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Municipal Broadband Networks—Opportunities, Business Models, Challenges, and Case Studies

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The accelerated use of digital services during the COVID-19 pandemic has highlighted the importance of high-speed Internet access. Yet a large share of adults in emerging markets still live in cities where the availability of high-speed Internet is limited. There is a strong case to be made for municipal broadband networks, which are fully or partially facilitated, built, operated, or financed by local governments, often in partnership with the private sector. There are three basic models for creating and operating these networks, and every network must work in the unique context of the city it will serve. But if they are well implemented, these models can offer digital access to city residents, help close the digital divide, and create opportunities for private sector players in both advanced and emerging markets.

Key Findings

- Municipal broadband networks (MBNs) can result from a number of local initiatives, often in partnership with private sector investors, whereby cities can act as users, rule-makers, financiers, or infrastructure developers.
- Municipal broadband networks can be developed through three types of business models depending city's or private sector investors' involvement in the financing and construction of the network: (i) a passive infrastructure model; (ii) a wholesale access model; and (iii) a fully integrated model.
- Several municipal broadband network projects are implemented under public-private partnership (PPP) contracts. A variety of PPP contracts are available to achieve balanced partnerships between municipalities and private sector investors, where each party focuses on its own area of expertise and shares risks and benefits associated with network deployment.
- Successful and economically relevant MBNs can generate numerous economic and social benefits for local stakeholders, especially the local government, local businesses, and municipal residents, by increasing access to affordable quality broadband Internet.
- MBNs can, however, pose a number of challenges including: (i) PPP contract design; (ii) anticipation of network upgrade investment needs; (iii) risk of crowding-out of the private sector; and (iv) project management capacity.
- A review of a set of case studies suggests that when they are economically relevant and created under the appropriate business model, MBNs can be financially sustainable and support uptake of quality connectivity by end users, including low-income individuals.

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Why Municipal Broadband Networks?

Municipal broadband networks (MBNs) are high-speed Internet access networks that have been fully or partially facilitated, built, operated, or financed by local government.[1] MBNs can be rolled out using various broadband network technologies, including fiber optic cables, licensed wireless (e.g., 3G, 4G), and unlicensed wireless (Wi-Fi). Broadband Internet can be provided through various models depending on local goals and locally-based solutions.[2] These models involve the participation of public or private sector operators in the deployment of national or regional broadband networks, municipal or local networks, and community networks.

MBNs offer an alternative option to the provision of high-speed Internet connectivity to underserved individuals and businesses and can therefore help alleviate the digital divide in emerging markets. An estimated 3.7 billion individuals were offline in 2019, prior to the COVID-19 pandemic, representing 48 percent of the global population, and they resided primarily in developing economies, especially the Sub-Saharan Africa and Asia and the Pacific regions.[3]

During the pandemic, increased and sustained demand for cloud-based services required high-quality Internet access supported by advanced networks like 4G/5G or fiber-to-the-home.[4] Increasing the availability of high-speed Internet requires the engagement of all stakeholders, including private investors and municipalities. This is a pressing agenda, as 68 percent of the world's population is projected to live in urban areas by 2050, compared to 55 percent today; this amounts to at least 800 million people moving to urban areas over the next three decades.

Municipal broadband networks can be used to support digital connectivity services for a municipality or for the development of smart cities. Digital connectivity services supplied through municipal broadband networks include those used for the city's own operations (e.g., meter reading, municipal data network, supervisory control and data acquisition, and voice) and those provided to others (cable television, long-distance telephone, Internet access, broadband, fiber leasing, and local telephone).

MBNs can result from a number of local government initiatives, often in partnership with private sector investors.[5]

- **Local governments can act as broadband users.** As such, they indirectly attract private sector investors in the deployment of broadband networks through demand-side policies. In particular, a municipality can use its local leadership role or its role as a major telecommunications customer to assess, stimulate, or aggregate demand for broadband Internet access.
- **Local government as rule-maker.** Municipalities can adopt or reform local ordinances that affect the ease of commercial deployment, such as rights-of-way, utility pole attachments, road and building construction codes, zoning policies affecting wireless antenna placement, and cable franchise agreements. Digital maps of available infrastructure have supported the development of private broadband networks in urban areas. Many cities that had allowed aerial cable deployment in the past to promote broadband deployment have stepped in and passed regulations requiring telecom operators to bury their cables for safety and aesthetic reasons. Examples include cities as diverse as Bucharest, Bangkok, and Panama City.
- **Local government as financier.** Municipalities can provide subsidies for broadband users or private sector-led service providers, which may be direct or indirect in the form of planning or equipment grants, tax credits, or other incentives.
- **Local government can also act as an infrastructure developer.** In such instances, a municipality can adopt supply-side policies in which a division is ultimately responsible for the provision of one or more components of broadband network infrastructure.

