Unlocking digital connectivity in Africa

European Investment Bank
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White paper

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About this white paper

The Digital4Development (D4D) Hub is a strategic platform that aims to help make Europe a global leader and trendsetter in the digital domain. It is intended to foster a coordinated Team Europe approach to supporting partner countries' human-centric digital transformation. The aspiration is to form strategic digital partnerships and boost joint investments between Europe and partner countries worldwide.

As a D4D Hub member, the European Investment Bank (EIB) organised a series of workshops to unveil ways to unlock connectivity in Africa. These closed workshops brought together operators, energy providers, vendors, service providers, local governments and international organisations to find operational and financing solutions to bridge the digital connectivity gap in Africa.

A key objective was for industrial partners to collaborate on unlocking connectivity solutions for unserved communities, supported by EIB financing. Network-sharing solutions and the pathway to achieve their successful implementation were a particular focus of the workshop sessions.

Although demand enhancement is extremely important for effectively unlocking such solutions, the workshops aimed to address technical and financial solutions to make them feasible.

This white paper is part of the publications delivered by the EIB to support operators and governments in implementing new initiatives. It aims to provide inputs and examples supporting the EIB's Rural connectivity toolkit published in May 2021.

Executive summary

Africa's digital transformation is underway, generating transformational changes across all economic sectors and providing much-needed social upsides. On several market growth parameters for telecommunications, the continent has recorded the highest growth rates globally. However, a stark digital divide remains. An estimated 900 million people are still not connected to the internet; for those who are connected, connectivity prices remain mostly high and bandwidth is severely limited in many areas. Consequently, a huge proportion of Africa's population is excluded from the progress expected from digital technologies in pursuit of the Sustainable Development Goals.

The Digital4Development (D4D) Hub is a strategic platform that aims to help make Europe a global leader and trendsetter in the digital domain. It is intended to foster a coordinated Team Europe approach to supporting partner countries' human-centric digital transformation. The aspiration is to set up strategic digital partnerships and boost joint investments between Europe and partner countries worldwide.

While some operators are announcing the impending launch of 5G in urban areas, most western and central African countries have less than 20% 4G penetration and 3G covers only 60% of the population. For unserved areas, traditional mobile network operator (MNO) business models cannot be applied as in urban areas (due to long return on investment). Only new approaches (technical, financial or both) will solve the need for coverage and bandwidth.

The purpose of this paper is to present the conclusions of five recent EIB workshops on unlocking connectivity in Africa. Held in June 2021, these workshops brought together operators, energy providers, vendors, local governments and international organisations to find operational and financing solutions to bridge the digital connectivity gap in Africa. A key objective was to find the virtuous circle of collaboration between industry partners to set concrete connectivity solutions for underserved communities, supported by EIB financing. Strong focus is placed on identifying solutions and assessing their feasibility.

To complement the contributions of workshop participants, this paper also draws on prior literature analysis for additional information needed to clarify the presented solutions.

This paper is composed of five main sections that each address a fundamental theme of relevance to understanding the connectivity problems in unserved areas.

Section 1 presents the access problems and the new solutions deployed to address cost and coverage issues. It underlines the emergence of new players that bear part of the financial risk and provide lighter, adaptive solutions. These new players appear to be game changers and facilitators of ecosystem deployment.

Section 2 identifies the backbone and backhaul technologies and deployment strategies for connecting remote locations. It also analyses infrastructure-sharing models and their concrete applicability in different contexts. Finally, it provides an approach to network scalability from a mid-term perspective, based on "cover first, upgrade after."

Section 3 addresses the energy dimension of the ecosystem. Energy is a key component of deployments in unserved areas as it can be responsible for up to 60% of total costs. The installation of solar, off-grid solutions has allowed several new network deployments using sustainable resources. The business models of energy service companies (ESCOs) differ depending on the technical model type and relations with the MNO or network as a service company (NaaSCo). The section details these business models.

