/EU as the point of departure from which the present regime has emerged (Directive 2014/61/EU, 2014); the resilience layer – Directives (EU) 2022/2555 and 2022/2557 (Directive (EU) 2022/2555, 2022; Directive (EU) 2022/2557, 2022); the objectives layer – Decision (EU) 2022/2481 (Decision (EU) 2022/2481, 2022); the environmental layer – Directive 2011/92/EU (as amended) and Directive 92/43/EEC when access routes pass through protected sites (Council Directive 92/43/EEC, 1992; Directive 2011/92/EU, 2011); the funding layer – the 2023 broadband state aid guidelines, its predecessor of 2013, the relevant provisions of the general block exemption regulation and the main tools of Union funding (Commission Regulation (EU) No 651/2014, 2014; European Commission, 2013, 2023; Regulation (EU) 2021/241, 2021; Regulation (EU) 2021/1153, 2021). Provisions of the treaty concerning state aid, harmonisation and the effect of directives provide the constitutional frame (Treaty on the Functioning of the European Union [TFEU], 2012), and the property protection clauses of the Charter and of the First Protocol to the European Convention provide the limit against which the required access and compulsory wayleaves must be tested (Charter of Fundamental Rights, 2012; Protocol No. 1 to the ECHR, 1952). As to the submarine segments, the corpus includes the Convention on the Law of the Sea and the 1884

Convention as its historical predecessor (Convention for the Protection of Submarine Telegraph Cables, 1884; United Nations Convention on the Law of the Sea, 1982).

Cases were selected due to their relevance to the functions rather than exhaustively. Cases included concerns the pricing of access to legacy network elements (Arcor, C-55/06, 2008), the limits on Member States' discretion in transposing the sectoral framework (Commission v Germany, C-424/07, 2009), the scope of national regulatory powers over the operators of the access infrastructure (Polkomtel, C-397/14, 2016), the geographic scope of the framework (UPC DTH, C-475/12, 2014), the procedural rights of affected parties in the course of regulatory decision-making (T-Mobile Austria, C-282/13, 2015), and the borderline between sector-specific obligations and general rules of contract law (Telekomunikacja Polska, C-522/08, 2010). The regulatory soft law and reporting include guidance from BEREC on the definition of very high capacity networks (BEREC, 2020), Commission monitoring (European Commission, 2026a, 2026b), audit findings (European Court of Auditors, 2018) and statistical series only for the purpose of contextual background (Eurostat, 2026).

National implementation materials for Greece and Cyprus include the licensing framework for electronic communication networks, the single information point, heritage consent and municipal road-opening procedures (Hellenic Republic, 2002, 2020; Hellenic Telecommunications and Post Commission [EET'T], 2025; Republic of Cyprus, 1959, 2004). Literature on energy consumption of access networks is consulted to evaluate the sustainability claims regarding fibre (Andrae & Edler, 2015; Baliga et al., 2011; Coroama & Hilty, 2014; International Energy Agency [IEA], 2023; Lambert et al., 2012; Malmödin & Lundén, 2018); engineering cost studies on shared fibre deployment are consulted for orientation on cost structures (Rendon Schneir & Xiong, 2014).

Analytical procedure

Three analytical steps were used. The first step is functional decomposition. Each operative provision of the corpus was coded according to one of the nine regulatory functions, identified inductively from the text and iteratively narrowed down until every

operative provision could be coded into one and only one function without remainder. Definitions, procedural-institutional and transitional provisions were not coded. Table 1 lists the functions.

The second step is technique identification. The legal technique used for each function was categorised into one of the six types: mandated access, procedural constraint on administration, standard setting, ex ante market remedy, conditional funding, and risk management duty. The differentiation is important because the techniques vary significantly in their enforceability, the party bearing the cost of enforcement and the timing of enforcement. Mandated access, for instance, is enforced by a private party with a direct commercial interest and a short statutory timeline, while environmental consent conditions are enforced by an authority with competing priorities and no timeline.

The third step is friction analysis. For each function, the point where the technique fails was identified, and the friction type was identified – information, valuation, jurisdiction, temporal or incentive friction. Then, the cost of the friction was assigned to one of the parties involved. The friction analysis draws on implementation experience described by regulators and auditors and compares the relative positions of the mainland Member State and an island Member State. Table 2 outlines the friction typology.

Case selection

Case selection in comparative studies is purposive and not representative. Greece and Cyprus have been chosen due to four features making the jurisdiction particularly prone to the kinds of frictions the Gigabit Infrastructure Act was designed to overcome: dispersed, mountainous or insular geography that increases the share of civil works in the total cost of construction, dense archaeological and heritage preservation constraints on excavation that

introduce the consent regime without any statutory timeline and wide margin of appreciation, high dependency on submarine infrastructure increasing resilience risk in a small number of landing points, and the administrative culture that distributes permitting authority among a great number of authorities at multiple levels of governance. These features increase the informational, jurisdictional and temporal frictions, but make the jurisdictions informative for testing the instrument's design rather than representative for generalisation. In addition, they allow variation in scale while keeping the same legal family and administrative culture.

Limitations

Three limitations should be mentioned from the outset. First, Regulation (EU) 2024/1309 applies gradually, and most of its practical effect is dependent on the national implementing legislation and the emerging case law of dispute-settlement bodies. Thus, conclusions about its operation are necessarily prospective and are offered in the form of structural predictions rather than findings of fact. Second, the study relies on regulatory sources and not on interviews with permitting authorities or operators; thus, the administrative practice described is inferential and requires empirical validation. Finally, the friction analysis assigns sole dominant friction to each function, which is an analytic simplification; in practice, frictions are compounded.

