CROSS-SECTOR INFRASTRUCTURE CO-DEPLOYMENT

CLOSING DIGITAL CONNECTIVITY GAPS THROUGH COLLABORATION AND SHARING

Arndt Husar, Yoonee Jeong, and John Garrity

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Arndt Husar is a senior public management specialist in the Digital Technology for Development Unit of the Asian Development Bank (ADB). He facilitates the effective use of digital technology in lending operations and technical assistance by providing advice, developing insights, and sharing knowledge. He focuses on digital connectivity; tech start-up ecosystems; big data; and digital transformation in agriculture, urban development, and transport.

Yoonee Jeong is a senior digital technology specialist at ADB's Digital Technology for Development Unit. She focuses on bridging the digital connectivity gaps and building an inclusive and forward-looking digital economy and data governance framework. Her career spans global telecommunication and tech companies, consultancy, the United Nations, and the World Bank, where she worked on advancing digital policy and regulatory issues for Asia and the Pacific.

John Garrity is an economist, policy advisor, and project manager focusing on digital inclusion, universal internet access policy, and last-mile connectivity. He is currently the chief of party for the United States Agency for International Development's (USAID) Better Access and Connectivity (BEACON) project in the Philippines, and previously held positions at USAID, Cisco Systems, and the World Bank.

ASIAN DEVELOPMENT BANK

6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
www.adb.org

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ABBREVIATIONS

ADB	Asian Development Bank
BESCOM	Bangalore Electricity Supply Company Limited
BPC	Bhutan Power Corporation
COVID-19	coronavirus disease
DFI	development finance institution
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
GIS	geographic information system
GLA	Greater London Authority
ICT	information and communication technology
ITU	International Telecommunication Union
km	kilometer
SCADA	supervisory control and data acquisition
US	United States

EXECUTIVE SUMMARY

Infrastructure co-deployment and sharing between sectors is an effective and proven strategy to expand service coverage and reduce the aggregate costs of deployment. Co-deployment of fiber-optic cables or mobile towers alongside linear infrastructure such as railways, roads, water, sewage systems, and power transmission lines is a particularly pertinent approach to accelerate the rollout of digital connectivity and help future-proof the infrastructure assets. However, in practice, suboptimal levels of infrastructure co-deployment and sharing exist because of various market, institutional, and regulatory barriers.

This Asian Development Bank (ADB) Sustainable Development Working Paper, as part of a series reviewing essential topics related to digital infrastructure, details the tools to gauge the potential benefits of co-deployment and sharing; highlights recent examples and good practices; and presents recommendations for multilateral development banks to consider in their own infrastructure projects, as well as in providing guidance and direction to governments and other institutions.

Co-deployment and sharing offer financiers and asset owners the ability to expand the commercial viability of capital-intensive infrastructure investments. This paper discusses a wide range of potential benefits of co-deployment and sharing. These include (i) reduction in overall deployment costs (with savings for the public and private financiers), (ii) increased revenue potential, (iii) ability to leverage digital infrastructure for internal connectivity needs, (iv) accelerated deployment timelines, (v) improved resilience of infrastructure, (vi) reduction in disruptions (and the subsequent societal impact), (vii) reduced overall environmental impacts, and (viii) potential for the expansion of services to previous unserved and underserved geographies and communities.

Notwithstanding the wide-ranging benefits, infrastructure co-deployment and sharing presents risks related to market contexts that need to be identified early on and mitigated through the project cycle. There is no "one-size-fits-all" approach, and the legitimate concerns of key stakeholders, who are requested to potentially cede direct control of conception, procurement, construction, operation, and commercialization phases, need to be addressed head-on.

Success factors for the design of infrastructure co-deployment and sharing projects have included (i) establishing cross-sector collaboration and communication; (ii) allocating dedicated project management resources for coordination; (iii) developing a highly coordinated communication and resolution plan to keep all stakeholders, customers, and the public on board; (iv) establishing a well-defined incentive framework and strong governance structure; (v) ensuring a robust monitoring and evaluation process; (vi) obtaining high-level buy-in through the drafting of tailored business strategy documents and shared financial models; and (vii) building in the technical, operational, and commercial considerations required for co-deployment and sharing to deliver the targeted benefits.

In the policy domain, it is important to recognize there is a range of co-deployment intervention opportunities. Other important practices include (i) maintaining a shared geospatial inventory of infrastructure; (ii) coordination across national, international, and cross-industry levels; (iii) ensuring harmonization of sector regulations related to building standards and infrastructure co-deployment and sharing across different sectors; (iv) encouraging competition; and (v) addressing the challenges in locations where service provision is not commercially viable for the private sector.

Development finance institutions (DFIs), such as ADB, can further advance cross-sector co-deployment in projects by continuing to share knowledge about co-deployment strategies, providing appropriate technical assistance in the broader enabling environment as well as in project preparation, and by internally incentivizing cross-sector infrastructure sharing through revised processes and procedures. In the policy dimension, DFIs can encourage or incentivize governments to enhance information sharing of opportunities for cross-sector infrastructure co-deployment and sharing, encourage more flexible rules in the public sector, and carefully consider mandating action or introducing prescriptive regulation.

INTRODUCTION

This working paper aims to provide readers, particularly those focused on infrastructure development in developing countries in Asia and the Pacific, with a background understanding of the benefits of cross-sector infrastructure co-deployment or sharing of infrastructure assets and a framework knowledge on how to operationalize this integrated approach to maximize the economic benefits from the investment and facilitate digital transformation.

Robust digital infrastructure is recognized as a crucial component for achieving economic resilience against multiple global socioeconomic crises that have emerged since the coronavirus disease (COVID-19), and building future capacity against climate change. Digital infrastructure underpins the delivery of basic services in health, education, and other sectors, including soft infrastructure such as social capital and community development. As governments look to rebuild and strengthen their national economies with a recoupling of economic, social, and environmental prosperity, cross-sector infrastructure co-deployment and sharing provides mechanisms by which service delivery can expand to unserved and underserved areas (such as those with low population density, lower-income communities, or higher-cost geographies) as co-deployment and sharing address some of the prohibitive cost and revenue challenges.

Infrastructure co-deployment and sharing supports the digital transformation of critical sectors of an economy, such as energy and transportation. As rapid urbanization persists in Asia and the Pacific, starkly demonstrated by megacities adding millions of people to the population annually, the cost of new infrastructure projects results in increasing marginal costs due to the additional planning, coordination, or demolition considerations required.

Resource-intensive infrastructure investment projects, both in terms of capital expenditure and operating expenses, can therefore benefit from a co-deployment and sharing approach by lowering resource requirements for individual sector asset owners, improving infrastructure climate resilience, increasing revenue potential, accelerating deployment times, and improving utilities' internal operations (with improved telecommunication services, for example). Communities served by utilities that were designed with infrastructure co-deployment and sharing in mind potentially benefit from the reduction in future traffic disruptions and reduced environmental impacts. Some marginal benefits may also accrue from more efficient expenditure (public and/or private). As information and communication technology (ICT) enables new services and delivery methods for sectors such as health and education, these additional benefits may tip the balance in favor of expanding the utility and other services to previously unserved or underserved areas.

This working paper builds on available publications focusing on an audience in development finance institutions (DFIs) concerned with project design and deployment. It takes a 360-degree perspective and provides evidence on how other sectors could benefit from co-deployment with digital infrastructure, providing practical information that can inform project design and deployment.

This paper acknowledges the crucial role of policies and guidance—often driven by strategy and policy departments in DFIs—that can help incentivize these practices. Other available reports and analyses that are referenced in this paper have mainly focused on public policy, in the form of guidelines and regulations, that advocate, encourage, and institute cross-sector infrastructure co-deployment and sharing.

I. DEFINITIONS AND CHARACTERISTICS OF CROSS-SECTOR INFRASTRUCTURE CO-DEPLOYMENT AND SHARING

The co-existence of infrastructure delivering public services is not a new phenomenon. For example, a power grid infrastructure is commonly deployed along roads or railways, not only to ease access and rights-of-way for transmission, but also to directly support electrification for lighting. In the United States (US) and the United Kingdom, railways have often co-deployed telegraphy for internal communication purposes, then opened those assets for commercial traffic.

Examples of early cross-sector infrastructure co-deployment and sharing that included telecommunication service occurred between railways and overhead copper wires lines used in telegraph systems. One of the first demonstrations of telegraphy occurred in 1837, transmitting signals between two stations along the London and Birmingham Railway in the United Kingdom, and then in 1842 in the US between Washington, DC and Baltimore.[1] Wired telecommunication lines, used in telegraphy and the subsequent introduction of telephony, soon became the norm. By the turn of the century, railways and roadways were clogged with overhead lines (Figure 1), in part because of technical challenges that prevented intra-sector and cross-sector sharing.

With technological improvements and regulatory permissiveness, infrastructure sharing continued to expand between wired telecommunication and other linear infrastructures. The advent of wireless communications networks and greater reliance on high-capacity radio links, such as in cellular networks, microwave backhaul, and satellite communications, increased the need for facility-based sharing (rooftops, buildings, towers, etc.) relative to the rights-of-way and sharing of transmission corridors more necessary for wired telecommunications. However, a resurgence of investment in wired telecommunications to replace legacy copper twisted pairs and hybrid–fiber–coaxial assets with fiber-optic cables is expanding the reach of high-capacity networks as close as possible to end users (Figure 2). This dynamic is expected to accelerate with the deployment of 5G networks. Many more antennas are required for 5G than for 4G networks, and these antennas will essentially need to be connected to fiber-optic cables[2] to deliver the targeted speeds and capacity.

Fiber-optic cables form the backbone of the global public internet; fiber technology is already responsible for transmitting up to 99% of the global internet traffic between countries through high-capacity undersea and terrestrial links.[3] Improvements in fiber technology, transmission equipment, and civil works have reduced the cost of deploying fiber to the extent that it has become the most cost-effective option for deploying high-speed broadband where there is sufficient user density and willingness to pay.

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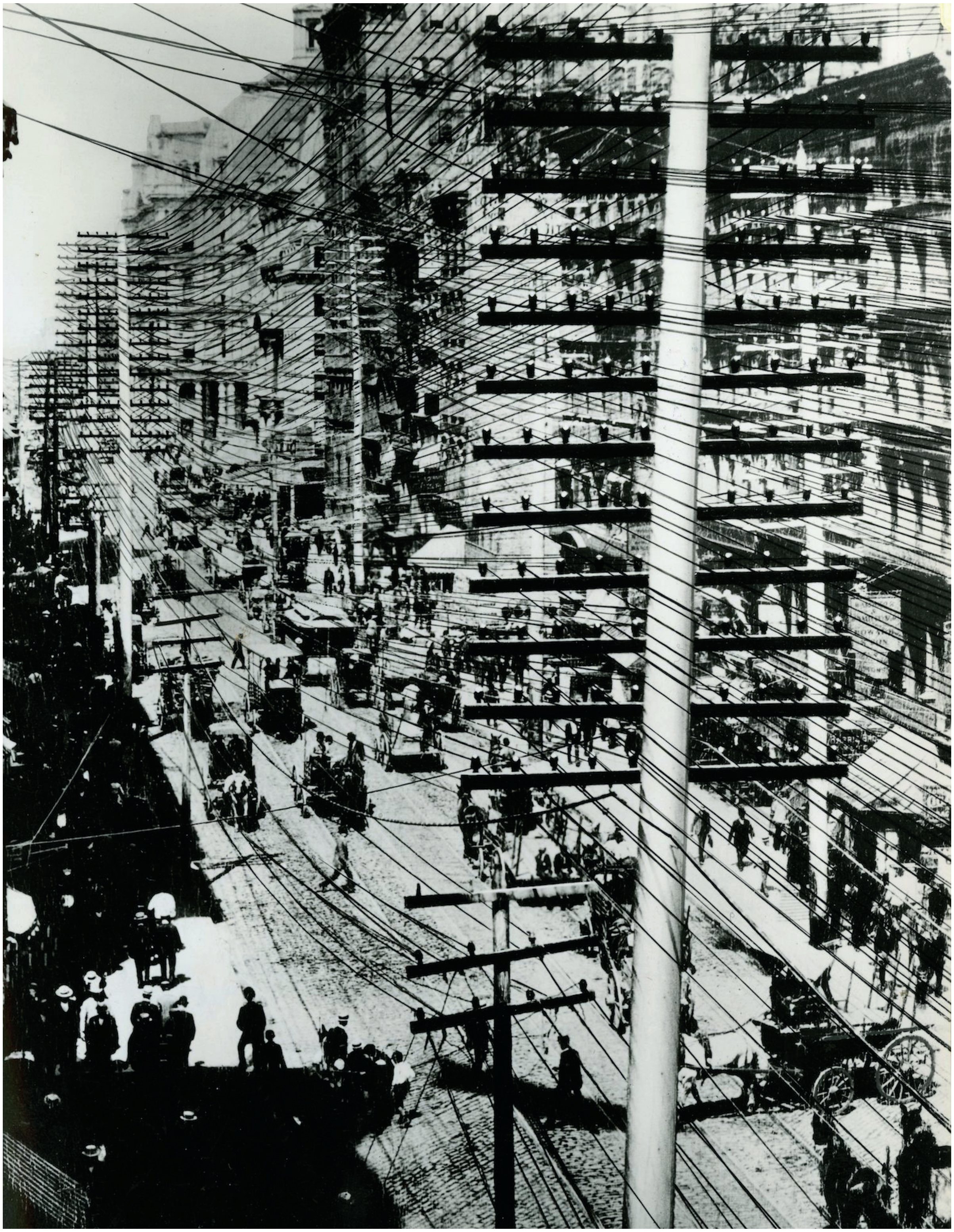
1 Macmillan Keck and Columbia Center on Sustainable Investment. 2017. *Toolkit on Cross-Sector Infrastructure Sharing*. New York.

2 Exceptions are locations where fiber is unavailable and costlier than alternative backhaul technologies.

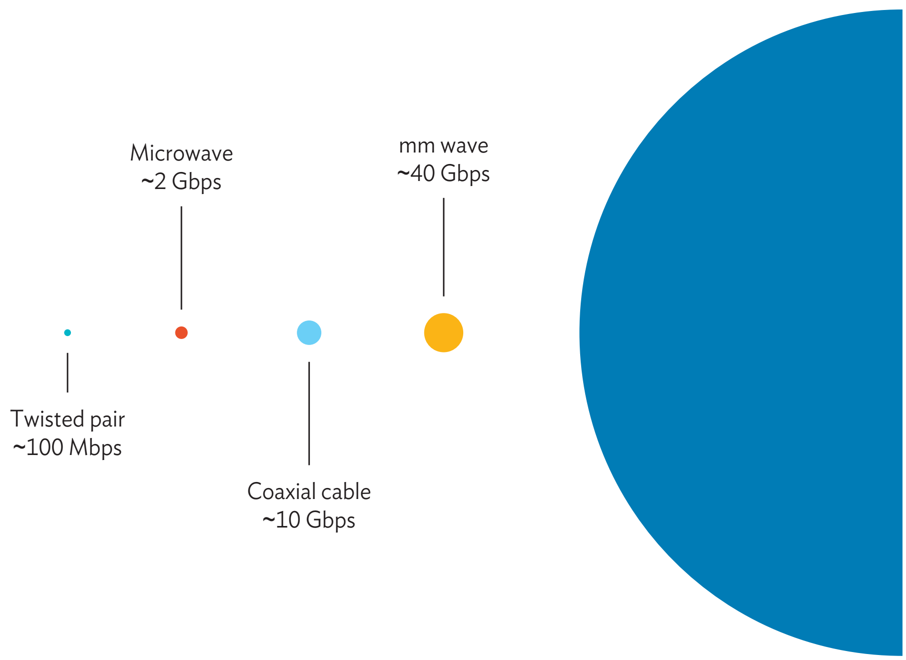
3 D. Brake. 2019. Submarine Cables: Critical Infrastructure for Global Communications. *Information Technology & Innovation Foundation*.