Section 4 presents the business models of different players. It outlines the shift in MNOs' approach from traditional economic evaluation per site to a global perspective, and describes the business models put in place by new players, such as build-own-operate-transfer, NaaSCo, and lease to purchase. The section also discusses the new shift in financing risks from MNOs to smaller players or vendors.

Section 5 presents development banks' approach when financing telecommunications infrastructure in unserved areas in Africa. It underlines the EIB's role in unlocking financing when a market failure exists or where,

to create growth dynamics, an ecosystem needs a first financial injection from an institution whose approach to risks differs from that of commercial banks. As the EU bank, the EIB can provide significant support in terms of advocacy, technical assistance and financing. However, the Bank is only one of many development institutions actively supporting public and private entities in local ecosystems in this field. The EIB aims to orchestrate the efforts of different players by providing support and coordination.

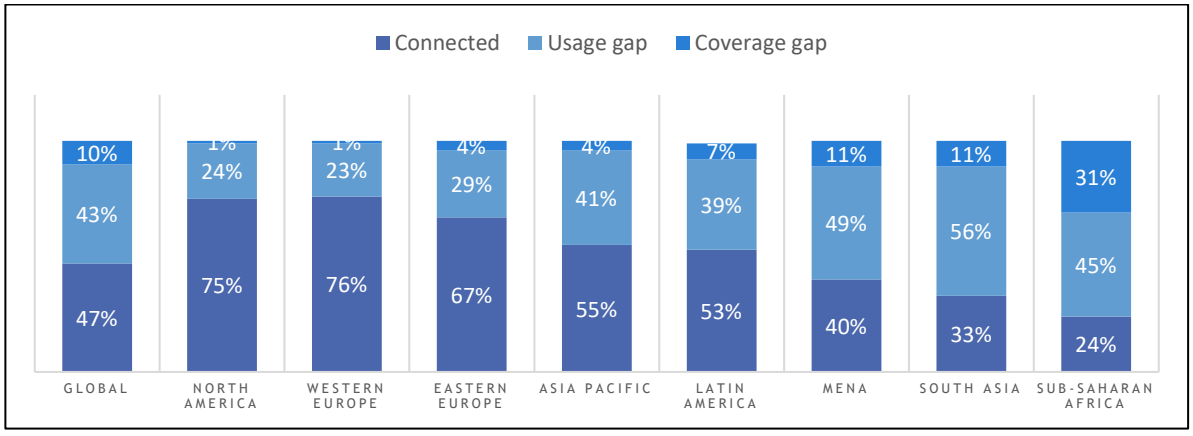
Contents

Introduction

With the greatest digital coverage gap in the world, Africa still needs sizeable investments in physical infrastructure to emerge as an inclusive digital economy. The networks that are available are seldom at the right price and/or quality point. To realise the potential socioeconomic benefits, access to broadband connectivity and digital infrastructure are priority areas largely shared by public institutions in sub-Saharan Africa.

There is a strong need across the continent to increase the capacity of transmission networks and leverage investment in infrastructure to promote last-mile connectivity to underserved areas. To respond to these needs it is essential to mobilise financing solutions. The use of development financing is justified when the market fails to invest in infrastructure with the potential to create positive economic returns. It is also widely recognised that private sector organisations are crucial to expanding connectivity and infrastructure and, increasingly, to supporting local innovations.

While strong improvements have been made at the demand and offer levels, Africa still has the biggest coverage and usage gaps in the world. This is explained by numerous factors, particularly the cost of connectivity and devices and the need to enhance skills to promote usage.



SUB-SAHARAN AFRICA HAS THE WIDEST COVERAGE GAP IN THE WORLD[1]

This white paper reports insights from five workshops run by the EIB in June 2021, in which various key sector stakeholders participated (see list in the "Acknowledgements").