RESULTS

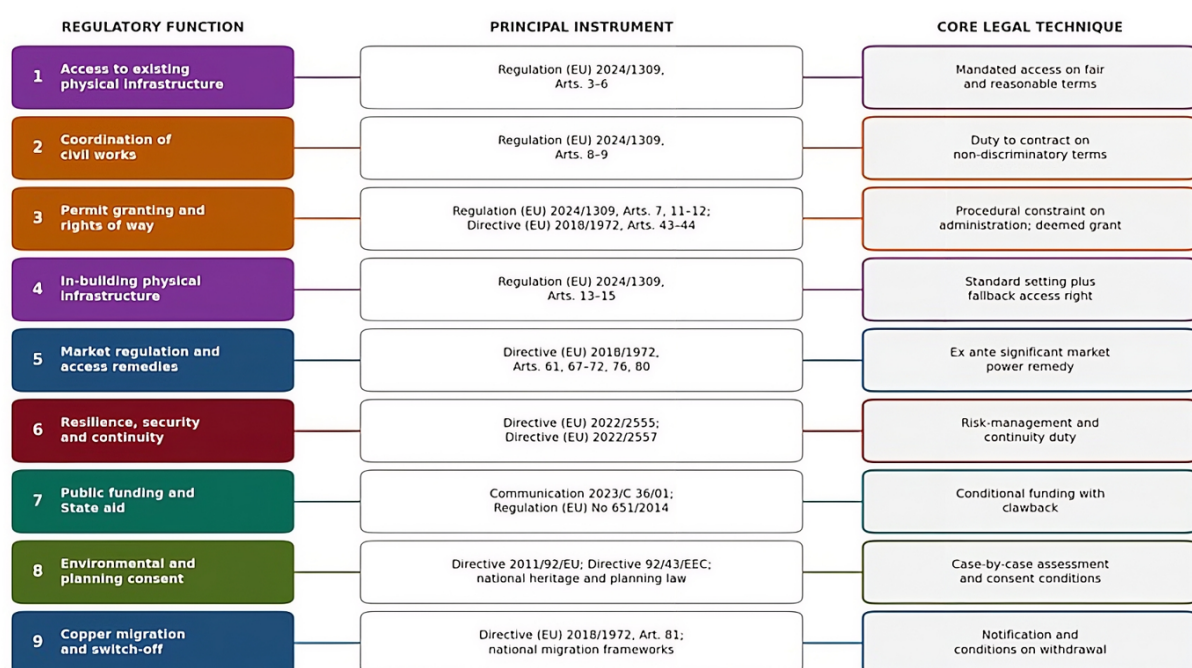
Nine functions of regulation are reconstructed. Table 1 below presents these functions, their primary tools and the legal techniques used. The results of friction analysis are shown in Table 2. We then explain each function. Figure 1 presents the same mapping visually, and Figure 2 presents the friction analysis.

Table 1. Functional map of the European legal framework for fibre-optic deployment

Regulatory function	Principal instrument	Core legal technique
1. Access to existing physical infrastructure	Regulation (EU) 2024/1309, Arts. 3–6	Mandated access to ducts, poles, masts and cabinets of network and utility operators on fair and reasonable terms, with binding dispute settlement
2. Coordination of civil works	Regulation (EU) 2024/1309, Arts. 8–9	Duty to accept reasonable co-deployment requests where works are wholly or partly publicly financed; transparency of planned works

3. Permit granting and rights of way	Regulation (EU) 2024/1309, Arts. 7, 11–12; Directive (EU) 2018/1972, Arts. 43–44	Single information point, deemed approval on expiry of the deadline, cost-oriented charges, non-discriminatory wayleaves
4. In-building physical infrastructure	Regulation (EU) 2024/1309, Arts. 13–15	Fibre-ready obligation for new and majorly renovated buildings; access to in-building infrastructure; voluntary label
5. Market regulation and access remedies	Directive (EU) 2018/1972, Arts. 61, 67–72, 76, 80	Ex ante significant market power remedies; forbearance in exchange for open co-investment; lighter regime for wholesale-only operators
6. Resilience, security and continuity	Directive (EU) 2022/2555; Directive (EU) 2022/2557	Risk-management, incident-notification, physical-protection and continuity duties for identified entities
7. Public funding and state aid	Communication 2023/C 36/01; Regulation (EU) No 651/2014	Conditional funding: mapping, consultation, competitive selection, wholesale access, clawback
8. Environmental and planning consent	Directive 2011/92/EU as amended; Directive 92/43/EEC; national heritage and planning law	Screening, assessment and consent conditions for trenching, landing stations and works in protected or archaeological areas
9. Copper migration and switch-off	Directive (EU) 2018/1972, Art. 81; national migration frameworks	Notification and conditions on withdrawal of legacy access, framed around protection of access seekers and end users

Source: authors' elaboration based on the instruments listed.



Two of the nine functions rest on classical telecommunications market regulation; seven are carried by property, administrative, planning, State aid, environmental and security law.