A number of factors affect the development of MBNs. Key determining factors of municipal broadband include: the engagement of public utilities; the involvement of the private sector in joint infrastructure projects; local demand for retail and wholesale digital connectivity services, often proxied by density of economic output;[6] and an enabling institutional and regulatory framework at the national or regional level.[7]

However, MBNs remain limited in emerging markets. Most MBNs initiatives have been undertaken in high-income economies like the United States[8] and the European Union, as well as in upper middle-income economies like Brazil, South Africa, and China. In emerging markets, especially in cities across lower-middle income and low-income countries, most MBN initiatives are limited to free Wi-Fi networks.[9]

Business Models of MBNs

MBNs can be developed under three types of business models, depending on the level of involvement of municipalities or private sector investors in the digital connectivity service value chain (Figure 1).

1. *Under a Passive Infrastructure Model*, municipalities facilitate investment in passive infrastructure such as ducts and dark fiber, while network access and services are provided by private sector operators. Examples include Bucharest Fiber Network in Romania (Case Study 1, below) and LinkNYC, a wireless network in New York (Case Study 4).

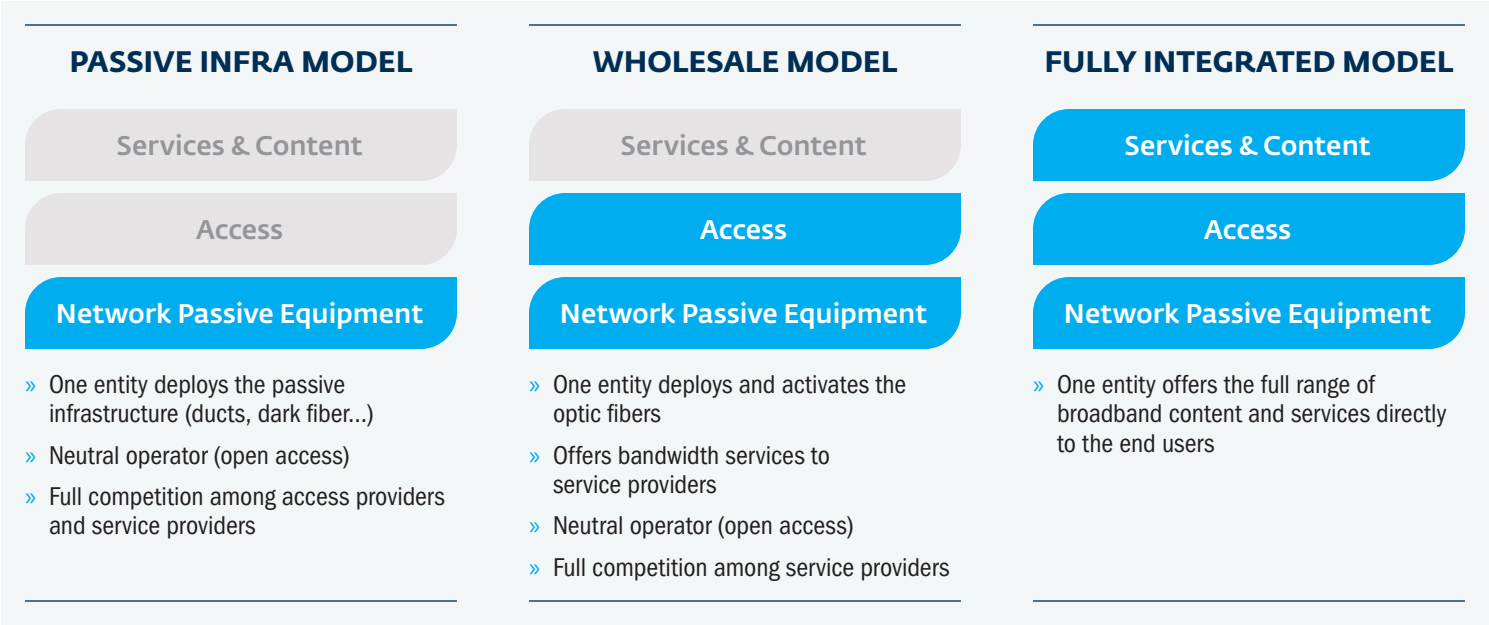

FIGURE 1 Municipal broadband networks business models

Source: IFC. Note: Services and content refer to retail connectivity services and value-added contents.