These workshops addressed several complementary issues. The global objective was to identify technical and business models having shown their concrete operability and learn from experience in the field to support the EIB's investment actions in unserved areas. This paper aims to:

1. Overview new solutions for network connectivity (access and backbone), aimed at removing barriers;
2. Consider the energy solutions developed to bring coverage to unserved areas;
3. Address various aspects of investment in this domain, including identifying the barriers and challenges confronting parties involved, evaluating the attractiveness of investment in this market area, and overviewing investment approaches for new solutions in digital connectivity;
4. Present the approaches of development finance bodies to addressing unserved areas.

As addressed in this paper, innovative solutions cannot only consider technical issues but must also integrate innovative business models.

Most of the examples presented, even if already implemented in several countries, are still at an early development stage, and little quantitative data are available on the results of these new solutions. The reported case studies have been selected because they either represent a type of innovation creating new interactions in the related ecosystems (energy provision, backhaul solutions, access solutions, business models) or demonstrate potential to accelerate mobile broadband coverage in uncovered or poorly covered areas.

[1] Source: GSMA Intelligence, 2018.

Innovation for efficient access

When considering unserved areas, most people think about rural and ultra-rural areas. Although rural coverage remains a crucial issue to solve in Africa, many city suburbs and mid-sized cities are also unserved. Numerous cities of less than 500 000 inhabitants are poorly covered by broadband connectivity, as shown in the figure below.

These areas are typically inhabited by the poorest segment of the population, living significantly below the country's average gross domestic product (GDP) per capita. In urban areas, meanwhile, fixed internet access can cost up to 90% of a country's monthly GDP per capita and mobile broadband up to 30%.