■ Telecommunications market regulation ■ Administrative and planning law ■ Public finance and State aid law
■ Property and access law ■ Security and resilience law ■ Environmental and heritage law

Figure 1. Functional map of the European legal framework for fibre-optic deployment

Source: authors' elaboration based on the instruments listed in Table 1.

Table 2. Dominant friction and incidence of cost by regulatory function

Function	Technique	Dominant friction	Party bearing the cost
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1. Physical infrastructure access	Mandated access	Valuation: 'fair and reasonable' is undefined ex ante	Access seeker, through delay and adjudication cost
2. Civil works coordination	Duty to contract	Temporal: request rarely aligns with the procurement cycle	Both parties; ultimately the public purse
3. Permitting and rights of way	Procedural constraint	Jurisdictional: parallel consents fall outside the deadline	Deployer, through duration and variance
4. In-building infrastructure	Standard-setting	Incentive: created by planning agencies which have no interest	End user, through the final-drop cost
5. Market remedies	Ex ante remedy	Informational: co-investment terms are opaque to entrants	Smaller access seekers
6. Resilience	Risk-management duty	Jurisdictional: duties without powers beyond territorial waters	Operator, and the state as residual insurer
7. Public funding	Conditional funding	Informational: mapping quality determines eligibility	Public authority and, on error, the beneficiary
8. Environmental consent	Case-by-case assessment	Temporal: no statutory clock in heritage regimes	Deployer, disproportionately in dense historic areas
9. Copper migration	Notification and conditions	Incentive: no environmental criterion in the test	Society, through foregone material recovery

Source: authors' elaboration.

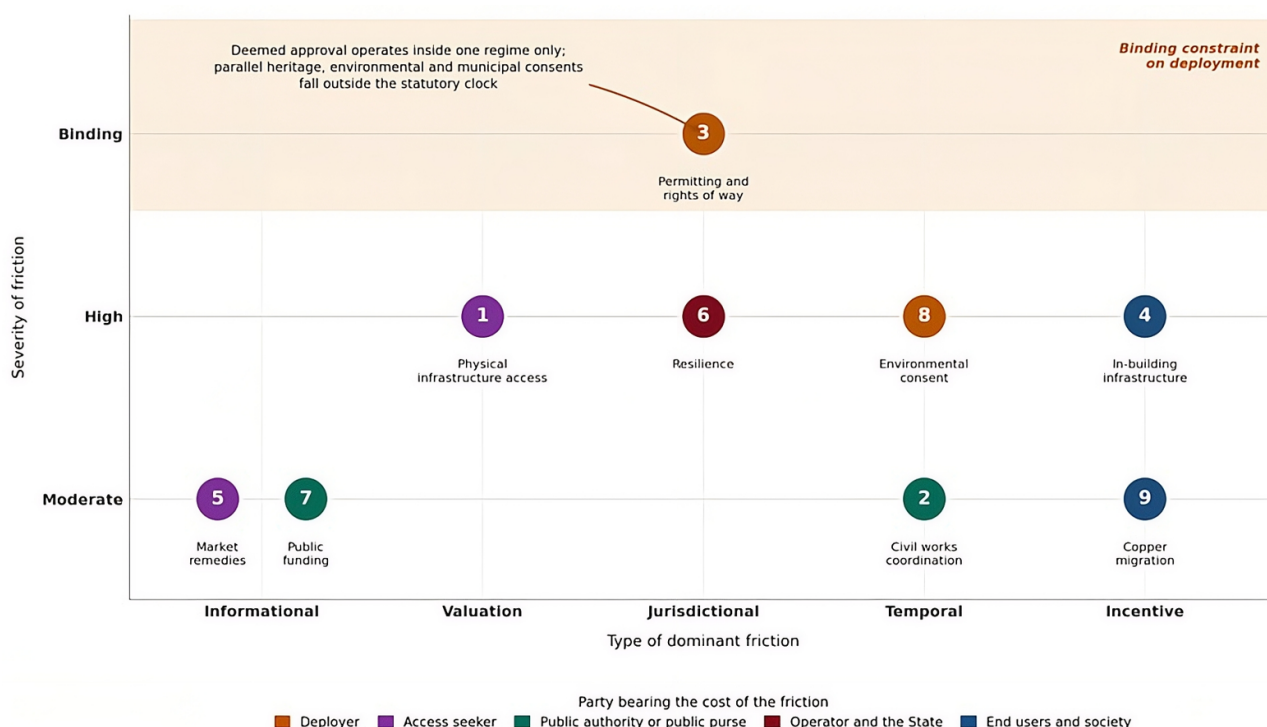


Figure 2. Friction analysis: type and severity of the dominant friction by regulatory function

Source: authors' elaboration. Severity is graded from the friction analysis reported in Table 2; the shaded band marks the function identified as the binding constraint on deployment.

Access to existing physical infrastructure

The first and most important function transforms ducts, poles, masts, towers, manholes, cabinets and buildings of operators of the network, and also of the companies in the

energy, transport and water sectors into a resource which a fibre deployer can require under fair and reasonable terms (Regulation (EU) 2024/1309, 2024). The technique used is mandatory access. It is guaranteed via the

operation of a state dispute-settlement body that has very short decision deadlines. The economic rationale behind this function is rather clear: trench, not the fibre, is the cost, and the cost of additional fibre in the existing duct is just a tiny fraction of the cost of building the duct itself (Rendon Schneir & Xiong, 2014). Legal difficulties here are also clear. Mandatory access involves a change in the use of the property of the other undertaking and, consequently, has to meet proportionality criteria relevant to the interference with the property (Charter of Fundamental Rights, 2012; Protocol No. 1 to the ECHR, 1952). The grounds for denying access, including technical unsuitability, lack of space, safety, necessity for network integrity and concerns about critical national infrastructure, are rather broad and encompass almost all possible disputes. The performance of this function depends not on the existence of the right itself, but on the timeliness and predictability of the dispute-settlement body; audits carried out under the previous Directive have shown wide discrepancies in this regard (European Court of Auditors, 2018).