2. ***Under a Wholesale Access Model***, municipalities are involved in the commercialization of wholesale access to the broadband network. Private sector operators purchase wholesale broadband access from the municipality and in turn provide Internet access services to end users. Examples include Ting in Westminster-U.S. (Case Study 2) and Wireless@SG, a wireless network supported by the city of Singapore (Case Study 5).
3. ***Under a Fully Integrated Model***, municipalities are involved in the entire value chain, from passive network deployment to activation of the network and services to end users. Examples include Anacortes Fiber Internet in the United States (Case Study 3) and Johannesburg Wi-Fi Network (Case Study 6). Historically, the networks that went to a fully integrated model created most value but also carried the greatest risk, e.g., Colt Telecom in London (UK), Torch Telecom in Yorkshire (UK), and Isis in Dusseldorf (Germany).

These business models can be funded through public funds or public-private partnerships. In emerging markets, especially low-income countries, cities may face limited availability of public funds to support broadband network development. Broadband networks, especially fiber optic cables, can be expensive to deploy, and PPPs can allow municipalities to attract private capital when it would not be feasible otherwise. PPPs come in a variety of contracts and, as such, can be adapted to local contexts, generate various incentives, and achieve balanced partnerships, where each party focuses on its area of expertise and shares risks and benefits associated with the network deployment.

PPP contracts for MBNs can be grouped into two categories depending on the city's involvement in the financing and construction of the network:

1. ***Municipality-funded MBN.*** This category includes PPP contracts such as a third party-run service, lease, and special purpose vehicle (SPV). Under the third party-run service contract, the network is funded by the municipality, but end users' connectivity is provided by a private sector-led operator (such as a mobile network operator expanding into fixed broadband services, or an Internet service provider). End users pay a monthly subscription price to the municipality, which transfers a share of the revenue to the private network operator to cover network maintenance expenses and operating and quality of services expenditures, and allows for a return on capital. Under a lease contract, subscriptions fees are collected by the private sector operator, which transfers a share to the municipality to cover the network rental price. Under an SPV contract, both the municipality and a private entity co-finance, build, and operate the network—and share the return on investment.
2. ***Private sector funded MBN.*** This category includes PPP contracts such as "build, operate, and transfer" (BOT), and concessions. Under a BOT contract, the municipality facilitates the investment through a tender. The network is funded and built by a private operator; and end users pay a monthly subscription price to the municipality, which transfers a share of the revenue to the private network operator to cover network maintenance expenses and operating and quality of services expenditures, and allows

for a return on capital. Under the concession contract, the network is funded, built, and operated by a private sector company in return for concession fees to be paid to the municipality for the uses of municipal resources such as street poles and ducts. In this case, the private sector company owns the relationship with the end customers. However, under a wholesale open-access business model, the private sector company services telecom operators, which in turn serve end customers. Medellin, the second largest city in Colombia, is considering the development of a municipal broadband network under a PPP model in partnership with a private infrastructure company responsible for financing, designing, building, operating, and maintaining a neutral fiber optic network during the life of the contract.

Private partners are often infrastructure/utilities companies with the potential to leverage their existing infrastructure as well as public infrastructure to generate economies of scope, resulting in capex savings.

Opportunities Offered by Municipal Broadband Networks

The expansion of broadband connectivity is generally associated with increased social welfare[10] because it can enable efficiencies, innovation, and inclusion across an economy.[11] MBNs, when economically desirable, can generate numerous economic and social benefits to local stakeholders, especially local government, local businesses, and municipal residents.[12] Local businesses can leverage increased access to high-speed Internet to support digitalization of operations and services, engage in digital entrepreneurship and innovation, and strengthen their integration into national and international value chains.