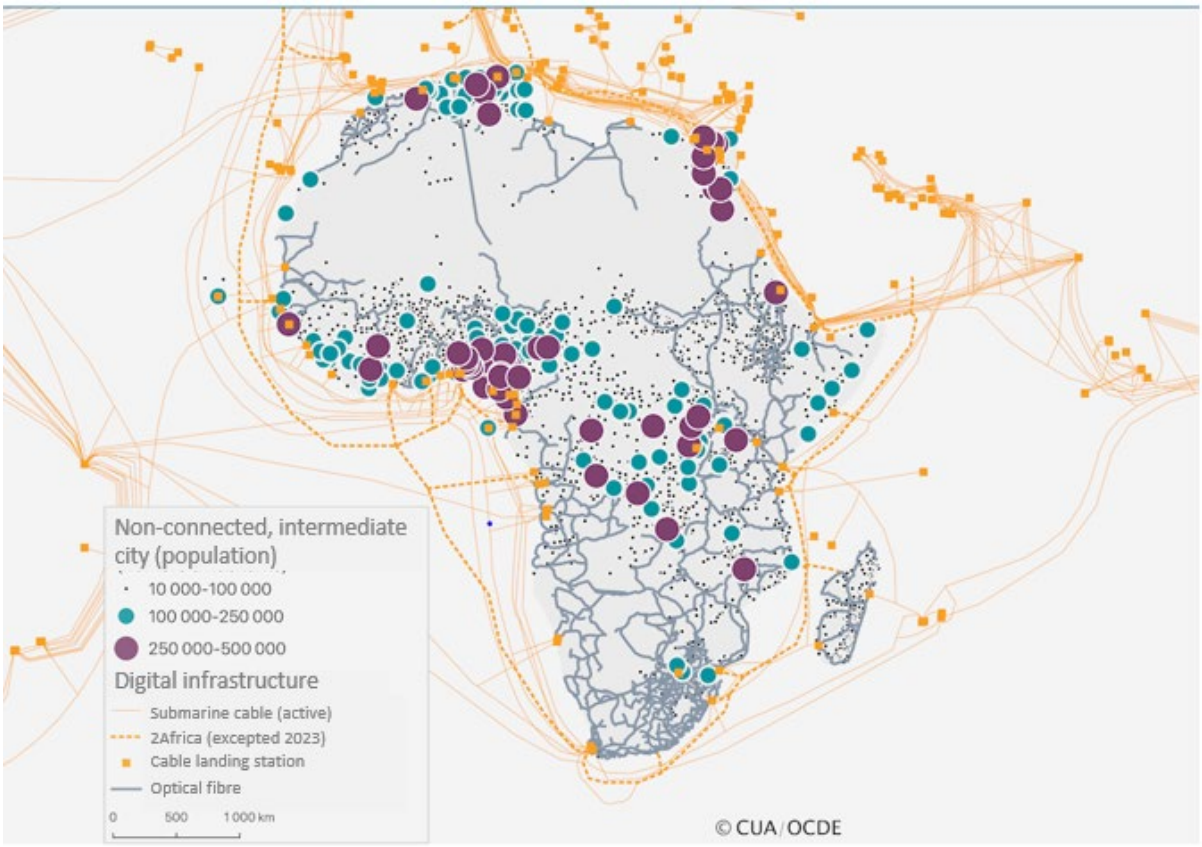


FIGURE 1: COMMUNICATION INFRASTRUCTURE AND NON-CONNECTED INTERMEDIATE CITIES, BY POPULATION SIZE, IN AFRICA (2020)[2]

Network deployment to rural and remote locations is constrained by a lack of basic infrastructure and, in particular, power provision. Consequently, mobile sites are often built in a self-sufficient manner, thus adding higher operational and maintenance costs to the upfront deployment costs.

In this context, all players of the information and communications technology (ICT) ecosystem face the challenge of deploying networks at the lowest possible cost. Their solutions are mainly based on infrastructure sharing and new deployment models based on subcontracting the access deployment as a whole.

[2] Source: OECD, 2021.

Technical context of unserved areas

Adapted solutions

Traditional access network designs are not fully adapted to the characteristics of most unserved areas, primarily because they are too costly. In terms of coverage, while urban networks need to provide contiguous connectivity, in Africa off-grid areas are addressed as "islands" to be connected by operators.

	Urban	**Off-grid**
Efficiency requirements	Spectral efficiency	Power and backhaul efficiency
Coverage requirements	Contiguous coverage	Localised coverage
Capacity requirements	Maximise simultaneous users	Minimal capacity needed for voice and text services
Investment	High capital expenditure, high operational expenditure	Low capital expenditure, low operational expenditure
Revenues	High revenues as a result of a high number of customers	Low revenues due to low average revenue per user and limited number of customers
Maintenance skills	Highly skilled labour	Low-skilled labour (easy to build, operate and manage)
Power availability	Accessible power	Power grid unavailable or unreliable: diesel or solar solutions
Power pricing	National electricity company KW price	Higher price than national electricity company Does not reach the scale needed to lower prices

DIFFERENCES BETWEEN URBAN AND OFF-GRID DEPLOYMENT NEEDS[3]

Urban equipment and off-grid equipment mainly differ in terms of operational efficiency (energy and maintenance). When looking to deploy adapted solutions to unserved areas, every component of the value chain needs to be considered.

Element	**Traditional solution**	**New solution**
Passive	Tower	Pole/light tower
Hardware	Weighty traditional hardware	Baseband hardware (light equipment)
Access	Mobile networks/microwave	Upscalable 2G networks Satellite
Backhaul	Fibre	Microwave/satellite
Energy	Diesel	Solar

ADAPTED TECHNICAL SOLUTIONS FOR UNSERVED AREAS[4]

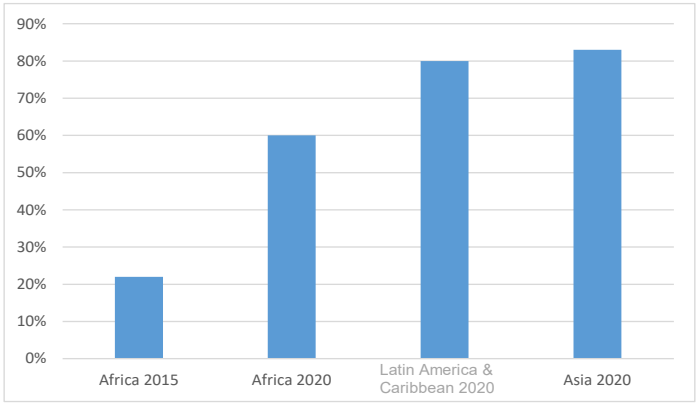
[3] Vanu at EIB workshops, June 2021.
[4] Source: Vanu & Sofrecom, 2021