The secondary difficulty in this function is its expansion beyond the electronic communications sector. Imposing an obligation to host a fibre cable from the electricity distribution operator means importing telecommunications logic into a sector regulated by a different authority, with different safety standards, a different regulator and a different tariff methodology. The instrument does not decide which authority should set the access price, and the dispute-settlement body designated to resolve disputes in electronic communications may lack either the mandate or the cost data needed to price access to the energy asset.

Coordination of civil works and transparency

The second function requires the operator of civil works, funded wholly or in part by public funds, to accept reasonable co-deployment proposals based on transparency obligations related to planning the works (Regulation (EU) 2024/1309, 2024). The technique used is a duty to enter into a non-discriminatory agreement mediated by cost-sharing. Friction involved in this function is temporal and informational. The incremental cost of deploying an additional duct during work with an open trench is very low, but

there is disagreement about the sharing of common costs, and the timing of the proposal usually does not coincide with the procurement process of the works. Namely, by the time of publishing the planned works, the contract has usually already been tendered based on the specifications which do not include the additional duct. As a consequence, performance is good for the major programmed works but poor for dispersed municipal works, which constitute the majority of excavation activity.

Permits and rights of way

The third function is the hinge upon which the whole system pivots. It places procedural restrictions on public administration: all information on conditions and procedures has to be provided via one information point, applications should be filed electronically, a decision should be made within the statutory time limit, and, importantly, administrative silence on expiration of this time limit results in deemed grant of permission (Regulation (EU) 2024/1309, 2024). Administrative charges should be justified in objective terms, cost-oriented, a requirement with deep historical roots in the sectoral framework (Directive (EU) 2018/1972, 2018), and one for which the Court has set strict standards in cases when national charges were higher than the cost of the administrative process (Commission v Germany, C-424/07, 2009). Rights of way over public and, where applicable, private property are subject to non-discrimination and proportionality, and the Court has established that the exercise of Member State discretion in setting out such rights falls within the framework objectives (Polkomtel, C-397/14, 2016).

That is where we find the locus of the binding restriction. Deemed grant is a powerful tool, but it applies only to the system in which it is embedded. In jurisdictions rich in heritage, environment and municipal layers, there are many consents that lie outside the clock set by the statute. A deployer in a culturally valuable Greek or Cypriot city will get a deemed telecommunications permit, but he would still be legally unable to conduct archaeological digs, because heritage clearance operates under a different statute, with no time limit and a broad scope for national discretion (Hellenic Republic, 2002), and because road opening consent is a municipal competence exercised under general legislation on construction and roads (Republic

of Cyprus, 1959). The single information point brings these regimes together without aligning their decisions.

Physical infrastructure in buildings

The fourth function targets the last and, proportionally speaking, the most costly segment. Buildings under construction and major renovation have to be equipped with fibre-ready in-building physical infrastructure and a concentration point; operators have a right to access this infrastructure under fair terms, and a fallback right to build into the premises where the building owner fails to comply with the requirement (Regulation (EU) 2024/1309, 2024). This approach combines building standards with mandated access, and includes a voluntary labelling scheme aimed at leveraging the value of fibre readiness into property price. The difficulty lies in the enforcement design: the obligation is fulfilled in the process of issuing a permit for construction and administered by the planning authorities, which lack any institutional link to the electronic communications regulator, any information on the fulfilment of the obligation and any incentive to enforce it. The cost of failure manifests itself much later, in the final drop, and is paid by either the consumer or the operator, but not the developer who saved it.

Market regulation and access remedies.

The fifth function keeps the classic *ex ante* remedy structure for significant players, but changes its orientation (Directive (EU) 2018/1972, 2018). The Code limits the presumption in favour of remedies in cases involving very high capacity networks, allows regulatory forbearance in exchange for the commitment to open co-investment, and introduces a special and less burdensome regime for wholesale-only operators. The response is direct to the theoretical discussion of the trade-off between access and investment (Bourreau et al., 2018; Cave, 2010) and to the evidence that the price of access on the legacy network influences the speed of transition to the new one (Bourreau et al., 2012). The evidence suggests that the impact of remedy design on fibre deployment is real but very sensitive to the design details (Briglaue et al., 2018), and the experience of copper unbundling suggests that competition driven by access is good for consumers but does not necessarily lead to investment (Nardotto et al., 2015). From a legal

perspective, the reorientation results in the shift of conflicts from regulatory appeals, where the standard of judicial review and evidentiary rules are firmly set, to the interpretation of long-term commercial agreements, where they are not. The Court's concern about not letting sector-specific obligations displace general legal remedies comes into play here (Telekomunikacja Polska, C-522/08, 2010), as well as its case law on the procedural standing of undertakings affected by the regulator's decisions (T-Mobile Austria, C-282/13, 2015).