Key opportunities for local governments include:

- ***Improved delivery of municipal services*** through access to quality digital connectivity. Examples include online payment of municipal taxes and online requests of access to municipal facilities.
- ***Smart city projects*** through digitalization of municipal infrastructure. Cities can leverage high-speed Internet access to support improvements in transportation networks (e.g., e-ticketing and online scheduling of public buses, bike sharing), water and sewage systems, waste management, and a transition to smart power grids.
- ***Monetization of municipal infrastructure.*** MBNs can rely on infrastructure owned by municipalities and therefore deliver additional revenues to the local government. For instance, there are economies of scope between municipal power providers and municipal telecommunications providers.[13]
- ***Increased revenue*** through taxation of new services in sectors such as tourism, e-commerce, and transportation.
- ***Resilience.*** Access to high-speed Internet can support a city's preparedness for emergencies and resilience to disasters or shocks induced by events such as the COVID-19 pandemic.[14]

For private sector investors, especially broadband operators, MBNs can deliver a number of benefits, including:

- ***De-risking of expansion of broadband network in high-cost or low-profitability areas***, thereby supporting enhanced revenue growth for telecom operators.
- ***Improved productivity growth for businesses*** through digitalization and development of tech ecosystems, as MBNs enable increased access to quality connectivity for businesses. Municipal residents can benefit from digital inclusion, increased job opportunities, and economic and social inclusion.

More specifically, MBNs can support:

- ***Digital inclusion*** through increased access to affordable quality broadband Internet. A recent study from the United States finds that municipal broadband networks come with lower prices and higher quality than private networks.[15]
- ***Increased job opportunities*** through the development of local digital ecosystems, with digital startups creating employment opportunities, especially for women and youth in verticals such as ride hailing, e-delivery, and bike sharing.
- ***Economic and social inclusion*** through improved access to municipal services, including public schools and civic engagement (such as voting) for low-income individuals. For example, in Nigeria, mobile broadband coverage reduces the proportion of households below the poverty line;[16] in France, broadband expansion resulted in higher income gains for the poorest than for middle-income earners or the rich, primarily through increased employment in manual jobs.[17]

Challenges Posed by Municipal Broadband Networks

The development of MBNs entails a number of challenges for both municipalities and private sector operators.[18] The most common challenges include:

- ***PPP contract design.*** MBN projects can fail due to limited incentives embedded in the PPP contract or inadequate risk sharing between the private sector operator and the procuring public authority. The design of the PPP contract is critical to the successful implementation of any MBN project; and particularly important are clauses that increase private sector participation through adequate risk sharing, as well as aligned incentives between the procuring government authority and the private sector partner.

- *Network upgrade needs.* Unlike traditional utilities that are relatively static such as electricity distribution, broadband is dynamic, requiring regular investment to keep up with changing technologies. Failure to anticipate investment in network upgrades can negatively affect the economic viability of the MBN in the medium to long term.
- *Crowding-out of the private sector.* Private sector-led network operators focus on potential profitability, while municipalities tend to respond to other factors, including political considerations (for example, the desire to provide competition to incumbents or extend the network to underserved areas and users with limited disposable income). As a result, municipal providers tend to serve markets that private operators do not.[19]

  However, the presence of a municipal provider in a market can decrease the probability that a private operator also serves that market, with the risk that the municipality creates a monopoly over the infrastructure. Municipal networks are often deployed first in low-cost, high-return business districts, making it difficult for private sector operators that would have been prepared to develop the network without the government incentives.[20] The presence of an MBN can be associated with limited incentives for private sector operators to upgrade their networks, especially in densely populated cities.[21]
- *MBN project management.* Municipal broadband networks are complex infrastructure projects that require a long-term strategy, relevant expertise, and significant funds. There is a history of municipal networks that failed to meet their financial targets, forcing taxpayers and or municipal utility customers to shoulder large financial losses.[22] Organizational skills and financial capabilities are needed to successfully manage complex municipal broadband network projects. Such capabilities are limited in many emerging markets, especially in low-income countries. Several municipal networks have failed, and those that remain financially viable often owe their success more to government subsidies or unique circumstances than to their ownership model.[23]

Case Studies of Successful Municipal Broadband Networks

A number of initiatives have been implemented, mostly in advanced economies, with lessons that can be relevant for emerging market municipalities and private sector investors seeking to develop MBNs. Case Studies 1, 2, and 3 address "availability or quality" issues, using each of the three business models discussed above. Case Study 1 (Bucharest, Romania) illustrates how regulatory interventions can be used by cities to increase quality of connectivity. In Case Studies 2 and 3, the city is considered too small by local Internet service providers to deploy fiber. Westminster and Anacortes used different strategies for their municipal broadband networks. Case Studies 4, 5, and 6 address an "affordability" issue to bridge the digital divide through the deployment of free Wi-Fi networks.

CASE STUDY 1
Bucharest, Romania: Availability of Quality Connectivity Under the Passive Infrastructure Model

CHALLENGE: In 2002, Bucharest allowed a reduction of deployment costs for aerial cable, which fostered fiber cable deployments. By 2006, Bucharest was full of overhead cables, affecting the city's aesthetic and creating safety and reliability issues.