Technology issues

According to the GSM Association (GSMA), 35% of the African population has 2G handsets (although this value may be overestimated because some people have multiple handsets). In underserved (particularly ultra-rural) areas, most connectivity deployments are 2G. A number of factors justify this: the licences are already amortised, most of the target population has a 2G terminal, and the towers are lighter and use less energy.

Offering connectivity where none exists represents a big step towards digital integration. It gives populations their first access to communication, information, and some specific services accessible through EDGE[5]. However, deploying 2G does not fully solve the digital divide, as fewer services are accessible through this technology than via broadband. Therefore, deploying 2G risks perpetuating the digital divide between ultra-rural and urban populations and so should be considered as a bridge solution for progressing towards higher bandwidth. **Cover first, upgrade after** can be the path to more extensive use of digital services.

The leap from 2G to 4G needs to be considered in future deployments in unserved areas and when covering unserved suburbs close to 4G urban towers.



PERCENTAGE OF POPULATION WITH 4G COVERAGE[6]

Although 4G penetration in Africa has grown by 120% since 2015, operators in some countries are still considering moving from 2G to 3G before envisaging 4G. Technically, the transition through 3G is not considered necessary. 4G uses less energy than 3G and will enable the growth of usage over five to seven years. To minimise the costs of switching to a new technology, it is recommended to deploy the latest generation available, as long as no areas lose coverage and the population can access the technology (for example, there is no need to deploy a 5G network if the population cannot access 5G-compatible terminals). The minimum recommendation is to deploy equipment compatible with the technical generations in place, so that only software upgrades are needed to switch to new technology[7]. Regarding terminals, most 3G handsets are 4G-compatible.

[5] Enhanced data rates for GSM.
[6] Source: GSMA, 2021.
[7] https://www.eib.org/en/publications/rural-connectivity-toolkit

Infrastructure-sharing models

It is broadly accepted that infrastructure-sharing models for mobile access reduce costs and optimise operational expenditure. They appear to be the best solution for covering unserved areas where financial equilibrium is difficult to find. Although sharing is a first step to enabling more efficient coverage, the choice of sharing solutions depend on the deployment context (distance from cities, electricity availability, size of the population to be covered). The figure bellow shows the different types of sharing for mobile access.

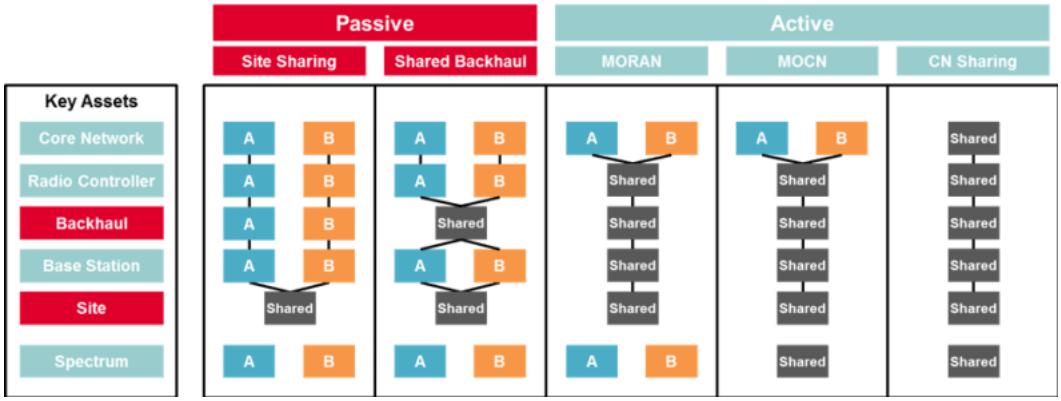
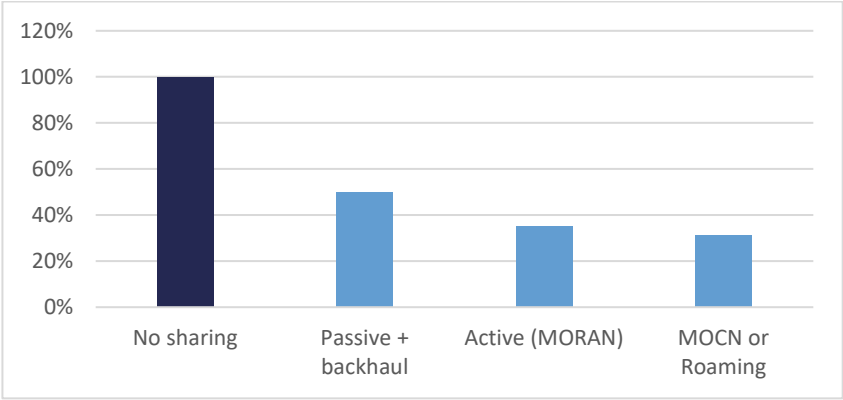