Resilience, security and continuity

The sixth function is both the newest and the least integrated part of the framework. Operators of the electronic communications networks and digital infrastructure are subject to risk management and incident reporting requirements in the cybersecurity framework (Directive (EU) 2022/2555, 2022), while the critical entity resilience regime brings physical security, business continuity and background verification requirements for entities designated by Member States (Directive (EU) 2022/2557, 2022). For a jurisdiction that relies on just a few submarine cable landings for its international connectivity, this function is crucial, rather than administrative. And yet submarine cables beyond territorial waters are governed mainly by the law of the sea, under which the freedom to lay and maintain cables coexists with a weak enforcement mechanism against third-party damage to them (Convention for the Protection of Submarine Telegraph Cables, 1884; United Nations Convention on the Law of the Sea, 1982). The doctrinal literature calls this situation a gap in protection resulting from the mismatch of flag state jurisdiction and the location of the harm (Beckman, 2014; Burnett et al., 2014; Davenport, 2012). The EU resilience law does not address the gap: it imposes duties on the operator but lacks any enforcement mechanisms against third parties who inflict most of the damage, be it anchoring, trawling or targeted interference. Studies of cable route environments show that the physical impact of the cable is minor, which means that the regulatory problem is protection, not impact (Carter et al., 2009).

Public funding and state aid.

The seventh function regulates the use of public money. Guidelines of 2023 allow public funding in the cases of mapping and public

consultation proving the nonexistence or unlikelihood of existence of such a network in the future, competitive selection of the beneficiary, provision of open wholesale access, and use of a clawback mechanism for recovering excess profits (European Commission, 2023). Block exemption provides an easier path for specified categories (Commission Regulation (EU) No 651/2014, 2014), and there are two main Union mechanisms for providing the funds (Regulation (EU) 2021/241, 2021; Regulation (EU) 2021/1153, 2021) – both within the Treaty-based regime of aid (TFEU, 2012). The approach is that of conditional funding, which is exceptionally efficient due to the fact that compliance is a condition of funding and not of ex post enforcement. The limitation of the approach is its informational requirement since it relies on the accuracy of mapping exercises and declared investment plans, and both can be inaccurate due to strategic considerations. The evolution of the 2013 guidelines to the 2023 text shows the strengthening of these informational requirements (European Commission, 2013, 2023), but the burden of verification rests on the authorities, who lack independent data. An additional weakness is that the tool covers supply problems for areas not served by the market, and monitoring results clearly show that the discrepancy between coverage and penetration rates is larger than that of supply (European Commission, 2026a, 2026b; Eurostat, 2026).

Environmental consent and planning permission

The eighth function is residual and almost fully national. Trenching, landing stations, ducting of linear infrastructure through protected territories, and works in archaeological zones are controlled by the procedure of environmental impact assessment and by national laws on heritage protection and spatial planning (Council Directive 92/43/EEC, 1992; Directive 2011/92/(EU, 2011; Hellenic Republic, 2002). There is no European instrument tailoring these regimes to linear telecommunication infrastructure as the trans-European energy framework does for energy projects of common interest, where the permitting procedure is centralised in one authority, limited in terms of time, and prioritised in national procedures (Regulation

(EU) 2022/869, 2022). Such asymmetry is one of the clearest results of the reconstruction. Comparable linear infrastructure gets significantly better procedural treatment when carrying electrons than when carrying photons, even though the footprint of a fibre duct is smaller and its restoration is easier than that of a transmission line or pipeline.

Copper migration and switch-off

The ninth function regulates the retirement of the legacy infrastructure. Notification, transparency, and conditions protecting interests of access seekers and users apply to withdrawal of access points of legacy technology (Directive (EU) 2018/1972, 2018). The framing is purely economic. No environmental criterion applies to this decision-making despite the fact that it is one of the very few points in the life cycle of access networks where environmentally harmful effects are both concentrated and manageable from a legal perspective. Technical literature is unanimous about the lower energy consumption per delivered bit of optical access compared to the replaced copper technologies (Baliga et al., 2011; Lambert et al., 2012), and sectoral accounts prove that access and transmission networks are a major and ever-increasing share of communications' energy consumption (Andrae & Edler, 2015; IEA, 2023; Malmödin & Lundén, 2018) – though with certain methodological caveats related to the attribution of energy consumption to data volumes (Coroama & Hilty, 2014). Copper recovery also involves valuable secondary material regulated by the general waste legislation and not by any of the provisions of the electronic communication framework.

Cross-cutting results

Two conclusions can be drawn from the framework reconstruction. First, it demonstrates the migration of the centre of gravity of legislation from classical telecoms market regulation into the territory of property, administrative, planning, funding or security law. Competent authorities become correspondingly dispersed, and the sectoral regulator, which still possesses analytical capability, cost data and appellate experience, gains control over a shrinking share of operative obligations. Institutional design does not follow the substantive shift. The single information point is

an information aggregation tool responding to the decision aggregation problem.

Second, the issue of sustainability is present in the framework as rhetoric, but not as an operative obligation. Objectives instrument frames connectivity in the context of a green and digital transition (Decision (EU) 2022/2481, 2022), and monitoring reports repeat the framing (European Commission, 2026b), but none of the functions in Table 1 imposes any environmental obligations specifically tied to the fibre. Function 8 uses general environmental law without adaptations; function 9 deals with the only moment when significant environmental effects are concentrated without applying an environmental criterion; and function 7, which is the most enforceable technique in the framework, imposes no specific environmental obligation beyond general ones. Sustainability claims of the gigabit framework are thus inherited from the technology and not from the law.