SOLUTION: Bucharest decided to build a municipal citywide network of ducts and encouraged telecom operators to move their cables underground using this new infrastructure, and a 49-year PPP was signed with UTI in 2008. A dedicated company (Netcity) was set up, with exclusive rights to implement and manage Bucharest's telecommunication infrastructure network.

As part of the PPP, Netcity had to build and operate (BOT) the network with 100 percent private investment; royalties (12 percent of revenues) were paid to the city for concession rights; and wholesale open access to the ducts was provided at regulated tariffs.

OUTCOMES: Some 11,230 buildings were connected, 880 kilometers of fiber was deployed on 1,382 streets, and 330,000 inhabitants were covered at the end of 2012, after $40 million of investment.

Network deployment stopped between 2013 and 2017 due to a dispute over Netcity's tariffs, which were deemed high by the telecom regulator and were challenged by some of the small ISPs in the country. In 2018, Netcity and Bucharest municipality signed an amendment to the tariffs and work resumed to double the length of the network to over 1,800 kilometers. Some 1,520 kilometers of cable were deployed and 20,300 buildings were connected by the end of 2019.

CASE STUDY 2
Westminster, Maryland, United States: Availability of Quality Connectivity Under the Wholesale Access Model

CHALLENGE: Westminster is a relatively small city (19,000 inhabitants) with no fiber option from local ISPs. The city considers a fiber broadband network a necessity for its long-

term development, but it did not want to get involved in the marketing of the offers and wanted instead to strengthen competition in the local market.

SOLUTION: In 2014, Westminster decided to build a municipal citywide dark fiber network (paid, built, owned, and operated by the city of Westminster). Total cost was estimated at $23 million. Westminster leased the network through a PPP to a local ISP (Ting), which ensured revenues to the city of Westminster. Ting operates the network on an open and nondiscriminatory access basis (with an initial two-year period of exclusivity), and Ting and Westminster shared the risks in case the project did not generate enough revenue.

OUTCOMES: As of March 2019, Westminster received about $1 million in leasing revenue. About 108 miles of fiber optic cable have been deployed since October 2014, and 5,774 premises are reached by the network, with a conversion rate of 20 percent, or 1,147 customers signed.

CASE STUDY 3

Anacortes, Washington, United States: Availability of Affordable Quality Connectivity Under the Fully Integrated Model

CHALLENGE: Anacortes is a relatively small city (18,000 inhabitants) with no fiber option from local ISPs. In 2016, the city investigated ways to upgrade the radio telemetry system used to monitor its water and wastewater utility. The system included a water treatment plant, a wastewater treatment plant, 23 sewer pump stations, four water pump stations, four water reservoirs, and other facilities (including fire stations).

SOLUTION: Anacortes decided to deploy a fiber backbone for its own use (mainly telemetry for its water utility) and to leverage this asset as a backbone to deploy a full FTTH network. The fiber network has been designed, owned, paid, built, and operated by the city. There was a 20 percent price discount for low-income households.

OUTCOMES: Phase 1 (2017): 33 miles of fiber have been deployed in water pipes over two years for telemetry purposes. Total cost of phase 1: $3 million.

Phase 2 (2019): FTTH trial. 1,000 premises reached, with a conversion rate of 40 percent.

Phase 3 (2021): full network to be deployed within four years. Estimated cost of phase 3: $12 million.

CASE STUDY 4

New York City, United States: Connectivity Service Affordability Through a Citywide Wireless Network Under the Passive Infrastructure Model

CHALLENGE: In 2014, NYC launched a call for ideas to reinvent the 12,000 telephone booths located throughout the city. There was a strong desire to help bridge the digital divide, so the new booths would have to be spread throughout the city and include free phone and Internet access. Also, NYC didn't want to pay for the new booths.

SOLUTION: NYC signed a PPP in 2014 with a private consortium (CityBridge) for 12 years, 100 percent funded by private funds and 50 percent ad revenue to NYC for the concession rights. CityBridge oversaw the installation, ownership, and operations, and was responsible for building the necessary optic infrastructure under the streets. The resulting kiosks provide free phone calls in the U.S., free access to the Internet through an integrated tablet, and free Wi-Fi.

OUTCOMES: As of Sept. 2020, after five years of operations, 1,800 kiosks have been deployed. Ad revenues have been slower than initially expected, slowing the deployments and payments to NYC. The kiosks have been used for over 500,000 average calls per month, one billion total sessions, and five million monthly users in September 2018. The most-dialed number on the kiosks was the helpline for the state's electronic benefit transfer system, which distributes food stamps to low-income residents.