Figure 1: Telephone Wires over New York, 1887



Sources: Library of Congress. *Photo, Print, Drawing: Telephone Wires Over New York, 1887*; Macmillan Keck and Columbia Center on Sustainable Investment. 2017. *Toolkit on Cross-Sector Infrastructure Sharing*. New York.

Figure 2: Typical Maximum Capacity over Each Backhaul Technology



Gbps = gigabits per second, Mbps = megabits per second, mm wave = millimeter wave.

Note: The size of each circle represents the typical maximum capacity that can be achieved over each backhaul capacity.

Source: K. Yogeeswaran. 2020. Making aerial fiber deployment faster and more efficient. *Engineering at Met.* 13 July.

One feature of fiber-optic cable technology is the need for end-to-end corridors for the physical transmission of signals, similar to wired telecommunications in the days of the telegraph and wired telephones. However, with urbanization and already congested land corridors, challenges exist in addressing the demand for rapid deployment and expansion of fiber networks, which has renewed the emphasis on sharing and leveraging rights-of-way and transmission lines with other sector infrastructure.

In contrast, the total electrification rate was over 95% in 2018, with less than 200 million people lacking access to electricity and no country having an electrification rate below 50%.[4] The penetration of transportation networks is also well above that of fiber networks, although rural road access differs significantly between countries; with some countries, such as the People's Republic of China, Nepal, the Philippines, Sri Lanka, and Viet Nam having an expanding network of rural roads, and a handful with less road network access, such as Papua New Guinea.

4 United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2020. *Policy Brief in Support of the High-level Political Forum 2020: Accelerating SDG7 Achievement in the Time of COVID-19.*

Nevertheless, the extensive power and transportation infrastructure networks across Asia and the Pacific present an opportunity for cross-sector infrastructure co-deployment and sharing. However, regulations, policies, incentives, and governance frameworks need to be in place (and aligned) before convincing infrastructure asset owners to co-deploy. Until then, the evidence is that co-deployment agreements are unlikely to materialize. Without top-down structures, outcomes highlighted in Figure 3 will continue to emerge. In the case of Myanmar, a fiber-optic cable is placed beyond the easement and cut into farmers' rice paddies rather than alongside the road proper, via either underground or aerial links (i.e., poles).

Figure 3: Fiber Rights-of-Way Challenges, Example from Myanmar

Notes: This specific example shows that there were several options for sharing rights-of-way permitting for a fiber-optic cable broadband backhaul network alongside a rural roadway in Myanmar. However, the only right-of-way permitted was in the flooded rice fields alongside the road, rather than the preferable options either along power transmission poles or under or alongside the main road structure in underground ducts. In this case the lack of access pushed the project into private farmland leading to stressed relationships with local communities, increased cuts to the service line as farmers plowed with tractors and seeded, and increased maintenance needs with seasonal flooding, all contributing to suboptimal resiliency in infrastructure deployment.

Source: P. Crilley. 2020. *Shared Broadband Infrastructures: Innovative Deployments & Rights of Way Initiatives.* Presentation for the Open Access Infrastructure Limited (openAI). Myanmar. 28 November.

Different Infrastructure Types: Economic/Hard Infrastructure, Social/Soft Infrastructure, and Enabling Infrastructure

Basic services, such as electricity, water and sanitation, road and rail transportation, and telecommunications, are examples of what is commonly referred to as economic, or hard, infrastructure. These are physical assets that require significant capital investment and are essential for economic activity and national economic development. Social, or soft, infrastructure describes the institutions and systems (for example, education systems, health-care systems, governance, the rule of law and justice, etc.) that are necessary conditions for the effective operation and growth of an economy.[5]

[5] Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT). 2021. *Cross-Sector Infrastructure Sharing for Broadband*. Republic of Korea.

Virtuous cycles exist between economic and social (hard and soft) infrastructure. Digital infrastructure, in particular, underpins the effective operation of other hard infrastructure (improving internal operations) and helps to improve the capacity and capabilities of social infrastructure. Digital infrastructure has become a critical investment for governments to consider as they look to drive joined-up economic, social, and environmental prosperity in their activities and goals coming out of the COVID-19 crisis.[6]

Given its connecting function for other aspects of the economy and society, digital infrastructure can be considered an enabling (or foundational) infrastructure. Such infrastructure includes systems (hard and soft infrastructure elements) that are essential to the day-to-day operation of countries, governments, industries, and communities. The destruction or incapacitation of these systems would cripple the functioning of aspects of daily life and could imperil public safety or national security (footnote 5). If secure access to these systems via digital infrastructure were compromised, it could have major economic and national security impacts, such as the interruption to the functioning of the Colonial gas pipeline in the US in May 2021 due to a cyberattack.[7] The ransomware attack shut down the largest refined gasoline products pipeline in the US that transports more than 100 million gallons per day across 5,500 miles throughout the southern and eastern US.

Definitions and Labels: Cross-Sector Co-deployment, Sharing, Dig Once, and Others

Cross-sector infrastructure co-deployment and sharing refers to the construction and use of related or connected physical assets by entities providing different infrastructure utility services.

Examples of shared physical assets include poles alongside roadways or railways, which may support electricity and telecommunication infrastructure, and ducts beneath carriageways and sidewalks or lain or buried alongside railways that may house electrical transmission lines, water, sewage, gas, or fiber-optic cable assets. Fixed facility structures such as buildings, homes, and businesses, as well as the land surrounding them, are often used for the placement of telecommunication fixed and radio equipment (Table 1).

Table 1: Examples of Cross-Sector Co-deployment and Sharing

Types of Infrastructure	Primary Sector	Secondary Sector	Sharable Elements
Terrestrial transportation corridors	Roadways, railways	Power lines, fiber-optic cables, water pipes	Civil works and rights-of-way (trenches, ducts, conduits, poles, towers, street furniture, and the inside of pipes)
Utility transmission lines	Electrical grid, petroleum and gas pipelines	Fiber-optic cables, telephony	
Urban underground passageways and manholes	Water and sewage systems, subways	Telephony, fiber	
Facility-based infrastructure	Other uses (housing, commerce, government)	Radio communication, fixed network concentration points	Rooftops, building structures, comms rooms, building facades

Sources: World Bank. *Cross-Sector Infrastructure Sharing Toolkit Module 3. Common Business Models*; Crowdband Solutions.

[6] ADB. 2021. *ADBI's Dean explains how infrastructure recoupling could deliver a more effective pandemic recovery*.

[7] CircleID Reporter. 2021. Close to hall of U East Coast fuel supply shutdown due to ransomware cyberattack. *CircleID*. 10 May.

The phrase “co-deployment” is used to describe the coordinated design and deployment of new (or upgraded) construction by multiple infrastructure asset owners. “Sharing,” on the other hand, can take place at any point in the infrastructure life cycle, and in many cases, existing infrastructure assets that may have only been serving one sector or service are opened for sharing after the initial infrastructure is already operational.

The phrase “dig once” has become synonymous with cross-sector infrastructure co-deployment and sharing, particularly to describe the bundling of infrastructure with fiber-optic cables. It refers to the installation of common ducts or conduits (flexible plastic pipes for future fiber-optic cables) along roadways or other carriageways that are accessible by other utility asset owners. In 2012, the Obama Administration in the US issued an executive order encouraging practices that were designed to reduce the number and scale of repeated excavations alongside transportation corridors and to accelerate fiber-optic cable deployments through common standards.[8] To date, at least 11 US states and 18 cities have implemented some form of formal or informal policies related to the concept of dig once.[9] The G20 Global Smart Cities Alliance is advocating a co-deployment approach to urban development and has developed a model dig once policy for cities to implement. In their formulation, dig once applies not only to the coordination between utilities in new construction, but also to existing facilities and renovations, such as leveraging facility-based infrastructure to share physical elements that support the expansion of next-generation wireless connectivity.[10] Similarly, the nonprofit organization, Geeks Without Frontiers, has developed a model law on dig once intended for legislatures and municipalities to consider, customize, and implement.[11]

It is important to note that various other phrases are used to describe the phenomena of cross-sector infrastructure deployments. These include integrated infrastructure, bundling infrastructure, and infrastructure coordination, among others. The lack of a universally used defining phrase may be limiting the familiarization and utilization of the concept.

Business Models of Cross-Sector Infrastructure Co-deployment and Sharing

Commercial arrangements between an infrastructure owner, telecommunication network operators and telecommunication service providers can take many different forms. The success of co-deployment and sharing arrangement depends heavily on applicable regulations (e.g., infrastructure sharing, rights-of-way, licensing), market dynamics (e.g., availability of interested parties, demand for bandwidth) and fiscal as well as technical capabilities of the participating infrastructure owners and the information and communication technology (ICT) stakeholders. Figure 4 illustrates the high-level scope and types of business models, and Table 2 describes some of the more common business models and the pros and cons of each model.

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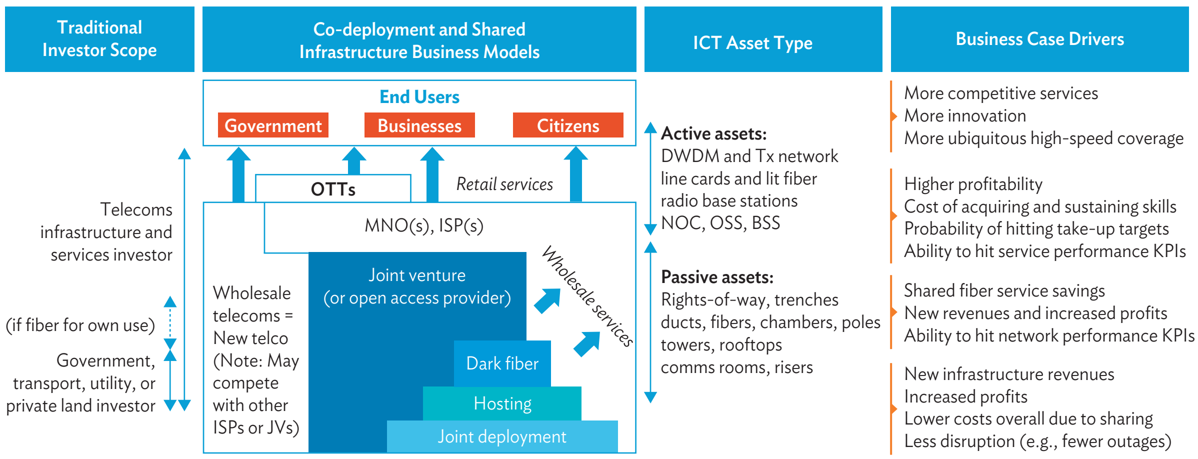
8 The White House. Office of the Press Secretary. 2012. *Executive Order – Accelerating Broadband Infrastructure Deployment*.

9 T. Cooper. 2021. Dig Once: The Digital Divide Solution Congress Squandered and Policy that Could Save $126 billion on Broadband Deployment. *BroadbandNow.* 30 November.

10 G20 Global Smart Cities Alliance. Dig Once: Live, Model Policy, Operational and Financial Sustainability.

11 Geeks Without Frontiers. 2016. Model Law on DigOnce!

Figure 4: Scope and Types of Co-deployment and Sharing Models



BSS = business support systems, DWDM = dense wavelength-division multiplexing, ICT = information and communication technology, ISP = internet service provider, JV = joint venture, KPIs = key performance indicators, MNO = mobile network operator, NOC = network operations center, OSS = operational support systems, OTT = over-the-top.

Source: Crowband Solutions.

Table 2: Common Business Models of Cross-Sector Infrastructure Sharing Involving Telecommunication

Business Model	Description	Pros	Cons
Joint deployment	Infrastructure owners and network operators coordinate in planning and constructing or refurbishing infrastructure	Potential to secure efficiencies in civil works planning and execution activities since sharing is considered beforehand Ownership and property rights may reside with either the infrastructure owner (see Hosting business model) or the network owner	Not applicable when most sharable infrastructure is already made available for sharing, and is not slated for refurbishment any time soon
Hosting	Infrastructure owner hosts third-party telecommunication equipment by authorizing a network operator to design, build, operate, and commercialize its own telecommunication facilities (conduits and/or fiber) on the infrastructure	The oldest and most common form of cross-sector infrastructure sharing with well-established agreements and examples	Ownership and property rights reside with the primary infrastructure owner, so less bargaining power for infrastructure being hosted

continued on next page

Table 2: ***Continued***

Business Model	Description	Pros	Cons
Dark fiber	Infrastructure owner designs, installs, and commercializes conduits and/or dark fiber to network operators, either in a long-term agreement through an indefeasible right of use (IRU) or in a short-term lease	Infrastructure owners expand the fiber network concurrently with linear infrastructure expansion bearing the share of dark fiber capital expenditure	Potential licensing requirements for the infrastructure owner as the provision of dark fiber IRUs/lease can be treated as the provision of a telecommunication service in certain countries
Joint venture	Infrastructure owner provides a network operator partner with use of existing infrastructure, which may already include conduits or existing fiber, to design, build, operate, and commercialize telecommunication facilities and/or services on a profit-sharing basis	Close coordination could result in efficiency gains, and competitive service offers through the instigation of open-access fiber models Skills can be brought in from dedicated wholesale telecommunication businesses and maintained on an ongoing basis	Requires a high level of cooperation and coordination between government (regulator, departments, and budgetary office); investors; utilities; network service providers (fixed and wireless); landowners; and users (government, enterprise, and residential users)
Wholesale telecommunication	Infrastructure owner designs, builds, operates, and commercializes wholesale telecommunication facilities and/or services directly to network operators	Ability to capture full profits on transmission infrastructure and offer maximum benefits to the value chain for ICT service delivery, operation, and commercialization	Higher business risk as the infrastructure owner needs to develop and maintain the requisite technical and business capabilities, and performance levels of a dedicated wholesale telecommunication business

ICT = information and communication technology.

Source: World Bank. *Cross-Sector Infrastructure Sharing Toolkit Module 3. Common Business Models*; Crowdband Solutions

II. THE IMPACT OF CROSS-SECTOR CO-DEPLOYMENT AND SHARING: FRAMEWORKS TO EVALUATE THE BUSINESS CASE

Cross-sector co-deployments have demonstrated tangible and intangible benefits associated with coordination and sharing. In many cases, the benefits outweigh any additional costs imposed by building in co-deployment, including coordination time, effort, and capital. The positive impacts of co-deployment can be segmented into groups, depending on if their benefits accrue primarily to the infrastructure asset owners (such as utility providers) or the general public (including government bodies and society at large). Table 3 highlights this segmentation and each area of benefit are discussed in further detail.