FIGURE 2: TECHNICAL CLASSIFICATIONS OF INFRASTRUCTURE-SHARING SOLUTIONS[8,9]

In the mobile market, more access layers are shared, resulting in a higher positive impact on cost.



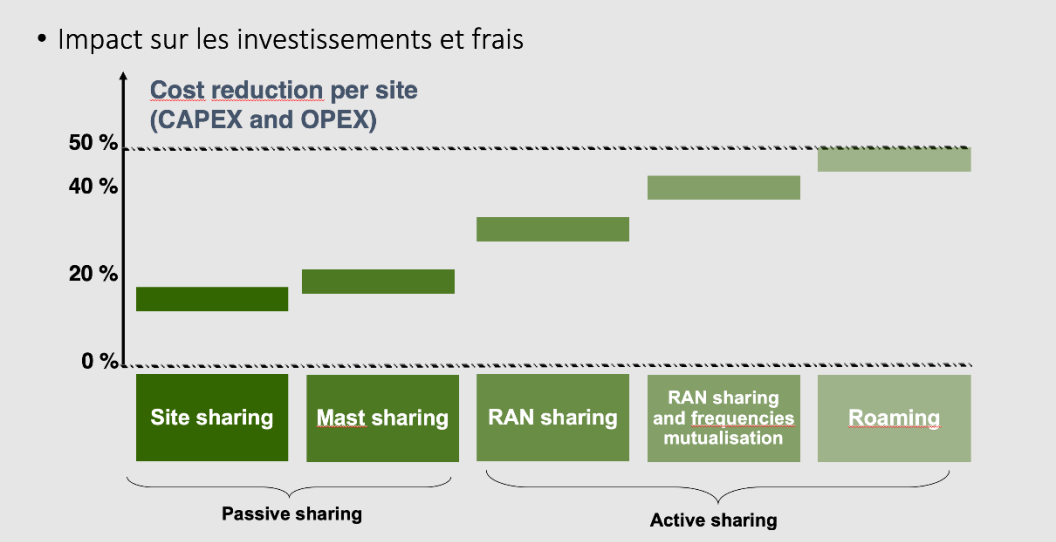
IMPACT OF DIFFERENT INFRASTRUCTURE-SHARING MODELS ON OPERATIONAL AND CAPITAL EXPENDITURE COSTS OVER FIVE YEARS FOR RURAL/REMOTE NETWORK EXPANSION[10]

Site sharing, mast sharing and network roaming are the most common forms of infrastructure sharing because they are technically and commercially relatively simple. However, there is a growing tendency to move to active infrastructure sharing, driven by the aims of reducing operational expenditure and energy consumption.