CASE STUDY 5

Wireless@SG, Singapore: Improved Affordability of Quality Connectivity Under the Wholesale Access Model

PROBLEM: Singapore decided to promote a wireless broadband lifestyle among the city's residents. It launched a nationwide FTTH program with a carrier-neutral network. However, affordability and quality remain limited for many users. The city considered launching Wireless@SG, a Wi-Fi network in parallel, as the nationwide FTTH program, providing free Wi-Fi access, no usage limitation, and seamless roaming between hotspots.

SOLUTION: A PPP was agreed to between the government and private operators. The network opened in December 2006 with three operators (iCELL Network, QMAX Communications, and SingTel). The program was initially designed to last for two years (to the end of 2008) but has been extended several times. IMDA, the development agency, temporarily provided subsidies to operators and premises owners.

OUTCOMES: Between 2006 and 2009, 7,500 hotspots were created with 512 kbps download speed connecting 1.5 million users, at a cost of US$30 million subsidy by IMDA. By 2018, 20,000 hotspots were deployed (1 hotspot per 280 inhabitants), with 5 Mbps download speed.

By June 2018, 2.5 million users logged into Wireless@SG each month (roughly 45 percent of the population) with usage at approximately 11 hours per user per month.

CASE STUDY 6

City of Johannesburg, South Africa: Improved Affordability of Connectivity Under the Fully Integrated Model

CHALLENGE: MTC (Metropolitan Trading Company) is a Municipality Owned Entity in charge of managing Johannesburg's broadband network (over 1,100 km of fiber cables deployed). The City of Johannesburg (CoJ) wanted to bridge the digital divide, as half of its 4.8 million residents and 80 percent of informal settlement residents did not have access to the Internet in 2015. CoJ decided in April 2014 to leverage its already existing fiber network to deploy free Wi-Fi throughout the city.

SOLUTION: A Wi-Fi network fully paid by CoJ. The target was to install 1,000 hotspots by 2016, with free access to a range of basic services through a new portal, "Maru A Jozi." It included 300 MB per day and unlimited access to the portal (www.maruajozi.joburg). The city recruited 3,000 ambassadors equipped with tablets to train CoJ residents to use free Wi-Fi and the portal.

OUTCOMES: By mid-2016, over 400 hotspots were deployed and 25,000 citizens trained. After the election of a new mayor in 2016, the project was considered nonessential and all deployments stopped. By mid-2020, 84 hotspots remained with an average of 6,000 single devices connecting each day to the network, or about 71 single users per day per hotspot. Following the election of a new mayor in 2019, and with the advent of the COVID-19 crisis, CoJ relaunched its free Wi-Fi project ($2.5 million per year over 3 years). Service has been upgraded to 500 MB per day.

Looking forward

Ensuring that all citizens and firms are properly connected to the Internet has become an essential component of smart city programs, requiring strong city involvement through municipal broadband networks. However, successful development of a MBN depends on a clear screening of the opportunity and scope for local government intervention. The World Bank Group's Maximizing Finance for Development (MFD) approach provides a framework for such screening: a clear priority must be given to commercial financing, policy reforms, and risk mitigation instruments before public and concessional financing are considered.[24]

As such, and depending on the city context, a passive infrastructure business model should be considered first, followed by the wholesale access model and the fully integrated business model, respectively.

Granting access to public furniture such as bus stops and street lights, encouraging infrastructure sharing, or coordinating road digging works between utilities when deploying fiber may be enough to reduce deployment costs and incentivize private sector investment in MBN. When incentives for private sector investment in local broadband networks are limited, municipal engagement should be minimal and based on an open access model (e.g., non-discriminatory, cost-oriented, and with stable tariffs), and should adhere to national network standards to foster service competition.

Cities will continue to play an important role in the expansion of broadband networks with the advent of 5G, which requires a strong densification of networks and robust backhauling. To support new services requiring higher bandwidth and lower latency, 5G "small cells" will need to be deployed every 200 meters in dense urban areas. Such high deployment density will only be possible through the use of street furniture.

Municipalities may have no choice but to get involved in broadband deployments since they own a large portion of both street furniture and underground infrastructure (ducts, manholes, sewage networks). They could take advantage of this to facilitate infrastructure sharing between telecom operators, as well as other network operators, in order to reduce costs and nuisances and ensure telecom operators provide full coverage of the city, ensuring that no resident is left uncovered.

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