DISCUSSION

The results call for a reassessment of the manner in which fibre deployment regulation is to be designed and where efforts are to be made to reform. There are seven implications that flow.

The binding constraint has shifted from the legal regime to the administration

Regulatory policy and funding programs are structured in terms of capital: the presupposition is that fibre deployment is not financed and thus is not being done. As we have shown, in the majority of cases in the Union, the binding constraint has shifted. When the deployer needs to get consents from several authorities, each of which operates in accordance with different clocks, different procedures of appeal and different standards of evidence, the expectation about the duration of the permitting process and its variance become the elements of the investment appraisal decision. Variance is more damaging than the length of the permitting process itself. It is not diversifiable at the level of the local deployment process; it cannot be hedged, and it increases the discount rate applied to the whole project as opposed to the delay. Thus, a regulatory reform that would halve the variance of the permitting process duration would do more good for

coverage than an equivalent subsidy. This is the general property of the regulatory design in connection with the circulation of capital: the rate at which the invested money returns to productive use is determined not only by its nominal cost but equally by the certainty of the process (Challoumis, 2021), and the allocation of financial resources among competing uses responds not only to their central tendency but to their distribution as well (Challoumis, 2019).

The implicit levy falls unevenly. Large operators have permitting departments and are able to deal with the variance; smaller and locally embedded enterprises, including those municipal and cooperative deployers on whose deployments rural coverage relies, are not. The administrative fragmentation thus works as an informal entry barrier that cannot be tackled with any competition policy instrument, as it is produced not by any particular undertaking but by the aggregate administrative structure.

Deemed approval does not help when there are several regimes

Deemed approval is the main advantage of the Gigabit Infrastructure Act relative to the previous legislation. It is well-designed in its regime of application. However, it is effective only within its regime. When, in addition to the digging permit, the deployer needs clearance on heritage protection, environmental screening or municipal road opening, the deemed grant gives permission that is legally invalid. What has to be done is consolidation, following the example of the trans-European energy infrastructure (Regulation (EU) 2022/869, 2022): a dedicated one-stop shop with a right to coordinate constituent permits, a single scheme deadline running through all permits, and a single appeal route. The transposition of this structure onto the field of electronic communications would require Member States to accept the procedural centralisation that they were reluctant to, and would need proper design in the cases of heritage protection that is constitutionally protected. However, the case for this measure is compelling when one puts two regimes side by side, since the environmental impact of the works subject to the less stringent procedure is the larger one. Figure 3 sets the current fragmented procedure and the proposed consolidated one side by side.

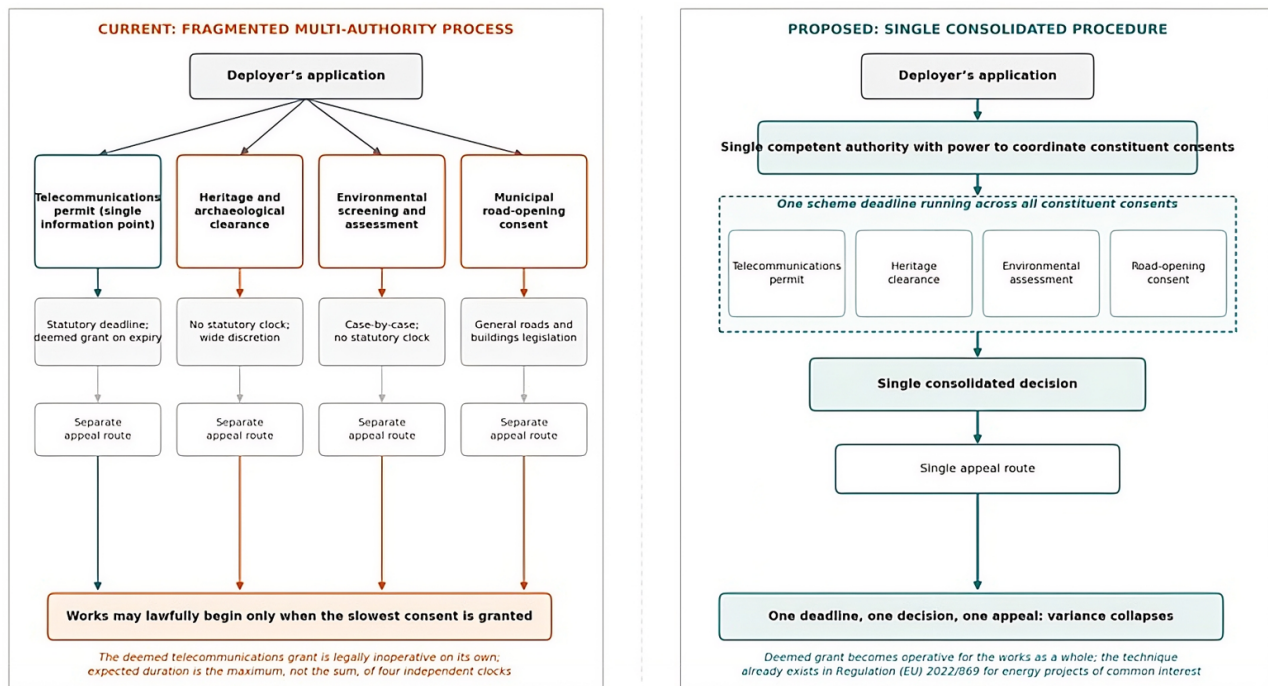


Figure 3. Consolidated permitting compared with the current fragmented procedure

Source: authors' elaboration, drawing on the single-authority permitting model established for energy projects of common interest by Regulation (EU) 2022/869.