Table 3: Benefits Grouped by Private Impacts (Infrastructure Asset Owners/Utility Providers) versus Social Impacts (to the General Public)

Private Impacts (Infrastructure Asset Owners)	Social Impacts (Public Sector/Governments, General Public)
Reduction in overall deployment costs	Reduction of future costs (more efficient public expenditures)
Improved resilience of infrastructure	Reduction in disruptions (societal impact)
Increased revenue potential for infrastructure assets	Reduced environmental impacts
Leveraging digital infrastructure for internal utility operations (indirect benefits)	Expansion of services to previously unserved or underserved areas
Faster deployment times	Creation of new Smart City zones that attract more foreign direct investments and increase earnings potential for employers and citizens

Source: Authors' analysis.

Reduction in Overall Deployment Costs

Co-deployment of infrastructure between sectors has a direct impact on costs for each sector. These impacts have been measured extensively with regard to the benefits in capital expenditure reductions for the deployment of digital infrastructure. The civil works component of new fiber-optic cable infrastructure deployments is estimated to take up to 80% of the total cost of the investment, with the remainder for the fiber itself and other electronic equipment.[12] Sharing of existing (or future) civil engineering works, as well as other future-proofing (streamlining permits and building codes conducive to fiber cable deployments), could save network operators between 20% and 30% of high-speed network deployment costs. Table 4 presents a range of studies that have estimated the beneficial cost impacts to digital infrastructure deployment.

Co-deployments reduce costs for existing operators and support the entry of new players, particularly for services that require significant initial capital costs. This is achieved through various efficiencies, such as avoiding duplication while undertaking construction works in the same corridor and reducing the number of permits and the fees for the use of rights-of-way. Co-deployments increase the economic viability of new and more ubiquitous services. In a competitive market setting, deployment cost savings are often passed on to end users through reduced retail prices and can stimulate a virtuous circle whereby more affordable access pricing leads to more subscribers and greater per-subscriber consumption, increasing net demand, revenues, and profits, thereby increasing the capital resources available for further network expansion. Figure 5 conveys how reductions in the capital and operating costs of digital infrastructure deployments, which can occur in part via co-deployment, impact overall economic progress.

[12] Inter-American Development Bank. 2020. *Digital transformation infrastructure sharing in Latin America and the Caribbean.* Washington, DC.

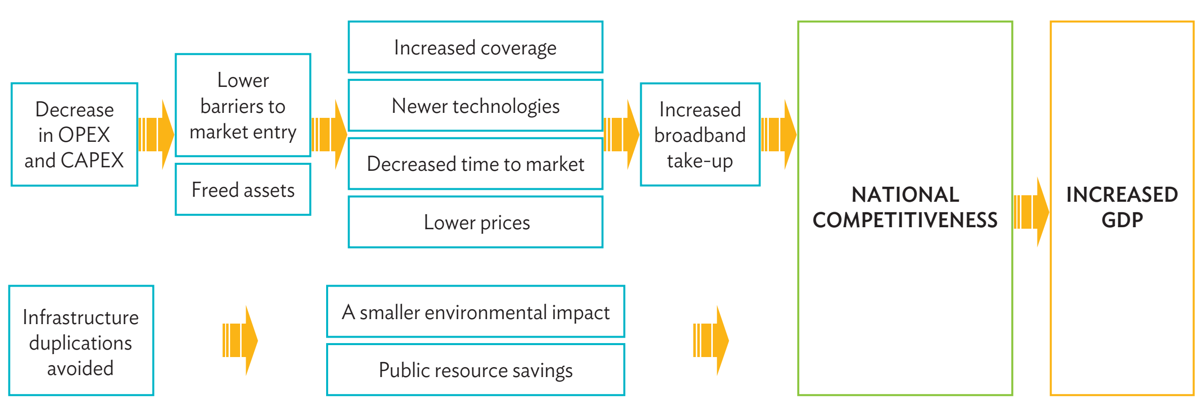
Table 4: Cost Savings from Infrastructure Sharing

Study	Savings	Summary
Analysys Mason, *The Costs of Deploying Fiber-Based Next-Generation Broadband Infrastructure* (2008)	16%–24%	Potential cost savings from the reuse of infrastructure owned by utilities depend on the areas covered (urban vs. national) and technologies chosen (FTTC vs. FTTP).
Analysys Mason, *PIA versus Self-Build Fiber in the Final Third: Digging into the Financials* (2012)	29%–58%	Cost savings that may be achieved by using passive infrastructure sharing in the United Kingdom depend on areas covered and additional works to be done. Savings could range from 29% in relatively densely populated areas using a combination of infrastructure sharing and traditional trenching to 58% in sparsely populated areas using the cheaper slot-cutting trenching approach.
OFCOM/CSMG, *Economics of Shared Infrastructure Access* (2010)	57%–67%	Sharing infrastructure networks such as reusing existing ducts where possible could result in up to 57% cost savings in urban and 67% in suburban areas.
EC, *Impact Assessment* (2013)	75%	The initial cost of network deployment in Western Europe using existing ducts ranges €20–€25 per meter compared to an average of €80–€100 per meter for deployments that require digging.
BEREC, *Report on Infrastructure Sharing* (2018)	16%–35%	Cost savings depend on the type of sharing: passive sharing cost savings are 16%–35% of capital expenditures (CAPEX) and 16%–35% of operating expenditures (OPEX); active sharing (excluding spectrum) cost savings are 33%–35% of CAPEX and 25%–33% of OPEX.

FTTC = fiber to the curb/cabinet, FTTP = fiber to the premises

Source: Inter-American Development Bank. 2020. *Digital transformation infrastructure sharing in Latin America and the Caribbean*. Washington, DC.

Figure 5: Benefits of Infrastructure Sharing



CAPEX = capital expenditure, GDP = gross domestic product, OPEX = operating expenditure.

Source: Inter-American Development Bank. 2020. *Digital transformation infrastructure sharing in Latin America and the Caribbean*. Washington, DC.

In the US, a 2016 Federal Highway Administration report highlighted that up to 90% of the cost of deployment of fiber-optic networks can be in the cost of re-digging roadways, and a co-deployment or dig once approach, if fully implemented across the country, would have reduced the cost of a national high-speed broadband network from $140 billion to just $14 billion.[13] Joint builds allow infrastructure asset owners, telecommunication operators, and other users to share the cost of civil works, significantly reducing the burden on individual entities and lowering the barrier to entry for new players. For example, in 2009, South Africa's Broadband Infraco entered into a consortium with telecommunication operators and the national roads agency to co-deploy via a common trench, which would host the fiber-optic cables of the consortium members. The 680 km trench cost was split evenly between three telecommunication operators, resulting in significant savings in civil works.[14]

Deployment cost reductions also occur for sectors not involved in digital infrastructure. As the Kiribati Road Rehabilitation Project (Box 1) demonstrated, long-term aggregate costs for all sectors considered (transportation, water, telecommunication) would have been greater than the combined cost of building in all three components in stages. Similarly, the case study of infrastructure coordination by the Greater London Authority highlights how coordination between various sector utilities in timing their construction activities significantly reduced costs to each utility in the form of shared (reduced) construction fees and permitting.[15] Coordination and co-deployment create an opportunity for greater efficiencies for the utilities involved, by reducing unnecessary duplication and costs, and may speed up deployment if well managed (Box 2).

Box 1: Kiribati—Road Rehabilitation Project Example (ADB)

Starting in 2010, the Asian Development Bank (ADB) began supporting a $7 million road rehabilitation of South Tarawa's main road in Kiribati alongside cofinancing from the World Bank, the Government of Australia, and the Government of Kiribati. The focus on the project was to improve the socioeconomic conditions of the people of South Tarawa by ensuring the population has access to a safe, sustainable, and well-maintained road network, particularly as the road provides access to all essential services on the atoll, connecting airport, seaport, and the administrative capital of Bairiki.

To achieve this, the project focused on rehabilitating and upgrading the road network, supporting community-based enterprises to maintain the road network, and engaging the relevant Kiribati ministry to provide implementation support. During the project design for the road rehabilitation, other sector issues were raised, particularly the need to improve 11 kilometers of existing water mains running alongside the road. Coordination between different sectors was identified as a challenge, and a co-deployment approach was recommended by the project's funders, including adding an open access open duct that could be leveraged for fiber-optic cable for telecommunication in the future and would prevent a repeat digging up of the roadside.

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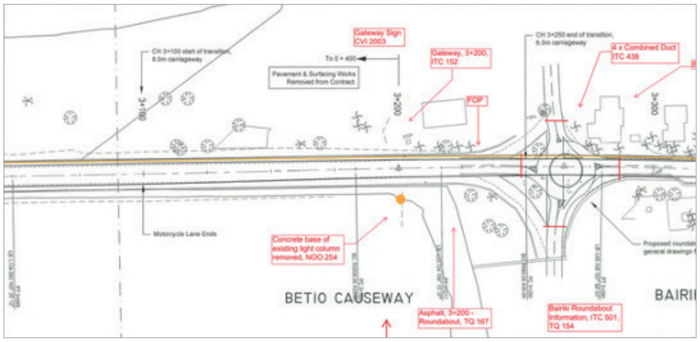
13 Global Connect Stakeholder: Advancing Solutions. 2016. *Dig Once: A How-To Guide*; T. Cooper. 2021. Dig Once: The digital divide solution Congress squandered and policy that could save $126 billion on broadband deployment. *BroadbandNow.* 30 November.

14 World Bank. 2017. *Cross-Sector Infrastructure Sharing Toolkit Module 8: Business and project case studies.*

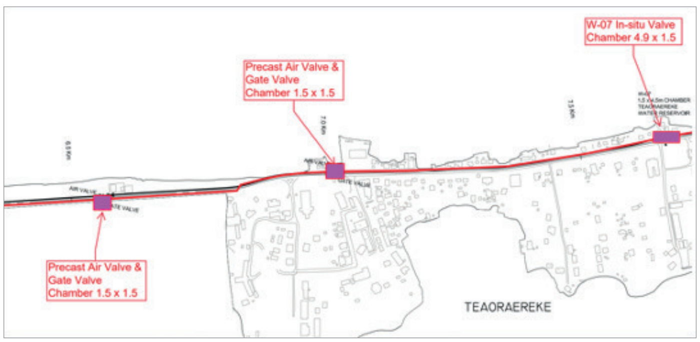
15 J. Garrity. 2021. Interview with Greater London Authority, Andrew Sherry, and Molly Strauss dated 7 June.

Box 1: *Continued*

Services ducting



Water transmission main



Kiribati – Road Rehabilitation Project. The photos show the improvement of 11 kilometers of existing water mains running alongside the road. (Sources: ADB. 2018. *Completion Report. Road Rehabilitation Project in Kiribati.* Manila; Presentation materials from ADB webinar: Bridging the Digital Divide via Multi-Sector Infrastructure Sharing and Co-Deployment: Connectivity, Power, Transport and Water).

It was recognized that the additional cost of adding the duct was negligible in the context of the overarching project costs and would outweigh the overall benefits (i.e., avoidance of digging and related disruptions in the future), but since no specific telecommunication service could be identified as a client at the time, potential revenues could not be factored in. Since the project completion in 2017, at least one telecommunication service provider has expressed interest in utilizing the open duct running along 32 kilometers of the road.

Sources: ADB. 2018. *Completion Report. Road Rehabilitation Project in Kiribati.* Manila; Presentation materials from ADB webinar: Bridging the Digital Divide via Multi-Sector Infrastructure Sharing and Co-Deployment: Connectivity, Power, Transport and Water.

Box 2: Gas and Fiber Co-deployment

Two of the world's leading Tier 1 telecommunication carriers, Verizon, and Lumen, had their origins in gas co-deployment.

In 1985, Williams Pipeline Company and Teleconnect built a 1,200 mile fiber-optic network in the United States (US) Midwest by pulling cables through disused liquid petroleum pipelines[a]—the first of many successful gas and fiber co-deployments.

Williams Pipeline Company soon increased its investments, creating subsidiary Williams Telecommunications (WilTel) to help exploit its pipeline assets and valuable rights-of-way. In 1987, WilTel purchased Kansas City Southern's LDX Network. While LDX was primarily co-deployed with the KCS railway, it was also America's first instance of fiber co-deployed with aerial power lines.[b]

By 1990, WilTel was America's fourth-largest network operator, managing more than 17,700 kilometers (km) (11,000 miles) of fiber.[c] In 1995, WilTel was sold to LDDS/Worldcomv retaining a single pair of fiber for their Vyvx video company.[d] Today, WilTel fiber is an important part of the tier 1 Verizon Communications backbone.

Williams re-entered the telecommunication market in 1998 as the Williams Network, leveraging their Vyvx fiber pair.[e] With this new venture, Williams began to co-deploy more fiber, this time on rights-of-way held by Transcontinental Gas Pipeline Corporation.

Williams' second fiber venture failed in 2002,[f] but the network they created remains valuable. It was acquired by Level 3 Communications,[g] and today is part of the global Tier 1 network known as Lumen Technologies.

Opportunities for co-deployment also include installing fiber inside active gas lines and sewer pipes. By 1998, an Alcatel system was in use in Gevelsberg, Germany[h] and by 2003 in Taipei,China.[i] Sempra Fiber Links and Gastec developed similar systems around the same time.[i] The complexity of running fiber in active lines is perhaps why the practice is not widespread. At 400 km, Taipei,China has the largest installation. By 2007, installations in a dozen cities in Germany, Italy, the Netherlands, and the US together spanned only 87 km. No new fiber in gas projects have been announced since then.

[a] R. Knight. 1985. Old oil pipelines offer unique conduit for US fiber-optics communications network. *The Christian Science Monitor.* 13 June.

[b] T. Parvin. 1987. Ldx Net Regional Fiber Optic Network. *Proc. SPIE 0715, Fiber Telecommunications and Computer Networks.* 1 January.

[c] A. Richardson. 2019. WilTel's fiber-optic connection // Turning pipelines to profit. *Tulsa World.* 13 July.

[d] A. Myerson. 1994. LDDS to Purchase WilTel for $2.5 Billion. *The New York Times.* 23 August; Associated Press. 2015. WorldCom Timeline. *FoxNews.com.* 13 January.

[e] *Oil&Gas Journal*. Williams mulls telecoms spinoff.

[f] D. Fisher. 2002. Williams Communications Stares Chapter 11 in the Face. *Forbes*. 25 February.

[g] C. Bellamy. 2002. Level 3 Bids for Williams Communications. *The Channel Co. CRN.* 24 July.

[h] M. Fuller. 2002. Live gas lines to carry energy and information. *Lightwave*. 1 July.

[i] Alcatel. 2001. *Optical Telecommunication Links in Gas Pipes Innovative RoW Solution Exclusively at Alcatel*. Paris.