Operators' priorities differ when addressing urban markets rather than unserved areas. In particular, they focus on increasing capacity and coverage and on low power consumption. Because of their greater flexibility to

[8] GSMA, "Infrastructure Sharing: An Overview."
[9] MORAN (Multi-Operator Radio Access Network), MOCN (Multi-Operator Core Network), CN (core network) sharing
[10] Source: Coleago, in GSMA, "Connected Society — Unlocking Rural Coverage: Enablers for commercially sustainable mobile network expansion," 2017.

incorporate components that best address these unique needs, open radio access network (RAN) products are even better adapted to unserved areas than to urban areas. The figure below summarises capital and operational expenditure savings in different sharing models.

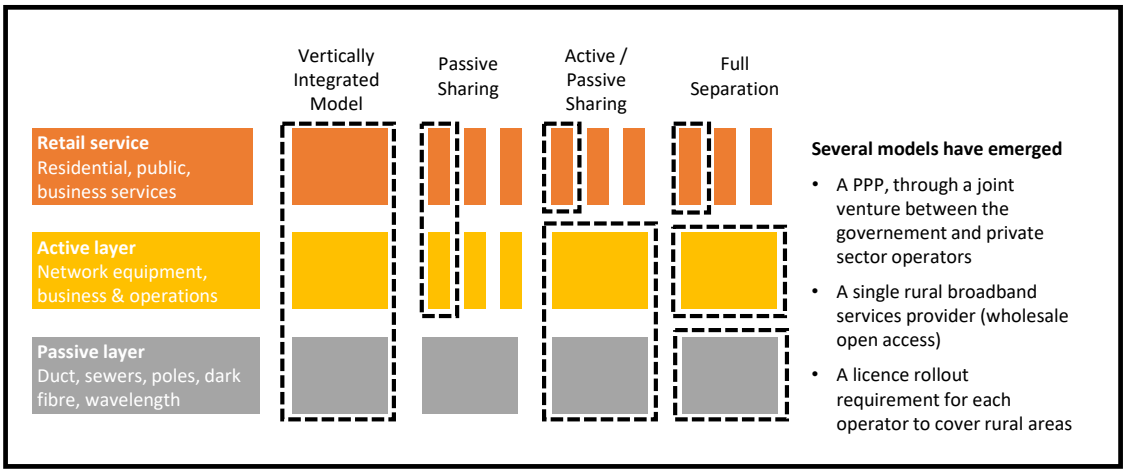


IMPACT OF SHARING ON COSTS AND EXPENSES[11]

The role of competition

To meet the needs of unserved areas, several different operating models have arisen, all sustained by a certain level of infrastructure sharing.

Regarding competition, it is necessary to find the right level of competitive pressure and to consider market evolution indicators, such as penetration rate and average revenue per user. This approach is universal.



INFRASTRUCTURE-BASED VERSUS SERVICE-BASED COMPETITION[12]

[11] Source: Sofrecom, Infrastructure Sharing presentation, 2020.
[12] Source: Nokia, "Rural connectivity, models and policy perspectives," 2021.

Service-based competition

Applying competition regulations to the telecom market in areas with the lowest market uptake and revenue potential might result in the very slow development of digital services.

To address the market failure to invest, a favoured option is to designate a single market player (private operator or public entity) to deploy infrastructure. To maintain retail competition, an open access model is preferred. The different types of models include:

- Vertically integrated model: management by a single operator that exchanges traffic with other operators;
- Active sharing: licence for all operators on the basis of service;
- Local exclusivity: the operator that deploys the network is given a limited number of years of exclusive operations, but must provide access to its passive and active infrastructure to other operators once financial equilibrium is reached (and after the exclusive period ends).

Government intervention

When an area experiences market failure (i.e. goods and services are not efficiently distributed in a competitive market), government intervention is fully justified. This provides the basis for various models from concession to open access, as well as different levels of public participation.

In the telecom sector, this public participation can either be financed by the state budget or a Universal Service Fund (USF). The success of a USF depends on:

1. A clearly defined framework;
2. A reliable open access universal service provider;
3. Strong governance.

If any of these conditions is absent, universal service actions are inefficient, which explains why 47% of the money was unspent in the 37 countries with a USF in 2020. Therefore, USF support should only be provided for carefully selected projects and limited to specific unserved areas meeting the three above-mentioned criteria.