The cost allocation requires publication of the methodology

Both mandated access and co-deployment require pricing, while the framework specifies only that the price shall be fair and reasonable (Regulation (EU) 2024/1309, 2024). Absent a published methodology, every dispute will become a valuation dispute, and informational asymmetry will favour the infrastructure holder, which has all the necessary cost data. The case law of the Court shows that these questions are justiciable but time-consuming (Arcor, C-55/06, 2008). Regulators can greatly lower the framework's operating costs by publishing cost models for duct and pole access, as they do for all other wholesale products, drawing on existing engineering literature (Rendon Schneir & Xiong, 2014). The objection to the publication based on the assertion that utility ducts are not telecommunications assets is jurisdictional rather than substantive and can be addressed through the joint guidance with the energy regulator.

Incentives should drive enforcement

The in-building function provides an example of the fundamental design flaw: the obligation resides in the regime to which it topically relates rather than in the process in which the party that incurs its costs makes its decision. Fibre readiness is decided by the

developer during the design process and enforced, if at all, by a planning authority with nothing at stake in the result. Placement of the obligation in the context of the developer's decision – in the certificate of completion, in the connection of utilities, in the sale of the building via the labelling scheme – would align enforcement and incentive at zero additional cost to the administration. The same holds for co-deployment: placement of the obligation in the tender documentation rather than in a subsequent request procedure would resolve the temporal tension described in Table 2.

The small and peripheral jurisdiction is exposed to a structural risk which the framework does not address

Cyprus is an illustration of the class of risks which the framework rhetorically acknowledges but regulates insufficiently. Connectivity, which relies on a few submarine cable landings, is legally vulnerable exactly in the one area where European law does not cover: outside territorial waters, where the regime gives the operator freedom to lay and repair cables, but where little practical protection from damage can be obtained (United Nations Convention on the Law of the Sea, 1982) and where the identification of the operator as a critical infrastructure entity implies duties without enforcement powers (Directive (EU)

2022/2557, 2022). The gap in protection is amply documented in the specialist literature (Beckman, 2014; Davenport, 2012). Effective protection requires instruments which the framework does not provide: route-diversity requirements tied to public funding conditionality, the most enforceable technique available (European Commission, 2023); mandatory protection zones with effective sanctions within territorial waters, permitted by the law of the sea (United Nations Convention on the Law of the Sea, 1982); and pre-agreement on vessel access for repair in the event of an outage. Redundancy of connectivity is a question of sovereignty and should be regulated as such, rather than left to commercial calculation of the cable consortiums.

Sustainability has to be turned from a claim to an obligation

The environmental case for fibre is compelling in terms of supply, but the framework does not make it actionable. Three amendments would turn rhetoric into obligation, each of them based on techniques included in the framework. First, copper switching-off plans could include an environmental impact statement on the energy savings and copper recycling involved, in addition to the consumer and access seeker safeguards (Directive (EU) 2018/1772, 2018). There is a technical basis for such statements in the literature on energy accounting (Baliga et al., 2011; IEA, 2023; Malmödin & Lundén, 2018), subject to the caveats this literature itself sets out with regard to the attribution of network energy use to data volume (Andrae & Edler, 2015; Coroama & Hilty, 2014). Second, public funding conditionality could include a duct-sharing first rule, under which any subsidised project will have to prove an assessment of the existing physical infrastructure and the unavailability of the latter as a precondition for new excavation; this turns function 1 from the right of the deployer into the condition that the funder must check (European Commission, 2023; Regulation (EU) 2024/1309, 2024). Third, environmental assessment of linear works could be made simpler in return for agreement to standard reinstatement and habitat protection conditions, turning case-by-case assessment into a standard regime, thus addressing the temporal tension in function 8 without relaxing substantive

protection (Council Directive 92/43/EEC, 1992; Directive 2011/92/EU, 2011).

Read against the 2030 Agenda, these three amendments are the point at which the framework would begin to deliver the Sustainable Development Goals it invokes. The environmental impact statement on copper switch-off and the duct-sharing-first condition are instruments of Goal 12: they convert the recovery of secondary copper and the avoidance of unnecessary excavation from an incidental by-product of the transition into a condition of lawful action, which is what targets 12.2 and 12.5 require. The consolidation of permitting is an instrument of Goal 16 before it is an instrument of infrastructure policy, because the defect it corrects is the effectiveness and accountability of the administration rather than the adequacy of the capital; on the diagnosis advanced here, the institutional target 16.6 is the operative condition of the infrastructure target 9.1 and not a parallel aspiration. The route-diversity requirement for peripheral and island jurisdictions is in turn the resilience limb of Goal 9, which speaks of infrastructure that is reliable and resilient rather than merely present. The difficulty of the framework is not that it ignores these goals. It is that it states them in its recitals and in its objectives instrument while placing none of them in the operative techniques – funding conditionality, notification conditions and consent standards – through which they could be enforced.