One method for estimating the potential net benefits of co-deployment over time versus separate deployment of corresponding infrastructure is to compare the corresponding net present value of each case. The toolkit developed by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) provides a detailed walkthrough of such an approach for co-deployment of digital infrastructure alongside road transport and energy infrastructure.[16] The economic efficiency of co-deployment can be proven by comparing the pace of value increase between co-deployment model against a "do nothing or do minimum" option. Here, the ratio of net cash flow from the start of the billing period to the end of the project period and the volume of investment for the current year was used to calculate the pace of value increment. When using the net present value method, it is recommended to include rigorous stress testing of various discount rates, ranges of benefits and costs, and scenarios whereby the benefits and costs are modeled differently over the course of the project (e.g., benefits are spread evenly over the life of the project, benefits accrued only in later years, cost front-loaded, costs front-loaded and benefits accrued in later years, and investment back-ended).

Increased Revenue Potential for Infrastructure Assets

Infrastructure asset owners can create additional revenue opportunities through leasing or renting out space and infrastructure capacity. For example, in 2003, the Bhutan Power Corporation (BPC) deployed a fiber-optic cable network with Bhutan Telecom Limited—which had initially been planned for its own internal operational needs (telemetry, voice, and video communication for control and management, and its supervisory control and data acquisition or SCADA system). Taking advantage of its existing power transmission assets, BPC entered into a co-deployment agreement with Bhutan Telecom Limited that allowed fiber-optic cables to be strung alongside its network. This reduced the planned capital expenditure for BPC's communication investment and generated operating income from regular maintenance and lease fees from Bhutan Telecom Limited.[17]

Similarly, in December 2020, ADB approved a $190 million loan to upgrade the power distribution system in Bengaluru, India, supporting the Bangalore Electricity Supply Company Limited (BESCOM). During project design, BESCOM recognized an opportunity to increase potential revenues by installing fiber-optic cable alongside their electrical transmission system, with the intention to lease out this capacity (Box 3).[18] Other utility entities in India, such as the Power Grid Corporation of India Limited,[19] have dedicated subsidiaries focused on telecommunication for revenue generation purposes.

Similar trends can be observed both in the region and around the world. In the Philippines, for example, the National Grid Corporation of the Philippines agreed to lease more than 6,000 km of dark fiber it owned to the Department of Information and Communications Technology in 2018, enabling the implementation of sections of the National Broadband Plan to provide high-speed internet network across the country.[20] In Africa, Kenya's state-owned power transmission and distribution provider

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[16] A special calculator tool (in *.xlsx format) using this methodology for assessing economic efficiency is available at https://owncloud.onat.edu.ua/index.php/s/jL200B8MsjBQryZ; UNESCAP. 2020. *Toolkit for ICT Infrastructure Co-Deployment with Road Transport and Energy Infrastructure.*

[17] UNESCAP. 2019. *ICT Co-Deployment with the Electricity Infrastructure: The Case of Bhutan.*

[18] ADB. 2020. *ADB approves $190 million loan to upgrade power distribution system in Bengaluru*. 4 December.

[19] Power Grid Corporation of India Limited. https://www.powergrid.in/telecom.

[20] C. Mercer. 2018. Philippines Gov't to use 6,000 km of unused fiber-optic from National Grid. *CIO*. 27 June; Government of the Philippines, Department of Information and Communications Technology. 2017. *National Broadband Plan.* Diliman, Quezon City.

Kenya Power is seeking to leverage its power network, which has already co-deployed fiber-optic cables across the country but does not use the full capacity for internal purposes. By leasing out access to unutilized dark fiber, Kenya Power is seeking to unlock a new revenue stream. The dark-fiber assets will cater to the needs of multiple telecom providers who can connect the unlit fiber-optic cables to active network equipment to offer additional capacity and meet the market's increasing bandwidth needs for voice, data, and video service.[21]

Energy providers are leading the adoption of co-deployment and sharing initiatives, particularly as the sector continues to face declining margins from traditional services due to increasing energy efficiency, less energy-intensive industrial processes, energy-conscious consumers, and more distributed energy generation. Diversification of revenue by leasing underutilized or unutilized facilities is an increasing trend.

Box 3: Bengaluru—Power Distribution System Example (ADB)

In December 2020, the Asian Development Bank (ADB) approved a $190 million loan to upgrade the power distribution system in Bengaluru, India, supporting the Bangalore Electricity Supply Company Limited (BESCOM) with a $100 million sovereign loan and a $90 million loan without sovereign guarantee. The project converts 7,200 kilometers of overhead distribution lines to underground cables while at the same time installing 2,800 kilometers of fiber-optic cable for communication, smart metering, distributed automation systems, and other communication network uses.

Moving the aboveground electrical transmission lines to underground to protect the transmission from environmental conditions and other interference is estimated to reduce technical and commercial losses by about 30%. Further, in designing the project, BESCOM recognized an opportunity to increase potential revenue by installing fiber-optic cable alongside their electrical transmission system specifically for lease, similar to how other utility entities in India, such as PowerGrid, have dedicated subsidiaries focused on telecommunication for revenue generation purposes.

Source: ADB. 2020. *ADB approves $190 million loan to upgrade power distribution system in Bengaluru*. 4 December.

Leveraging Digital Infrastructure to Improve Internal Utility Operations

Aside from the macro-level benefits, co-deploying digital infrastructure alongside utilities, road, and energy projects helps make the internal operation smarter, safer, and more efficient by paving the way for digital transformation.

For power utility providers, their SCADA systems usually require only a fraction of their own internal fiber network capacity, presenting an opportunity to lease the excess, or indeed sell the assets and lease back what is needed as a managed service or for internal management. Similarly, railway network operators often have excess capacity in their control systems. In addition to this opportunity to monetize the latent value of existing infrastructure, these networks are critical operational components. Table 5 shows the variety of uses of communications networks in the operation of a utility's core business.

21 M. Siele. 2021. Kenya Power Eyes Telco Billions with Fibre Optic Network Extension. *Business Today*. 3 May.

Table 5: Communication Needs of Utility Providers

Core Utility Business	Communications Needs of Infrastructure Owner
Roads and Highways	• Intelligent transportation systems • Signaling • Traffic monitoring (e.g., vehicle detection systems, CCTVs) • Dynamic signage and road user information • Connectivity to public safety and work crews • Toll collection and settlement • Traffic flow analysis and forecast (e.g., estimated travel time, accident information via Variable Message Signage)
Railways	• Signaling • Switching • Rail track safety management and train control • Internal voice and data links • Wireless connectivity to rolling stock
Electric Power	• SCADA systems • Network protection • Load management • Outage detection • Self-healing grids • Management of bi-directional electricity flows • Video surveillance and security • Smart metering • Internal voice and data links • Connectivity to line crews
Water and Sewer	• SCADA systems • Connectivity to pumping, treatment, and control facilities
Oil and Gas Pipelines	• SCADA systems • Connectivity to wellhead, control points, and delivery points

SCADA = supervisory control and data acquisition.

Sources: World Bank. 2017. *Cross-Sector Infrastructure Sharing Toolkit Module 8: Business and project case studies*; UNESCAP. 2018. *Co-Deployment of Fibre Optic Cables along Transport Infrastructure for SDGs Including Cross Border.* Bangkok.

In the Republic of Korea, the national road authority was able to access fiber-optic cable thanks to mandatory co-deployment in greenfield highway projects. The new fiber-optic cable asset was leveraged to install sensors for fault detection, displays for customer information, and CCTVs for speed sensing and policing; and video analytics improved management and disaster recovery and response times.[22] The deployment of the Freeway Traffic Management System was expected to lead to a potential 25% reduction in traffic congestion in freeways, amounting to annual savings of $112 million (footnote 22).

22 UNESCAP. 2018. *Co-Deployment of Fibre Optic Cables along Transport Infrastructure for SDGs Including Cross Border.* Bangkok.

Further, the network connects commercial services along the roadway (including ATMs and other kiosks). In a contemporary example from the United Kingdom, the national railway operator Network Rail is currently planning to upgrade its data transport infrastructure and is seeking a £1 billion co-investment in return for fiber-optic cable bandwidth capacity that will be deployed as part of the upgrade.[23]

Faster Deployment Times

While co-deployment can increase coordination costs and planning time, overall, it can decrease aggregate deployment times between sectors by negating duplication and costs associated with rights-of-way permitting, other required licensing, as well as safeguard studies for publicly financed infrastructure (environmental and social safeguards, etc.) The time and effort required for acquisition of permits, particularly those around rights-of-way, can be a time-consuming process that significantly affects digital infrastructure deployment as networks can traverse many various licensing boundaries, particularly when there are several public jurisdictions.[24] By utilizing the preexisting rights-of-way of infrastructure asset owners, fiber deployments can be started and concluded much more quickly, especially when conduit pipes or open ducts are already in place at the time of installation. The BPC example, cited above, demonstrates a co-deployment whereby the time required to begin and complete network deployment was reduced because of existing transmission infrastructure of the power utility (footnote 19).

Improved Resilience

When properly designed with resiliency and redundancy in mind, co-deployments can further serve to improve the resilience of utility infrastructure. Aboveground low-voltage power transmission and telecommunication lines, for example, are subject to a wide range of disasters and examples highlight the damage wrought to aboveground lines by wildfires (for example, in California),[25] by hurricanes and typhoons (for example, in Puerto Rico)[26] and extreme climate variability (such as the deep freeze in Texas).[27] Co-deployment of transmission lines, especially by placing them in underground access ducts, improves the resilience of critical infrastructure. In Bengaluru, converting overhead power distribution lines to underground lines in order to protect transmission and operations from natural hazards is expected to reduce technical and commercial losses by up to 30% (footnote 20).

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23 H. Baldock. 2021. All aboard? Network Rail seeks £1bn fibre co-investment. *Total Telecom.* 27 April.

24 UNESCAP. 2018. *Fibre-optic co-deployment along the Asian highways and trans-Asian railways for e-resilience: The cases of India and Bangladesh.*

25 D. Baker. 2020. Burying PG&E's lines to stop fires could cost $240 billion. *Bloomberg.* 23 January.

26 N. Thieme. 2018. After Hurricane Maria, Puerto Rico's internet problems go from bad to worse. *New America.* 23 October.

27 R. Hebner. 2021. What the Texas-Freeze Fiasco tells us about the future of the grid. *IEEE Spectrum.* 23 February.

Reduction in Future Costs (and More Efficient Public Expenditure)

Unnecessary network duplication or multiple civil works in the same physical area can be avoided in some cases by taking a co-deployment approach—potentially reducing public infrastructure expenditure. In an era of increasing public sector debt burdens, hard infrastructure (and social infrastructure) investments have experienced delays.[28] However, the cost savings of co-deployment approaches can free up available funds for other initiatives. Legislation that would have implemented a national standard for the co-deployment of fiber-optic cable conduits in the US fiber-optic network could have decreased the estimated total of national broadband deployment from $140 billion to $14 billion, according to one estimate (footnote 9) (Box 4).

Box 4: Water and Fiber Co-deployment

Pioneered in the 1980s, fiber in drainpipes capture headlines, but is surprisingly rare.

Storm drains and sanitary sewers reach all buildings in a city and have plenty of spare capacity to host fiber cables. Operators have existing high-capital, low-return access networks in place for telecommunication access.[a] Using existing pipes for fiber could lead to shorter construction periods; fewer traffic disruptions; reduced instances of excavation; less noise pollution; and often, reduced number of permits. Technology to install fiber in pipes has been around since the 1990s—so why is the practice uncommon?

In the late 1980s, water engineers in Tokyo installed 850 kilometers (km) of fiber inside human accessible sewer pipes under the city.[b] Their goal was to reduce the labor required to control remote treatment facilities. Tokyo's world-first network is today still the world's largest.

Most pipes are smaller than 700 millimeters in diameter and not human accessible, so installing fiber inside them takes considerably more effort. In 1996, the sewer department of the City of Vienna, Austria invented a robot with a company called CableRunner to address the problem, which attaches conduits to the inside of smaller pipes. Vienna's 400 km network, the world's first fiber-in-pipe network designed for telecommunication, is today the world's second largest.[c]

Complicated installations, expensive materials, and concerns by sewer operators over damage to fiber and pipes has kept deployment low. By 2007, around 33 cities had built around 820 km of fiber outside of Tokyo,[d] and by 2016, market leader CableRunner had installed around 2,000 km across its projects.[e] With individual companies manufacturing millions of kilometers of outdoor fiber per year, fiber in pipes has remained a niche application.

[a] M. Kennedy. 2002. Utilities Go The First mile or FTTH. *Paper on America's Telecommunications.* January.
[b] Y. Shinoda. 1987. Remote Control of Sewerage Facilities Using Sewer Optical Fiber Teleway. *Research Report of Tokyo Metro Government*.
[c] Cable Runner International. Case Study Vienna: Building a Fiber Optic Network.
[d] J. K. Jeyapalan. 2007. The Pipe is There: Using Existing Infrastructure to Speed FTTH Deployment. *Broadband Properties*.
[e] World Bank/ITU. Fiber Open Data – making data available for Africa. Presentation by Chrisphine Ogongo.

[28] ADBI. 2021. *ADBI's Dean explains how infrastructure recoupling could deliver a more effective pandemic recovery*. Manila.

Furthermore, a formal process of identifying upcoming utility investments or upgrades helps to optimize public expenditure. As an example, London has coordinated its infrastructure deployments through the use of both an infrastructure mapping component, and financial encouragements to accelerate forward-planned investments.

Reduction in Disruptions (and Increased Societal Impact)

Infrastructure disruptions can be both unintentional, for example, accidental damage during new construction; or intentional, for example, during regular maintenance, repairs, and renovation. Road networks and any utilities buried beneath the surface are liable to particular damage when fiber networks are installed. The uncoordinated plans of multiple network operators compound this risk and the resulting damage to the carriageway, sidewalk, or verge and any assets buried therein. By installing ducts or laying dark fiber when the road is first constructed, the infrastructure owner can reduce the risk of damage from additional construction (footnote 25). In 2017, according to data presented at the Geospatial World Forum 2019, there were at least 316,442 instances globally whereby underground utilities infrastructure was unintentionally hit and damaged by construction activities as a result of lack of location information, with an estimated total cost of $1.3 billion.[29]

Reduction in disruptions can also be measured as a positive societal impact. Key performance indicators include road health and safety, displacement or relocation of people, and displacement of economic or social activities (for example, as a result of vehicular traffic pattern disruptions). In London, coordination of infrastructure deployment and upgrades between transportation, water, and gas utilities resulted in reducing disruption on busy stretches of road corridors by 242 days.[30] This reduced disruption equated to an estimated £2.3 million–£4.1 million in societal benefit between 2019 and 2020 based on the avoided daily impact of traffic delays and congestion.

Reduced Environmental Impacts

Cross-sector infrastructure co-deployment can generate positive externalities for the environment because of the reduction of construction activity, infrastructure development, and the resulting smarter ways of living and monitoring consumption. Co-deployments can reduce the need for additional utility corridors that would otherwise limit the use of land and unnecessarily burden the environment in terms of noise, aesthetics, and pollution.

Environmental benefits also accrue from reduced resource consumption, increased energy efficiency, and the contribution of co-deployment to sustainable growth. Infrastructure sharing reduces the overall carbon footprint of construction activities through a reduction in materials, energy, and emissions, with one analysis suggesting that 36% of a fiber network's carbon footprint can be reduced by leveraging existing physical infrastructure (footnote 12). In London, infrastructure coordination on stretches of roadway repairs was deemed to have reduced harmful emissions, including air pollution and carbon.

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29 World Bank/ITU. Fiber Open Data – making data available for Africa. Presentation by Chrisphine Ogongo.

30 Mayor of London. Stoke Newington Supercharged Collaboration. Infrastructure Coordination Streets Services and TfL Network Performance.

In some cases, the impetus for encouraging co-deployments includes the potential positive environmental impact. In Bangladesh, the national regulator specifically encourages an infrastructure sharing approach in part to protect the environment from the proliferation of mobile network tower installation.[31] South Africa's FibreCo, which operates a 2,400 km dark fiber network available on an open-access basis, was constructed through infrastructure sharing with the intent of providing economic benefits, as well as positive environmental spillover effects (footnote 15). In Bhutan, the BPC's decision to allow the installation of telecom operator fiber using its infrastructure was in part driven by the assumption that any additional damage to the natural environment from the co-deployment was minimal (footnote 17).

Expansion of Services to Underserved Areas

The emergence of unserved or underserved areas reflects the normal market behavior of private and public institutions that focus on maximizing financial and social returns. Features such as low population density and low per capita buying power result in higher infrastructure costs per home or end user, and lower returns. The resulting lack of basic utility services (water, power, telecommunication, among others) is expected and needs redress. Infrastructure sharing is one of the tools that can be used to make this redress by expanding services more economically to more remote or difficult-to-serve areas. Sharing is essentially a business arrangement, or mechanism, that reduces the investment cost to serve and provide coverage through the concurrent use of infrastructure and related investments to build and operate those assets (footnote 12).

Creation of New Smart City Zones That Attract More Foreign Direct Investments and Increase Earnings Potential for Employers and Citizens

As new infrastructure-sharing opportunities emerge to address unserved and underserved areas, there are also increasing opportunities to leverage infrastructure sharing in brownfield developments and brand-new greenfield developments. These cases may offer strong financial returns and require little to no investment on the part of the government or its agencies due to the relatively high population density and earnings capabilities of the impacted population and businesses. The Karachi Bus Rapid Transit Red Line Project is an example (Box 5). The project is expected to not only solve a transport issue facing the area, but also create an ICT corridor that will serve and attract current and new businesses.

In these cases, the role of authorities can include coordination and vision setting to go beyond marginal economic, societal, and environmental benefits, and achieve transformational benefits. Smart city visions depend on efficient, modern, and futureproof utility infrastructures that support modern living and ways of working. Such initiatives depend on infrastructure sharing, attract new levels of foreign direct investment in new buildings and business relocations, and result in an uplift in earnings and quality of life for all. The New Clark City project under development by the Philippines' Bases Conversion and Development Authority, with the support of ADB, is an example where appropriate scoping of network and business end points is expected to set a benchmark for smart city development in the region.

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[31] A. Richardson. 2019. WilTel's fiber-optic connection // Turning pipelines to profit. *Tulsa World*. 13 July.

Box 5: Karachi—Bus Rapid Transit Red Line Project Example (ADB)

The Karachi Bus Rapid Transit Red Line Project is a 26.6-kilometer transportation corridor redesign that is intended to directly benefit at least 1.5 million people by improving travel time, vehicular operating costs, and air quality, as well as reducing carbon emissions, improving public health, and mitigating climate change, as well as making Karachi safer, greener, more inclusive, and competitive.

The full redesign includes moving aboveground utility transmissions (electrical power, telecommunication) to a shared duct underground that will include elements of water, main sewage, and gas lines. While still in the early stages of the project deployment, the project team recognized the need to build a co-deployment approach, particularly by establishing clear and regular communication between all utility implementers.

Source: ADB. 2019. *Report and recommendation of the President to the Board of Directors: Proposed Loan to Pakistan for the Karachi Bus Rapid Transit Red Line Project.* Manila.

III. CHALLENGES, GOOD PRACTICES, AND LESSONS LEARNED

Challenges and Obstacles to Co-deployment

Challenges to the implementation of cross-sector infrastructure co-deployment and sharing projects can range from *set-up* challenges that create impediments, friction, and inertia on utility-by-utility projects, to challenges that arise during project *implementation*.

Lack of awareness, incentives, and coordinating mechanism

Key government stakeholders in charge of constructing and maintaining transport, energy, and water infrastructure may lack awareness of the benefits of infrastructure co-deployment and sharing. As a result, they have little incentive to disrupt the progress of separate utility deployments by pausing to plan for and execute the integration of telecom conduits and fiber. In some cases, infrastructure asset owners have a misguided notion that co-deployment and sharing can compromise physical security and cybersecurity. In reality, co-deployment involves the provision of either conduits or optical fibers and offers the opportunity to consider end-to-end security and resilience from a holistic perspective, thereby reducing systemic exposure to security threats.

The incentives for infrastructure sharing or co-deployment can range from political to commercial returns. While such activity might make financial sense for society and at an aggregate level, what matters is whether individual infrastructure asset owners are encouraged and incentivized, if not mandated, to initiate or participate in such arrangements. A business case needs to be made for each initiative highlighting the costs, risks, and benefits of co-deployment and sharing. Additional revenues, societal benefits, and avoidance of costs and/or risks need to outweigh the incurred additional costs, time, effort, and risk involved in co-deployment and sharing.

Further, many countries lack mandate and institutional mechanisms at the national, provincial, and local levels to enable effective coordination between different infrastructure management agencies and telecommunication operators in the planning and execution phases to enable co-deployment.

Regulatory constraints

The legacy mandates of state-owned public utilities may limit the potential for collaboration between different infrastructure asset owners, in particular regarding public procurement, disposition of public assets, limits on partnerships, and public concessions. For example, the mandates of power companies in New Zealand did not allow them to install communications cables over private land until a legislative change in 2017.[32]

Other regulatory constraints include price regulations on utilities that disincentivize collaboration between utilities. Institutional silos for infrastructure investments (even within multilateral development banks), as well as domestic, regional, and departmental interference, have sometimes prevented co-deployment opportunities. Siloed public infrastructure funding and decision-making, budgetary controls, and performance reward mechanisms, for example, may prioritize lower short-term additional costs (in terms of time and capital needed for coordination efforts), over long-term benefits of co-deployment and sharing.

Structural market issues may be rooted in legal or extra-legal concerns, such as corruption in state-managed projects, or lobbying on behalf of incumbents to prevent competitor entry in entrenched markets. Other motive issues include questions of fair compensation for infrastructure sharing, particularly when the infrastructure is to be shared with state-owned entities.

Outside of these specific issues, the lack of a clear legal and regulatory framework for infrastructure sharing can discourage infrastructure asset owners from engaging with entities looking to access their infrastructure. This may also be related to a lack of experience with telecom networks, discouraging infrastructure asset owners from offering access for fear that this is beyond their area of expertise.

Implementation Challenges

Implementation challenges, on the other hand, relate to difficulties directly involving infrastructure sharing and co-deployment. For dig once policies, for example, this can encompass a lack of sufficient funding to accommodate the construction of conduits. Long-term commitment to infrastructure sharing, particularly from the state in terms of policy and financing, can help catalyze sharing agreements between operators and infrastructure asset owners. Similarly, dig once policies that hinge on road or other civil works may encounter difficulties due to delays relating to the host civil works. Finally, permitting and land use issues may prevent infrastructure asset owners from legally sharing resources and rights-of-way with network operators.

32 Government of New Zealand, Parliamentary Counsel Office. *Telecommunications (Property Access and Other Matters) Amendment Act 2017.*

Lack of capacity can be another concern. Power companies, for example, may refuse to share their optical ground wire because they do not have staff with adequate technical knowledge and experience to manage issues with access, safety, and outages. A combination of these challenges, particularly in uncompetitive markets, are why a report by the Inter-American Development Bank only identified eight countries in the Latin American and Caribbean region with any sort of cross-sector infrastructure sharing (footnote 12). Security concerns and logistical challenges around providing access to a third party to critical infrastructure can also be a hindrance to operationalizing the dig once approach.

Good Practices in Project Design and Implementation

The importance of strategic investments and high-level buy-in

The tangible benefits of infrastructure sharing, especially with regard to ICT, are subject to a time lag as new suppliers, innovations, services, and end-user pricing emerge and grow over time, and savings are invested elsewhere. One of the early challenges for project managers is to obtain and sustain the buy-in of stakeholders in the long-term benefits of infrastructure sharing. For example, part of the rationale for sharing in the Bengaluru Power Distribution Project in India was proving the ability to increase revenue streams in the long term and align with the utility provider's internal objectives.

Other stakeholders in central and local government have an interest in securing nonfinancial or non-tangible benefits from infrastructure sharing. These may include, for example, the public interest goal of reducing the digital divide between communities and supporting the digital transformation of government frontline services to save lives and ensure better education outcomes. Entities that are already geared toward service provision as the main goal, such as not-for-profit utility cooperatives, can be natural champions of bridging the digital divide in their communities.

For other entities, project managers may need to engage and convince the senior executives and investors in infrastructure assets that there is a better net financial result from infrastructure sharing. Any such discussion will need to be tailored to each infrastructure owner's existing priorities.

Establishing cross-sector collaboration and communication

One of the biggest challenges is aligning the priorities of different government agencies, infrastructure asset owners, legacy and new network operators, and end users each with their incentives and goals for participating in a co-deployment and sharing project. Aligning priorities is a critical prerequisite to aligning plans and operations. Before details of infrastructure co-deployment and sharing plans can be developed, project managers need to facilitate a shared awareness of stakeholder plans and priorities. This awareness is the first step toward stakeholders merging their deployment plans and some aspects of operations under the infrastructure sharing project. For this to happen, project managers need to pay special attention to establishing communication channels that are conducive to collaboration at the very beginning of sharing discussions. For example, the infrastructure sharing project of the Greater London Authority (GLA) succeeded despite initial friction between Thames Water and the GLA as they lacked a common work schedule. Sustained communication helped to persuade Thames Water to shift its infrastructure plans forward to participate in GLA's proposed sharing agreement.[33]

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[33] Alcatel. 2001. *Optical Telecommunication Links in Gas Pipes Innovative RoW Solution Exclusively at Alcatel.* Paris.

Dedicated project management

Infrastructure co-deployment and sharing is a project unto itself, built on top of, but distinct from, the individual infrastructure projects contained within. Strong project management is required when multiple entities are co-deploying assets in the same physical space and according to an aligned schedule. Coordination needs to be planned for and communicated before and during the actual infrastructure deployment, such that the potential cost savings and operational efficiencies of co-deployment can be fully realized.

It is important that the overarching infrastructure co-deployment and sharing initiative be given sufficient attention and resources separate from the underlying projects. An effective way of doing this is to allocate dedicated project management resources focused on coordination. As in the GLA's experience, "having one person collating and facilitating all utility programs and actions into a single project management delivery gave a clearer and more precise overview and made it easier to keep the scheme and key outputs progressing (footnote 33)." In the same case, one of the responsibilities of the infrastructure sharing project management team was to host weekly project calls for all stakeholders (co-deploying or sharing entities) to "keep track [of any developments, and] adjust together as a group."

Coordinated external communications

Once buy-in is assured, and work begins against a shared project plan, the co-deployment activity may result in unexpected disruptions to utility services. Highly coordinated communications and resolution is critical to keeping stakeholders onboard.

The scenarios for potential disruption should be identified as part of the upfront project plan. Risks and risk mitigation activities need to be identified, agreed, and resourced ahead of the formal project launch. Disruptions to any critical utility services, including telecommunication, can be expected to create delays and may impact the support of key stakeholders. While the cause of disruptions may be easily attributed to individual entities, resolution is a shared goal for co-deployment initiatives requiring early, regular and coordinated communications to affected parties. The civil works themselves may also be more socially acceptable and supported if communities are aware that they are being done as efficiently as possible, and with minimal disruption through infrastructure sharing. Indeed, in some market the deployment activities themselves are used to pre-market the availability of planned new services.

Communicating the benefits of co-deployment and sharing to government, community, utility, and other external stakeholders helps motivate existing players to continue supporting such efforts, and new players to join in. For these reasons, a joint communication strategy is recommended, including, for example, joint communication to direct stakeholders, customers, and the public, single points of contact for managing complaints, assignment of an incident response team and related processes to be mobilized in the event of a disruption, as well as co-branded signage showing the collaboration.

Governance and incentives

Infrastructure co-deployment and sharing projects need a well-defined incentive structure or framework to encourage greater buy-in, participation, and commitment from stakeholders, particularly infrastructure asset owners. In place of a formal framework, case studies can be a useful way of demonstrating the tangible benefits of shared infrastructure deployment. Such case studies can also be a rich source of material to estimate potential cost savings, financial returns, and risks.

Project governance is essential to making sure that each stakeholder fulfils their commitments and roles to deliver the overall initiative. Strong governance helps reduce the risk that the benefits of co-deployment are eroded by unilateral nonperformance. Project managers are also responsible for ensuring that the milestones of each individual component project are achieved on time and to expectation. Given the interdependencies both during deployment and then in operations, the delivery of all milestones as planned may be critical for all stakeholders to justify their initial involvement.

Monitoring and evaluation

As with any project, monitoring and evaluation is critical to ensuring the project goes according to plan, within expected time frame, and within budget. Critically, a good monitoring and evaluation process will provide an accurate picture of the tangible benefits of infrastructure co-deployment and sharing, and will be based on both quantitative and qualitative measures that capture the financial, social, environmental, and other benefits of sharing.

Technical considerations for co-deployment

The technical considerations for infrastructure sharing and co-deployment differ depending on the nature of the infrastructure being shared. Sharing of passive infrastructure normally encompasses real estate, such as land, buildings, street furniture, and other fixtures. The considerations for sharing land or rights-of-way will differ compared to, say, sharing a tower, a conduit, a comms room, or a lamppost.

For co-deployments that include fiber-optic cable networks, a general good practice is to install conduits through which fiber can be routed alongside the infrastructure project, either as part of the project or at a future date by one or many players. Installing conduits alongside the construction of infrastructure such as roadways, railways, water, and sewer systems minimizes the need to re-dig channels for fiber at a later date, which would cause disruption and may lead to poor reinstatement of surfaces.

Project managers have to ensure that any conduits installed are built to a local standard that is agreed with potential users and relevant authorities, regularly inspected and maintained, and tracked and inventoried for future use. Poor practice in any of these areas may lead to the conduits breaking down, filling up with dirt or waste, being disrupted at a future date, or otherwise becoming unusable. The same issue may apply whether the conduits are left empty or preinstalled with dark fiber.

Other technical considerations include project aspects that are adjacent to the infrastructure deployment itself, such as a geographic information system (GIS) or asset management system to keep track of deployed conduits, or the creation of a pricing strategy for the infrastructure sharing scheme. Other aspects to be considered would include a full elaboration of the required passive and active telecom network assets and demarcation points, a service portfolio, controls on pricing, and the elaboration of a commercial strategy and relevant approvals for a party to manage these activities and the service wrapper. It would also typically require a transparent procurement process and pre-engagement of stakeholders. The cost of project management (including personnel costs), new billing and accounting processes, network operations center costs, and the creation of market research and business plans related to infrastructure co-deployment and sharing also need to be addressed. The costs and risks associated with these activities need to be compared in a dedicated business case to estimated savings, avoided costs, new revenues or social benefits stemming from co-deployment and sharing, and this for each stakeholder entity.