Connectivity coverage is not the ultimate goal; penetration and use are

The framework and its funding instruments are based on coverage, which is measurable, contractible, and attributable to a particular expenditure. However, the literature on economic impacts of connectivity associates growth with penetration and use rather than availability (Czernich et al., 2011; Koutroumpis, 2009; Röller & Waverman, 2001), and audits consistently show that there is a gap between the two in some Member States (European Commission, 2026a, 2026b). The factors influencing the gap lie mostly outside the scope of the framework: price, digital skills, and the absorptive capacity of the enterprise population, which determines whether the connectivity is used productively (Challoumis & Eriotis, 2025). As far as advanced digital capabilities are concerned, the effect is even more pronounced,

because the economic gain from artificial intelligence and similar technology concentrates in the firms and regions which already have high-capacity connectivity, making the distribution of the gains an economic governance issue rather than an engineering problem (Challoumis, 2025). Infrastructure theory predicts this pattern: the societal value of a common pool resource lies in its use rather than existence (Frischmann, 2012). A framework regulating the supply exhaustively and the demand not at all will achieve the former, but not the latter.

Boundary conditions of the argument. Three boundary conditions warrant acknowledgement. This analysis is prospective, as it applies only to an instrument that is applied in prospect, and the structural predictions made here concerning dispute resolution and deemed approval can be tested only when enough national experience has accumulated. Diagnosing permitting as the binding constraint, while consistent with the framework's structure, with the trend of European interventions, and with audit results (European Court of Auditors, 2018), would benefit greatly from systematically measuring the duration and variance of permitting processes. Such measurement is now possible: creating single information points creates an administrative record that can be used to extract data on permitting duration at very low marginal cost (Regulation (EU) 2024/1309, 2024). Finally, the comparative aspect of this paper is based on two jurisdictions chosen for the intensity of the frictions studied; extending the study to Member States with different administrative systems, in particular to those with unitary permit authorities, would determine how much of the diagnosis is general and how much is a property of fragmented administration.

CONCLUSIONS

Optical fibre is a legal object before it is an economic one. The European framework governing its use has been reconstructed over a decade with a single insight in mind, namely that the cost of the network is the cost of digging the trenches, and the latest instrument has attempted to implement it through compulsory access to infrastructure, coordinated civil works, permitting authority procedure discipline and building fibre-readiness (Regulation (EU) 2024/1309, 2024).

The reconstruction outlined above yields five conclusions. First, the legal centre of gravity in fibre deployment has moved away from telecommunications market regulation to property, administrative and planning law, with a growing security dimension; institutional design has not kept up with the shift, and the body with the expertise to deal with the problem oversees only some of the operative obligations. Second, the critical binding constraint is the duration and, above all, the variance of the multi-authority permitting process, which the deemed grant approach addresses but does not cure because it works within one regime whereas excavation is a multi-regime activity. Third, the framework deals with comparable linear infrastructure in an inconsistent manner, offering consolidated and time-limited permitting to energy projects of common interest but treating electronic communications through a fragmented national process, although the latter has a much smaller footprint. Fourth, resilience obligations have been placed on operators where the European law does not allow for enforcing them – leaving small and island Member States structurally vulnerable. Fifth, the sustainability dimension is asserted rather than implemented: copper migration, network energy intensity and material recycling are regulated, if at all, through provisions meant for something else.

This agenda is modest from a legal-technical standpoint but potentially transformative in effect. Member States should consolidate permitting for linear telecommunications works into one procedure with one avenue for appeals, modelled after the procedure for energy projects of common interest already in place. National regulatory authorities, in cooperation with energy regulators where competence calls for it, should make public reference cost models for duct and pole access so that reasonable and fair costs are assessed case by case. Obligations should be assigned to the party that bears the costs, meaning that fibre-readiness enforcement and co-deployment obligations must be transferred to the completion certificate and tender, respectively. Public funding should include a duct-sharing-first provision and an environmental impact statement upon switching off copper. Small and island Member States should make submarine route diversity a

prerequisite of connectivity policy rather than a commercial question for cable consortia. All of these solutions use tools that already exist in the framework in question, making them practical.

Three research avenues are apparent from the analysis. First, the permitting hypothesis needs empirical testing through the administrative records that single information points can provide; it will allow measuring the permitting duration and variance and correlating it with deployment results. Second, the comparison should also cover unitary permitting administration in Member States to disentangle the general aspects of the problem from those specific to permitting fragmentation. Third, the environmental effects of copper retirement need quantification using a reliable methodology, since policy currently asserts them without one. The life-cycle environmental effect of copper retirement is thus another research question. Fibre law is the law of permitting; treating it as such brings the legal framework closer to solving the problem it is meant to address.

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Data Availability Statement

This is a doctrinal legal study. The research draws exclusively on publicly available legal instruments, case law, regulatory and audit documents and secondary literature, all of which are identified in the reference list and are publicly accessible through EUR-Lex, the CURIA database of the Court of Justice of the European Union, the official gazettes of the Hellenic Republic and the Republic of Cyprus and the publishers of the cited works. No new datasets were generated or analysed during the study, and therefore no data were deposited in a repository.

Author Contributions

In accordance with the Contributor Roles Taxonomy (CRediT), the contributions of the authors are as follows. Constantinos Challoumis: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration. Alexios Constantinou: Investigation, Resources, Data curation, Validation, Visualisation, Writing – review & editing. Konstantinos Mavrommatis: Methodology, Validation, Investigation, Visualisation, Writing – review & editing. All authors have read and approved the final version of the manuscript.

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