Table 6 presents issues to consider across technical and internal dimensions for project deployments.

Table 6: Roadmap for Infrastructure Sharing

Technical	Internal[a]

• Pricing strategy for the services to be provided (model, LRIC calculation)
• Sales model (e.g., IRU/non-IRU model)
• Standard terms and conditions
• GIS and asset management system
• To close the national OPGW network gaps
• For provision of capacity services, in addition to the above the following is required:
  • To deploy IP/MPLS
  • To deploy DWDM
• For infrastructure sharing cross-border, the following is required—to close the international OPGW network gaps with neighboring countries
	• Setup of internal processes to support telecom activities
	• Model and process for billing and separate accounting
	• Flexible procurement process
	• Project manager (new employee)
	• Market research and business plan
	• Market activities plan
	• New plan for customer implementation process
	• Access to the sites (security process part of general terms and conditions)

DWDM = dense wavelength division multiplexing, IP/MPLS = internet protocol/multiprotocol label switching, IRU = indefeasible right of use, LRIC = long-run incremental costs , OPGW = optical ground wire.

[a] These activities are often better outsourced to a qualified third party.

Source: Inter-American Development Bank. 2020. *Digital transformation infrastructure sharing in Latin America and the Caribbean*. Washington, DC.

Good Practices in Government Policy to Encourage and Implement Co-deployment

Wide range of approaches

A wide range of approaches and justifications exist for cross-sector infrastructure co-deployment and sharing, encompassing different levels of cooperation between stakeholders. These can range from one-time projects, for example, involving the co-deployment of fiber along the construction of a new road, to long-term agreements involving the sharing of existing and future infrastructure. These approaches, in turn, may be instated by various mechanisms, ranging from voluntary industry initiatives, bilateral agreements, multisector projects, to local or national policy changes (Figure 6).

Each approach comes with its own set of costs and incentives for infrastructure asset owners and for telecommunication operators. Project managers can estimate the savings, or additional revenue, versus the risks and costs of a sharing project by analyzing the financial impact of the technical adjustments to a project to accommodate infrastructure sharing; and of the internal processes that need to be changed or created if infrastructure sharing is to be included.

Figure 6: Range of Intervention Types for Implementing Cross-Sector Co-deployment, Including Examples

ACTORS	Asset owners	Asset owners	Industry	City/Municipal	National/ subnational government	National/ subnational government
APPROACHES	**Direct investment by asset owners from different sectors**	**Bilateral agreement between asset owners from different sectors**	**Voluntary industry-led initiatives, membership-based services**	**Directives**	**Government-sponsored collaboration and PPP**	**National legislations, policies, and regulations**
EXAMPLES	ADB's Bengaluru Smart Energy Efficient Power Distribution Project (India)	Zambia CEC Liquid Telecom	BeforeuDig (Australia, New Zealand, Ireland, Singapore, and the United Kingdom)	Earthworks Guidelines by Urban Redevelopment Authority and Dial-before-u-dig (Singapore)	Poland, Ireland, NetLink Trust Singapore	Dig Once Policy (United States), Australia, Malaysia, Republic of Korea, People's Republic of China

ADB = Asian Development Bank.

Source: Authors.

Maintaining a geospatial inventory of infrastructure for sharing

Any infrastructure sharing project will benefit from a geospatial inventory of infrastructure. The inventory will help determine the full scope and scale of infrastructure to be shared and is especially useful in keeping track of infrastructure assets across entities or sectors. Examples include an inventory of all roadside conduits, or utility poles for the attachment of fiber.

In some cases, a cross-sector geospatial inventory of infrastructure is maintained at the national level. For example, Germany's 2009 Federal Government Broadband Strategy included measures optimizing the shared use of existing infrastructure, including the development of an infrastructure atlas and database on construction sites, promoting collaboration on ducts and other infrastructure. The Bundesnetzagentur (Federal Network Agency) infrastructure atlas now contains 15 different types of infrastructure from more than 750 infrastructure asset owners with over 18 million geo-data sets, and the data are primarily used for the expansion of broadband networks.[34] A similar initiative has been established since 2011 in Poland.

If well managed, a national-level geospatial inventory has the benefit of monitoring and analyzing the costs and impacts across multiple projects. For example, data presented at the Geospatial World Forum 2019 showed that in 2017 there were 316,442 cases of existing utilities being hit by excavation for new deployments with a total cost of $1.3 billion.[35] Each case directly costs an average of $4,000 to

34 GeoSoftware. The infrastructure atlas of the Bundesnetzagentur (Federal Network Agency).

35 M. Fuller. 2002. Live gas lines to carry energy and information. *Lightwave.* 1 July.

rectify, with indirect costs related to increased traffic and service disruption estimated to cost a further 30 times this amount. Another estimate in the US is that construction bids are inflated by 10%–30% to accommodate for the risk—and associated costs—of disrupting existing subterranean infrastructure.[36]

These disruptions can be minimized if project managers can consult with a geospatial inventory during planning and deployment. One approach is to have an inventory accessible to entities building new infrastructure, containing geospatial location of existing utilities. Some entities might be reluctant to make geospatial information on their assets accessible to third parties via a public inventory. An alternative model, such as that implemented in Sweden, involves entities consulting with a central body for clearance of their planned deployment, to ensure no existing utilities will be hit. Only this central trusted body has direct access to the inventory, assuaging possible privacy and competition concerns from owners of existing infrastructure. Similarly, in the Transport for London/Greater London Authority infrastructure collaboration example, the implementation of an infrastructure mapping application to provide visibility not only into existing infrastructure assets, but also future near-term plans, coupled with the involvement of the mayor's office providing political clout, allowed for discussions to occur about accelerating planned upgrades through co-deployment in areas that were already being disrupted by other utilities.

National, international, and cross-industry coordination

Infrastructure sharing works best if it takes into consideration all available infrastructure networks within an area, regardless of sector, and across municipal or even national boundaries. A lack of coordination or legal restrictions prevents operators and infrastructure asset owners from sharing their infrastructure. Addressing the barriers of cross-border and cross-sector infrastructure sharing is critical to the success of sharing projects, especially as they pertain to rights-of-way. Coordination can be instituted via a formal dig once policy, or via bilateral or multilateral agreements between stakeholders.

Harmonization of relevant sector regulations

Infrastructure sharing between telecom operators can be relatively straightforward, as all parties involved are bound by the same policies and regulations. On the other hand, cross-sector infrastructure sharing may be impeded by differing policies regarding deployment, particularly as they pertain to land use regulations for the deployment of passive infrastructure.

Land use rights that limit a utility's ability to share are a major impediment to cross-sector infrastructure sharing, as evidenced by the difficulties and delays that face telecommunication providers in securing rights-of-way. Harmonizing policies for land use and other permitting issues across sectors, or otherwise creating special provisions for infrastructure sharing, would help ease infrastructure sharing projects.

Stable and transparent regulations are also an important way to ensure that incentives for sharing remain sustainable for all stakeholders. Opaque or arbitrary changes to rules, such as imposing new rate regulations, are detrimental to the long-term attractiveness of sharing. Table 7 presents some regulatory and policy conditions between electricity and telecommunication industries for infrastructure sharing.

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[36] J. Garrity and R. Pepper. 2013. Convergent Objectives, Divergent Strategies. *World Economic Forum Global Information Technology Report 2013*.

Table 7: Roadmap for Infrastructure Sharing between Electricity and Telecommunication Network Entities

Regulatory
• Authorization from the energy regulator to engage in provision of other services (outside electricity market) • Explanation/decision of the energy regulator with regards to treatment of "non-regulated" revenues • Authorization (license) from the telecom regulator to engage in provision of wholesale backbone services/infrastructure • Review/update of the regulatory framework for infrastructure sharing, including dispute resolution • Perform/update an analysis of the relevant market for wholesale provisioning of trunk (backbone) segments of leased lines • Review/update the law on procurement to allow efficient and quick purchase of telecom equipment for (public) electricity company • For cross-border infrastructure sharing, review applicable regulation with regards to cross-border connections and contracts
Policy
• Relevant and coordinated policy provisions in relevant digital and energy strategies • Secure support toward infrastructure sharing through the ownership structure, including strategic and political support

Source: Inter-American Development Bank. 2020. *Digital transformation infrastructure sharing in Latin America and the Caribbean*. Washington, DC.

Encouraging competition

One concern with infrastructure sharing is that cooperation between multiple operators and infrastructure asset owners can lead to reduced resiliency and/or redundancy, collusion, inefficient network deployments and operations, and suboptimal prices for consumers. Related to this is the possibility that the greater market access an operator gains through infrastructure sharing will lead to market dominance, negatively affecting industry competitiveness.

Project managers will do well by addressing this ahead of any concerns by regulators or other parties. To do this, infrastructure providers should have transparent, commercially negotiated access rates based on actual cost or in accordance with regulated tariffs where these are established. A "fair market rate" is bound by the following principles (footnote 12):

- The charge should serve to promote the efficient use of assets and sustainable competition and maximize benefits for customers.
- Access charges must reflect a reasonable rate of return on capital employed and consider the investment made by the infrastructure provider.
- Access charges must only reflect the unbundled components that the infrastructure seeker wishes to use. An infrastructure provider must unbundle distinct facilities and corresponding charges sufficiently so that the infrastructure seeker need only pay for the specific elements required where this is in the interest of consumers and does not protect dominant market positions.

- Access charges must be transparent.
- Access charges must be impartial, nondiscriminatory, and no less favorable than those the infrastructure provider offers its subsidiaries, affiliates partners, or any other licensee.

Taken together, these ensure that infrastructure sharing resources are reasonably available to all interested market players, and in the long term, the sharing project does more to improve broadband access and rates than it does operators' profit margins.

Another concern is around mandates that may lead to inefficient outcomes. Mandating dig once, for example, may make sense in certain situations (such as high-density urban deployments), but may just delay the delivery of quick wins for large-scale rural builds, for example.

Addressing low-revenue areas

Low-revenue areas may present a challenge to infrastructure sharing projects, as few, if any, operators are likely to want to deploy infrastructure to these locations. On the other hand, low-revenue areas are more likely to benefit from shared costs and improved service delivery. Project managers will generally need to have a way to encourage both operators and infrastructure asset owners to extend fiber-based broadband networks to these areas where the economics for an individual infrastructure investor may be broken or marginal.

Some form of central coordination, public investment, or other incentive might be necessary to tip the business case and encourage the private sector to bring their infrastructure to these target communities. Use of the national shared fiber backbone in Bhutan, for example, is free to operators, provided they "take managed infrastructure to all 20 *dzongkhags* [municipality districts]." Government intervention in these communities can bring the most impact in terms of expanding broadband access. Sharing projects could consider accessing state resources or otherwise coordinating with government to deploy passive infrastructure to these low-revenue areas, ideally alongside planned public works such as highways or railways. The infrastructure, particularly conduits, can then be made available to operators on an open access basis.

IV. RECOMMENDATIONS

Multilateral development banks, donor organizations, and other international economic institutions are well positioned to play a leading role in advocating, encouraging, and implementing cross-sector infrastructure co-deployment and sharing initiatives because of their role and position in not only directly funding infrastructure projects, but also in providing technical assistance to project preparation, and guiding governments on policies and regulations across sectors. These efforts span advocacy and encouragement, through to mandates and regulations and encourage the pull-through of new private sector investment.

Encouraging cross-sector infrastructure co-deployment and sharing in projects

1. **Knowledge sharing: advocate for cross-sector infrastructure co-deployment and sharing, highlight good practice, and present relevant assessment tools.** Development finance institutions (DFIs) are leading infrastructure deployment and financing organizations that carry much influence with developing country governments and ministries. DFIs can play a significant role in sharing more information about the impact of cross-sector infrastructure co-deployment and sharing, and providing useful tools to assess the costs, risks, and benefits of co-deployment and sharing. Similarly, they can model perspectives that allow for cross-sector infrastructure co-deployment and sharing to flourish, such as emphasizing long-term budget planning, whereby the additional costs of co-deployment are recouped through longer-term benefits.

2. **Provide technical assistance in both enabling environment analysis, as well as project preparation that takes into account the potential of cross-sector infrastructure co-deployment and sharing.** Assistance can review key policy, legal, and regulatory frameworks for conduciveness of cross-sector infrastructure co-deployment and sharing and compare against relevant good practice examples. Similarly, project preparation assistance could include relevant assessment of the business case for taking a cross-sector approach.

3. **Review internal processes that could incentivize, or hinder, cross-sector infrastructure co-deployment and sharing in DFI projects.** DFIs fund tens of billions of dollars of infrastructure projects annually and catalyze much more through other mechanisms such as grants, technical assistance, and policy-based lending. Internal mechanisms could be adjusted to maximize the opportunity to build in cross-sector infrastructure co-deployment and sharing where it makes sense. However, the sector-based approach of DFIs can disincentivize the expansion of project scope.

Encouraging public policy that advances cross-sector infrastructure co-deployment and sharing

1. **Encourage governments to share information on opportunities for cross-sector infrastructure co-deployment and sharing.** Infrastructure atlases, databases, and repositories of existing and planned infrastructure deployments, as well as the rules for inclusion of and access to that information, are a critical step in opening the possibility of sharing to infrastructure asset owners and developers. This will help operators cost and plan their infrastructure deployment more accurately. Similarly, opening direct opportunities for cross-sector infrastructure sharing with publicly-owned infrastructure assets can spur greater sharing.

2. **Encourage more flexible rules for cross-sector infrastructure co-deployment and sharing in the public sector.** For example, the breaking down of institutional silos within the public sector can help build stronger cross-sector infrastructure initiatives governed by public procurements, public–private partnerships, public concessions, as well more flexible governance structures for state-owned assets and others. Creating standardized wayleave agreements for deployment of fiber and wireless networks, for example, could reduce cost and time.

3. **Consider mandates and regulations carefully.** Regulations that open the possibility to share infrastructure across sectors should be balanced and reviewed to ensure cross-sector infrastructure sharing does not lead to anti-competitive effects that may harm consumers. Rather, such regulations should ensure access to shared infrastructure is open, nondiscriminatory, and administered effectively and efficiently. All mandatory interventions should be reviewed and catered toward local market conditions.

APPENDIX 1: EXAMPLES OF CO-DEPLOYMENT PROJECTS

Country	Project Name	Sectors Co-deploying/ Sharing	MDB Involvement	Intervention Type
Kiribati[a]	Road Rehabilitation Project	Roadway; Telecommunications	Yes, ADB	Infrastructure asset owners: Direct investment in multiple sectors
India	Bengaluru Smart Energy Efficient Power Distribution Project[b]	Power (electricity); Telecommunications	Yes, ADB	Infrastructure asset owners: Direct investment in multiple sectors
Cameroon/ Chad[c]	Doba–Kribi pipeline	Energy (oil); Telecommunications	Yes, World Bank	Infrastructure asset owners: Multilateral agreement
Mali, Mauritania, Senegal	Société de Gestion de l'Energie de Manantali[d] (SOGEM)	Power (electricity); Telecommunications	Yes, (World Bank financed a consultancy to assist SOGEM in considering several business models for commercializing unused fiber on its network)	Infrastructure asset owners: Multilateral agreement
Kosovo	KOSTT[d]	Power (electricity); Telecommunications	Yes, Ministry of Economic Development received assistance from the World Bank to develop a GIS atlas that will serve as an inventory of existing and planned infrastructure assets so that the scope and opportunities for the sharing of infrastructure can be better visualized by public utilities and telecom companies.	Infrastructure asset owners: Direct investment in multiple sectors
Africa[e,f]	Programme for Infrastructure Development	Power (electricity); Railways; Roadways; Telecommunications	Yes, Islamic Development Bank/African Development Bank	Infrastructure asset owners: Multilateral agreement
South Africa[g]		Energy (not specified); Railways; Telecommunications	Uncertain	Infrastructure asset owners: Multilateral agreement
Rwanda[g]		Housing developer; Telecommunications	Uncertain	Infrastructure asset owners: Multilateral agreement
Lesotho	LEC Communications (Pty) Ltd[h]	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
India	RailTel[i]	Railways; Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Zambia	CEC Liquid Telecom[i]	Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Estonia, Latvia, Lithuania	Baltic Optical Network[i]	Power (electricity); Telecommunications	No	Infrastructure asset owners: Multilateral agreement
United States	Kennedy Interchange[i]	Power (electricity); Telecommunications	No	National/Subnational: policies and guidelines; Infrastructure asset owners: Multilateral agreement (project led by the DOT but paid for and agreed upon by different utility companies)
India	Bombay Gas[i]	Energy (gas); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors

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Country	Project Name	Sectors Co-deploying/ Sharing	MDB Involvement	Intervention Type
Malawi	Electricity Supply Corporation of Malawi (ESCOM)[i]	Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Spain	Adif-REE[h]	Power (electricity); Railways; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Japan	Sewer Optical Fiber Teleway Plan[c]	Sewerage; Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Ghana	Electricity Transmission Line Fiber[c]	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Tunisia	Société Nationale des Chemins de Fer Tunisiens[c]	Railways; Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Poland	Information Broadband Infrastructure System[c]	GIS mapping system; Telecommunications	No	(Program came first then policy after)
Tunisia[j]	Société Nationale des Chemins de Fer Tunisiens (SNCFT)	Railways; Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
	Tunisie Autoroutes; Tunisie Telecom	Roadways; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Kenya[k]	4G Special Purpose Vehicle (SPV)	Equipment vendor; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Morocco[k]	Office Nationale des Chemins de Fer (ONCF) – Meditel	Railway; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
	Office National de l'Electricité et de l'Eau Potable (ONEE) – INWI	Power (electricity); Water; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Jordan[k]	EDCO/EDCO – National Broadband Network (NBN)	Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreement
	NEPCO – telecommunications industry	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Libya[k]	Next Generation Backbone Network (NGBN) Project	Power (electricity, oil and gas); Irrigation; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Japan[l]	Tunnel Association	Railways; Roadways; Subways; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Tanzania[c]		Power (electricity); Railways; Roadways; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
India[e]	PowerGrid	Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreements (PowerGrid leases to telcos)
	GAILTEL	Power (gas); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors

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Country	Project Name	Sectors Co-deploying/ Sharing	MDB Involvement	Intervention Type
United States[m]	EPB – EPB Fiber	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Ireland[g]	ESB – SIRO	Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Norway[g]	36-utility partnership – Altibox	Utilities; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Italy[g]	Enel Energia – Open Fiber	Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreement
New Zealand[g]	Northpower – Northpower Fiber	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Switzerland[g]	IWB – IWB Net	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Germany[g]	SWM – M-net	Utilities; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Denmark[g]	14-utility partnership – WAOO	Utilities; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Australia[n]	Project Vista	Power (electricity); Telecommunications	No	Infrastructure asset owners: Direct investment in multiple sectors
Canada[o]		Cable; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
France[o]		Sewerage; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
		Municipal infrastructure; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Dominican Republic[p]	Programa de Fomento al Turismo Ciudad Colonial de Santo Domingo	Power (electricity); Cable; Drainage system; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
	Other areas	Power (electricity); Cable; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Bhutan[q]		Power (electricity); Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Mongolia[r]		Railway; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
	Ulaanbaatar–Darkhan road	Roadway; Telecommunications	Unclear, see p. 30	Asset owners: Bilateral agreement
Philippines		Roadway; Telecommunications[s]	No	Infrastructure asset owners: Bilateral agreement
		Railway; Telecommunications[t]	No	Infrastructure asset owners: Multilateral agreement

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Country	Project Name	Sectors Co-deploying/ Sharing	MDB Involvement	Intervention Type
India	Chhattisgarh[u]	Roadway; Telecommunications	No	Infrastructure asset owners: Multilateral agreement (TSPs renting ducts have not been specified, see p. 6 of source)
	BharatNet (formerly National Optical Fibre Network [NOFN] Project)[v]	Roadway; Railway; Power (electricity); Telecommunications	No	Infrastructure asset owners: Multilateral agreement
	Digging Free City[w]	Utilities; Telecommunications	Not specified, see p. 22 of source	Not specified
Bangladesh[u]		Roadway; Railway; Telecommunications	Not specified in source, see p. 14	Infrastructure asset owners: Multilateral agreement
Japan[24]		Sewerage; Telecommunications	No	Unclear from document
Republic of Korea[h]	Korea Expressway Corporation (KEC) – Korea Telecom (KT)	Roadway; Telecommunications	No	Infrastructure asset owners: Bilateral agreement
Russian Federation[h]		Roadway; Telecommunications	No	Infrastructure asset owners: Multilateral agreement
Thailand[h]		Roadway; Telecommunications	No	Infrastructure asset owners: Multilateral agreement

DOT = Department of Transportation, GIS = geographic information system, MDB = multilateral development bank.

[a] ADB. 2018. *Completion Report: Road rehabilitation project in Kiribati*. Manila.

[b] ADB. 2020. *ADB approves $190 million loan to upgrade power distribution system in Bengaluru*. Manila.

[c] Deloitte LLP. 2015. Unlocking broadband for all. Broadband infrastructure sharing policies and strategies in emerging markets. *The Association for Progressive Communications*.

[d] D. Brake. 2019. Submarine Cables: Critical Infrastructure for Global Communications. *Information Technology & Innovation Foundation*.

[e] APCICT. 2021. *Cross-Sector Infrastructure Sharing for Broadband.*

[f] African Development Bank Group. 2021. *Programme for Infrastructure Development in Africa (PIDA)*.

[g] CircleID Reporter. 2021. Close to Half of US East Coast Fuel Supply Shutdown Due to Ransomware Cyberattack. *CircleID*. 10 May.

[h] World Bank. 2017. Module 8: Business and project case studies. In: *Cross-sector infrastructure sharing toolkit*.

[i] Exceptions are locations where fiber is unavailable and costlier than alternative backhaul technologies.

[j] World Bank. 2014. *Broadband Networks in the Middle East and North Africa: Accelerating high-speed internet access.* Washington, DC.

[k] ITU Interactive Transmission Maps. ITU Interactive Transmission Maps. Note, however, the data presented by the ITU is limited in that the figures are based on population proximity to transmission infrastructure and underestimate proximity to fiber-optic cables in access networks, particularly in urban centers.

[l] Inter-American Development Bank. 2020. *Digital transformation infrastructure sharing in Latin America and the Caribbean.* Washington, DC.

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[n] CSMG. 2010. *Economics of share infrastructure access.* United Kingdom.

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APPENDIX 2: NATIONAL AND SUBNATIONAL CO-DEPLOYMENT POLICIES

Country	Name of Policy	Short Description	Intervention Type
Australia[a]	Dial before you dig	Membership-based organization	Industry guidelines/ initiatives (association)
Malaysia[b]	"Call-before-you-dig"	Communications and Multimedia Act Part X General, Chapter 1: Installation of Network Facilities, Access to Network Facilities etc.; connected to the Malaysian Communications and Multimedia Commission	National/Subnational: Policies and Guidelines
Republic of Korea	Road Act[c]	Road Act provides the basis for establishing communication facilities along the roads. It is mandatory for a road management authority to provide traffic information to the road users. Communication facilities are installed along the road as a road appurtenance. Article 3 (Responsibilities of the State) (1) The State shall formulate a comprehensive plan for the construction, management, safety, etc. of road networks and shall formulate and implement policies necessary therefor. (2) When a road management authority formulates a road plan or constructs or manages a road, it shall take the following principles into account: 1. The road management authority shall thoroughly reflect the consensus of residents, competent experts, and stakeholders to prevent social conflicts. 2. The road management authority shall minimize environmental impacts. 3. The road management authority shall ensure that the road is maintained in a proper condition. 4. The road management authority shall harmonize the road functions and the land use in adjoining areas, thus ensuring the road's sustainability. 5. The road management authority shall conserve local communities as much as possible. 6. The road management authority shall set up a road traffic information system for the safe and convenient use of the road. Article 60 (Establishment and Operation of Road Traffic Information Systems) (1) A road management authority may establish and operate a road traffic information system to efficiently conduct administrative affairs relating to using and managing roads. (2) A road management authority may collect and process the road information specified in the following through a road traffic information system and provide such information to the general public through the road traffic information system: 1. Information about road traffic. 2. Information about road accidents. 3. Other matters specified by Presidential Decree. (3) The details of information that shall be managed through a road traffic information system and matters necessary for the establishment and operation of a road traffic information system or the provision of information and the management of such administrative affairs through the road traffic information system shall be prescribed by Presidential Decree.	National/Subnational: Regulations, legislation, and mandates
Republic of Korea	National Transport System Efficiency Act[d]	National Transport System Efficiency Act provides a basis for the collection, communication, processing, and provision of traffic information, and the installation and operation of a traffic center. The act also stipulates that each road management authority should follow a standardized intelligent transport system (ITS) in Article 73. Article 73 (Formulation, etc. of Master Plans for ITS) – The Minister of Land, Infrastructure and Transport shall formulate a 10-year master plan for ITS on a national scale to promote the development and dissemination of intelligent land, marine, and air transport systems.	National/Subnational: Regulations, legislation, and mandates

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Country	Name of Policy	Short Description	Intervention Type
Republic of Korea	Telecommunications Business Act[e]	Federal Communications Commission This act provides a basis for the Road Authority to provide carriers. Article 35 (Provision of Equipment and Facilities) (1) Where a telecommunications business operator requests a common telecommunications business operator or an authority that constructs, operates or manages roads, railroads, subways, water and sewage systems, electrical equipment, telecommunications line equipment and facilities, etc. (hereinafter referred to as “facility management authority”) to provide him/her with ducts, common utility conduits, poles, cables, stations, or other equipment (including telecommunications equipment and facilities; hereinafter the same shall apply) or facilities (hereinafter referred to as “equipment and facilities”), such common telecommunications business operator or such facility management authority may provide equipment and facilities by contract with him/her. (2) Any of the following common telecommunications business operators or facility management authorities shall provide equipment and facilities by contract, notwithstanding the provisions of paragraph (1): Provided, that this shall not apply in cases where a facility management authority plans to use such equipment and facilities; 1. A common telecommunications business operator who possesses equipment and facilities indispensable for other telecommunications business operators to provide telecommunications services; 2. Any of the following facility management authorities who possess equipment and facilities, such as ducts, common utility conduits, or poles: (a) Korea Highway Corporation established under the Korea Highway Corporation Act; (b) Korea Water Resources Corporation established under the Korea Water Resources Corporation Act; (c) Korea Electric Power Corporation established under the Korea Electric Power Corporation Act; (d) Korea Rail Network Authority established under the Korea Rail Network Authority Act; (e) A local public enterprise under the Local Public Enterprises Act; (f) A local government under the Local Autonomy Act; (g) A regional construction management administration under the Road Act; 3. A common telecommunications business operator or facility management authority whose scale of the business, market share, etc. of common telecommunications services meet the standards prescribed by Presidential Decree. (3) The Korea Communications Commission shall establish and publicly announce the scope of equipment and facilities under paragraphs (1) and (2) and the guidelines for the conditions, procedures, methods, and calculation of prices for providing such equipment and facilities. In such cases, the scope of equipment and facilities to be provided under paragraph (2) shall be determined in consideration of the demand for equipment and facilities by common telecommunications business operators or facility management authorities falling under any subparagraph of the same paragraph. (4) A telecommunications business operator who has been provided with equipment and facilities may install the apparatus enhancing the efficiency of the relevant equipment and facilities to the extent necessary to provide telecommunications services.	National/Subnational: Regulations, legislation, and mandates

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Country	Name of Policy	Short Description	Intervention Type
		(5) The Korea Communications Commission may, as prescribed by Presidential Decree, order a telecommunications business operator or facility management authority to submit data concerning equipment and facilities, so as to efficiently utilize and manage equipment and facilities. In such cases, the telecommunications business operator or facility management authority shall comply with such order unless justifiable grounds exist. (6) The Korea Communications Commission may designate a specialized institution to provide equipment and facilities under paragraphs (1) and (2). (7) Matters necessary for the designation of a specialized institution under paragraph (6) and the methods of business operations shall be determined and publicly announced by the Korea Communications Commission.	
Singapore	BeforeUDig	Commercial entity	Industry guidelines/ initiatives (commercial entity)
Singapore	Earthworks Requirements	Policy of the Infocomm Media Development Authority to protect telco networks. Lays out practical steps that can be adopted to dig once approach elsewhere	National/Subnational: Policies and guidelines
Portugal[f]	Resolution No. 120/2008	Autoridade Nacional de Comunicações' (ANACOM) implementation of statutory powers to ensure access to the infrastructure of incumbent telecommunications operator Portugal Telecom (PT) and ANACOM's subsequent regulation of access prices. The implementation of a symmetric regulatory framework that mandated open access to all public infrastructure and established a centralized information system to coordinate access to and construction of civil works. Established the promotion of next generation access networks as a strategic priority of the country.	National/Subnational: Policies and guidelines
	Decree Law 123/2009	And its amendments establish the legal and regulatory framework that governs construction and access to passive infrastructure for telecommunications use.	National/Subnational: Regulations, legislation, and mandates
European Union (EU)	EU Guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks[g]	European Commission (29) Given that generally a large part of the cost of deploying NGA networks is in the civil engineering work (42), member states may decide in accordance with the EU regulatory framework for electronic communications, for instance, to facilitate the acquisition process of rights of ways, to require that network operators coordinate their civil engineering works and/or that they share part of their infrastructure. In the same vein, member states may also require that for any new constructions (including new water, energy, transport, or sewage networks) and/or buildings a connection suitable for NGA should be in place. Third parties may also place at their own cost their passive network infrastructure when general civil engineering works are carried out in any event. This opportunity should be offered in a transparent and nondiscriminatory way to all interested operators and should in principle be open to all potential users and not just electronic communications operators (i.e., electricity gas, water utilities, etc.) (43). A centralized inventory of the existing infrastructure (subsidized or otherwise), possibly also including planned works, could help the rollout of commercial broadband (44). Existing infrastructure does not only concern telecommunication infrastructure, such as wired, wireless or satellite infrastructure, but also alternative infrastructures (sewers, manholes, etc.) of other industries (such as utilities) (45).	Supra-national: Policies and guidelines

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Country	Name of Policy	Short Description	Intervention Type
European Commission	Directive 2014/61/ EU of the European Parliament and the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks.[h]	In an attempt to stimulate the rollout of NGA, the directive sets new rights and obligations directly applicable to telecom operators and other utilities. Its main goals are to reduce the cost of high speed broadband deployment by: giving electronic communications providers access to the physical infrastructures of utilities network operators, for example in the telecoms, electricity or waste water sectors, and to any existing in-building physical infrastructures; equipping all new or renovated houses with a 'high speed ready' infrastructure; providing time limits on the process of permit granting for civil works; and setting out requirements for the transparency of information on physical infrastructures and on dispute resolution procedures relating to access to such infrastructures.	Supra-national: Policies and guidelines
Morocco	Digital Morocco Plan for 2020 (Plan Maroc Numéric 2020)[i]	Government of Morocco (2) To promote, through regulatory provisions, synergies between civil engineering works (water, electricity, and road transport) and those related to the extension of the optic fiber backbone network and the copper network; (3) Encourage joint investments among operators to reduce costs;	National/Subnational: Policies and guidelines
Bahamas[j]		Utilities Regulation and Competition Authority Enacted a set of infrastructure-sharing regulations in September 2015, setting obligations, procedures, and directives on price setting for infrastructure sharing among operators. These regulations also include special provisions for construction, use, and sharing of communication towers.	National/Subnational: Regulations, legislation, and mandates
Germany[k]	Nationwide infrastructure atlas	Bundesnetzagentur The atlas contains spatial data information on existing infrastructures in Germany that can be shared in principle for the construction of broadband networks and to increase the transmission capacity of existing networks. Data are included in existing passive infrastructure provided by infrastructure asset owners from different industries. These include companies in the energy and telecommunication sector as well as relevant infrastructure of the public sector.	National/Subnational: Policies and guidelines
People's Republic of China	Urgent Circular on Promotion of Joint Construction and Sharing of Telecom Infrastructure[l]	Ministry of Industry and Information Technology (MIIT) MIIT, along with other regulators, issued the Urgent Circular on Promotion of Joint Construction and Sharing of Telecom Infrastructure, which specifically points out that "MIIT have decided to vigorously promote the joint construction and sharing of the telecom network facilities in response to actual conditions of the telecom restructuring and a new round of upcoming network construction with a view to further implementing the Scientific Outlook on Development and the requirements for construction of a resource saving and environment friendly society, reducing the consumption of land, energy and raw materials, protecting the natural environment and landscape, reducing the telecom reconstruction and improving the utilization rate of the telecom network facilities."	National/Subnational: Policies and guidelines
Hong Kong, China[l]	Article 36AA of Chapter 106 of the Telecommunications Rules	Office of Telecommunications Authority (OFTA) OFTA encourages operators to reach an infrastructure sharing agreement through voluntary negotiation. If operators cannot reach a business agreement of their own accord, OFTA can require the relevant operators to seek coordination or cooperation according to Article 36AA of Chapter 106 of the Telecommunications Rules.	National/Subnational: Regulations, legislation, and mandates

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Country	Name of Policy	Short Description	Intervention Type
Singapore[m]	Code for Telecom and Media	Infocomm Media Development Authority of Singapore Mandates sharing of: (a) radio distribution systems for mobile coverage in train or road tunnels; (b) in-building cabling (where the occupant elects to take service from another service provider); and (c) lead-in ducts and associated manholes.	National/Subnational: Regulations, legislation, and mandates
Canada[n]	Telecommunications Act (1993)	Canadian Radio-television and Telecommunications Commission (CRTC) Conferred the CRTC with the power to grant cable companies and telecommunication carriers access to the support structures of other carriers. Infrastructure sharing is recognized as providing competitive and environmental benefits. The CRTC's jurisdiction does not extend to utility infrastructure.	National/Subnational: Regulations, legislation, and mandates
Dominican Republic[o]	El Decreto 258-16 (República Digital)	El Gobierno de la República Dominicana In order to carry out this Program, it is necessary that all municipal districts have access to the fixed and mobile internet. Through the sharing of infrastructure, it is possible to expand these services to the entire country, especially to those municipal districts that do not have it. The sharing of infrastructure will allow services to be more accessible to the inhabitants of the Dominican Republic, thus achieving a maximum penetration of the highest fixed broadband in households. (via Google Translate)	National/Subnational: Regulations, legislation, and mandates
Bhutan[p]	National Broadband Masterplan Implementation Project	Department of Information Technology and Telecom (DITT) Encourages co-deployment of the information and communication technology and electricity infrastructure	National/Subnational: Policies and guidelines
	2014 Bhutan Telecommunications and Broadband Policy	Promote orderly and efficient growth of the telecommunications infrastructure and reduce unnecessary redundant infrastructure; Establish and enforce infrastructure sharing rules;	National/Subnational: Policies and guidelines
Mongolia[q]	Government Resolution #80 of 2004	Ministry of Infrastructure Transfers the ownership of the four core fiber-optic cable along the rail (owned by Ulaanbaatar Railways JSC [UBTZ]) to Telecom Mongolia.	National/Subnational: Regulations, legislation, and mandates
People's Republic of China (PRC)	Five Vertical and Seven Horizontal Highway Plan	Ministry of Communications (Formerly Ministry of Transport) Laid the foundation for a sustained and rapid development of PRC's expressway. As a result, the Expressway Communication, Monitoring and Toll Collection System was built simultaneously on this Beijing–Tianjin–Tanggu Expressway.	National/Subnational: Policies and guidelines
	No. Engineering [1992] 830	Communications Sector cooperates with the Highway Sector for the Main Line Communication Pipes, which are built within the rights-of-way of Highway by the Expressway Construction Project Entity. Laying of the Communication Pipes should be synchronized with the subgrade civil earthwork construction of Expressway.	
India[s]	National Digital Communications Policy 2018	Digital Communications Commission Establishing common service ducts and utility corridors in all new city and highway road projects, and related elements. Encourage and facilitate sharing of active infrastructure by enhancing the scope of infrastructure providers and promoting and incentivizing deployment of common sharable, passive as well as active, infrastructure.	National/Subnational: Policies and guidelines

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Country	Name of Policy	Short Description	Intervention Type
Turkey[r]	Turkey Transport and Communication Strategy, Goal 2023	Terrestrial networks along rights-of-way of Railways and Highways and Submarine Cables through the coasts will be realized.	National/Subnational: Policies and guidelines
	National Broadband Strategy and Action Plan (2017–2020)	Ministry of Transport and Infrastructure to be carried out in cooperation with Ministry of Environment and Urbanization, Information Technologies and Communications Authority, General Directorate Highways, General Directorate of State Railways, and some other entities. Facilitating the passive infrastructure installation with the purpose of developing new Generation Access Networks.	
	Policy Circular on Fiber-optic Cable (FOC)	Prescribes the Installation Procedures along the Highway Network of General Directorate of Highways. It aims for the inclusion of FOC Infrastructure in the Road Design Process and determines the Technical Rules for FOC laying on Highways/Roads open to traffic meeting the Communication needs of ITS on State Roads and the Highway Network of General Directorate of Highways.	
Pakistan[u]	Regulatory Framework	Government of Pakistan is laying dedicated optic fiber along our highways and motorways for electronic tolling and other facilities to provide ITS. This will also be available for use by other service providers in the telecom and communications sector.	National/Subnational: Policies and guidelines
Russian Federation[u]	Departmental building codes (VSN 116-2002) SSKTB TOMASS SP 42.13330.2011 RD 45.120-2000 (NTP 112-2000)	Federal road agency (Rosavtodor) Technical regulations for the laying of fiber-optic cables along federal roads	National/Subnational: Regulations, legislation, and mandates
North Carolina, USA[u]	Executive Order 91 forming the Task Force on Connecting North Carolina	Various state agencies Statewide "dig once" policy promoting the installation of broadband conduit or cables during road construction projects	National/Subnational: Policies and guidelines
Utah, USA[v]	R907-64. Longitudinal and Wireless Access to Interstate System Rights-of-Way for Installation of Telecommunication Facilities; Section 72-7-108	State Department of Transportation Utah's state government began implementing dig once policies ahead of the 2002 Salt Lake City Olympics. The state's DOT has since expanded the policy, requiring the installation of oversized conduit for certain road construction projects, while interested telecom parties can then extend that infrastructure to neighboring communities.	National/Subnational: Policies and guidelines
Arizona, USA[u]	Arizona REV. STAT. ANN. § 28-73	State Department of Transportation Arizona's dig once policies are targeted specifically at expanding broadband access to rural communities. The policy states that during road construction projects along rural highways, the DOT can coordinate with telecom companies to install conduit, and enables the agency to lease the conduit to telecom providers at a cost-based rate.	National/Subnational: Policies and guidelines
Minnesota, USA[t]	116J.39-116J.40: Coordination of Broadband Infrastructure Development	Minnesota's state laws encourage the state's Office of Broadband Development to coordinate with the state's DOT for "dig once" measures in planning, relocation, installation, or improving broadband conduit within a right-of-way. It enables the Office of Broadband Development to evaluate procedures and criteria for contracts or lease agreements with telecom companies as well as pricing requirements. It also allows for co-location of fiber and conduit with other utilities in the same trench.	National/Subnational: Policies and guidelines

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Country	Name of Policy	Short Description	Intervention Type
Nevada, USA[t]	SB 53, creating the Nevada Telecommunications Advisory Council	Nevada state legislature formed the Telecommunications Advisory Council within the state's DOT in 2017, outlining parameters and regulations for the DOT in coordinating with telecom companies for access to rights-of-way for installing telecommunications equipment. The law charges the council with seeking input from telecommunications providers and the public relating to broadband access, provide recommendations to the state DOT on offering access to rights-of-way to telecommunications providers, as well as approving or denying proposed fiber trade agreements between the DOT and a telecom provider. The DOT is also authorized to enter into agreements with telecom companies and charge fees to access to public rights-of-way, or receive in-kind compensation.	National/Subnational: Policies and guidelines
Maryland, USA[u]	SB 717 – Connecting Rural Maryland Act of 2017	Created the Task Force on Rural Internet, Broadband, Wireless and Cellular Service, which was charged with facilitating cooperation between telecom providers to reduce redundancy, save money, and ensure that all fiber assets are being used efficiently. The task force focused on facilitating cooperation between electric cooperatives and telecom companies. The task force's last report recommended the state include fiber-optic cable as part of its definition of telecommunications equipment, and that it allows utilities to lease excess fiber and/or pole attachment rights for telecommunications, including broadband, without obtaining a separate easement, in order to promote broadband access in rural parts of the state. It has requested that the state's legislature draft authority for electric cooperatives to coordinate with telecom providers in laying fiber.	National/Subnational: Policies and guidelines
	HB 961-Rural Broadband Communication Services	Specifies that nonprofit telecommunications services providers in rural and underserved areas of the State must be allowed to use the right-of-way or easement of specified State agencies for the installation of broadband communication infrastructure without being charged to do so.	National/Subnational: Policies and guidelines
Georgia, USA[w]	SB 402 – Achieving Connectivity Everywhere (ACE) Act	State Department of Transportation Enables the state DOT to develop and implement a long-term policy allowing public rights-of-way to be used for the deployment of broadband services and other "emerging communication technologies" either by the state or private providers. It also requires local governments' comprehensive plans to include elements to facilitate the deployment of broadband services, and it amends the OneGeorgia Authority Act to include broadband services. Finally, the bill authorizes the Georgia Technology Authority to establish policies and programs necessary to coordinate statewide efforts to promote broadband deployments between state agencies, local governments, and industry representatives.	National/Subnational: Policies and guidelines
West Virginia, USA[u]	HB 4447, creating new codes §17 – 2 E- 1-E-9	West Virginia's state government has developed a uniform system for conduit installation for telecom companies that are applying to install telecom infrastructure. Telecom companies must enter into an agreement with the state's Division of Highways for installing conduit in public rights-of-way; companies must also notify the West Virginia Broadband Enhancement Council and all other carriers on record within the state of installation permit. Other telecom companies that are interested in installing their own fiber have 30 days to notify the applicant of interest in sharing the trench. The telecom company is also required to run an advertisement in the relevant media for two weeks advertising the project, to allow other carriers the opportunity to respond. The law also allows the Division of Highways to charge fees for access to public rights-of-way, or accept in-kind compensation from sources such as conduit, dark fiber, access points; other telecom equipment or services or even bandwidth.	National/Subnational: Policies and guidelines

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Country	Name of Policy	Short Description	Intervention Type
Maine, USA[p]	Chapter 344, Sec. 1. 35-A MRSA §2503 sub-§2	Maine's law requires any public entity involved in a construction project to install broadband conduit and authorizes that entity to lease the conduit to telecom companies for installing broadband and/or wireless facilities for the purpose of providing service. The law states that telecom companies proposing broadband deployments must notify the ConnectME Authority with the location and description of the proposed facility and that the Authority must then disseminate that information to all other telecom companies or other entities that may be interested in installing broadband at the same time. The Authority is also tasked with maintaining a map of broadband conduit installations through the state.	National/Subnational: Policies and guidelines
Illinois, USA[u]	605 ILCS 5/9-131) Sec. 9-131	Illinois state law requires the state DOT and the Department of Central Management Services to collaborate in installing fiber network conduit where it does not already exist in every new state-funded construction project that opens trenches along state-owned roadways. Either department is authorized to allow a third-party company to manage the leasing of the conduit to telecom companies, so long as the state can receive market-based pricing for the lease. The state's DOT also coordinates with the Illinois Broadband Deployment Council to compile dig once best practices and draft ordinances for county and city agencies within the state.	National/Subnational: Policies and guidelines
California, USA[x]	Section 1405 of the Government Code	California requires the state DOT to notify telecom companies of state-led highway construction projects through its website to enable companies to collaborate with the state on installing conduit in public rights-of-way during each project.	National/Subnational: Policies and guidelines

DOT = Department of Transportation, NGA = Next Generation Access.

[a] Before You Dig.

[b] Call Before You Dig.

[c] Government of the Republic of Korea. Road Act.

[d] Government of the Republic of Korea. National Transport System Efficiency Act.

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Cross-Sector Infrastructure Co-deployment

Closing Digital Connectivity Gaps through Collaboration and Sharing

Infrastructure co-deployment between sectors is an effective and proven strategy to expand infrastructure service coverage and reduce the costs of deployment. However, in practice, suboptimal levels of infrastructure co-deployment exist because of various market, institutional, and regulatory barriers to infrastructure sharing and co-deployment. This Asian Development Bank Sustainable Development Working Paper details the tools to gauge the potential beneficial impacts of co-deployment, highlights recent examples and good practices, and presents recommendations for multilateral development banks to consider in their own infrastructure projects as well as in providing guidance and direction to governments.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members —49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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ASIAN DEVELOPMENT BANK
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org