Strong governance and support in structuring projects are often required for a USF to be deployed efficiently. Focus on specific regions/actions can allow more efficient results in achieving coverage for unserved areas.

Concessions

Governments can also delegate universal service obligations to a community/municipality/regional administration or to a single operator. An operator willing to open its infrastructure to others can be given a time-limited exclusive concession.

Case study: Benin's third mobile operator

As established operators have insufficiently invested in Benin's unserved areas, the government decided to respond to this market failure by launching a third mobile operator, funded by the state's USF and loans guaranteed by the fund. The aim of this MNO is to cover unserved areas, and it will be a wholly publicly owned global operator (wholesale and retail). Management of this operator will be determined by auction.

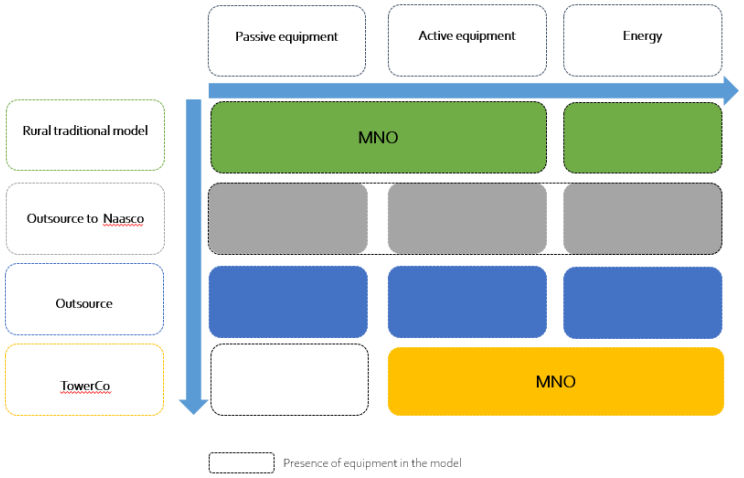
This project forms part of a broader set of measures including fibre optic densification, providing broadband connectivity to schools, and increasing digital skills in the country.

New players, new roles

New players have emerged to fill the coverage gap by creating lighter, easy-to-install access solutions.

Innovation has been brought to the market by tower companies (TowerCos), which have extended their traditional model to provide a more complete range of services. Another recent development is NaaSCos offering MNOs the option to fully subcontract access deployment. Prominent examples of these companies include Vanu, AMN and NuRAN.

TowerCos and NaaSCos are wholesale providers enabling MNOs to overcome cost constraints by providing lighter, flexible access solutions. Completing the landscape, energy service companies (ESCOs) such as Camusat, IPT Powertech and E-ING are providing off-grid solutions to power remote towers.



NEW PLAYERS' ORGANISATION TO DELIVER ACCESS[13]

TowerCo solutions

Major TowerCos have emerged and grown in Africa, driven by the huge opportunity to establish infrastructure enabling connectivity in the continent. IHS, Helios Towers, Eaton Towers, American Towers and other market players aim to fully harness the potential of telecom tower assets by selling space to multiple tenants.

TowerCos provide the tower structure on which telecom companies' radio equipment and antennas are placed, as well as value-added services such as powering and maintenance.

NaaSCos: All-in-one providers

These new players build and operate rural mobile towers and monetise these assets through different business models. NaaSCos provide all-in-one solutions including active elements and energy. In some cases, they even handle the commercialisation of scratch cards.

NaaSCos' services include site acquisition, building, powering and maintenance. The solution may stand on a dedicated base station, which optimises energy usage and access to backhaul. These players assume the financial risk of their investment, which relieves their customers' balance sheets.

The network as a service (NaaS) model allows MNOs to expand and/or upgrade their networks to address areas with low purchasing power, meeting coverage obligations and capacity requirements without capital investment.

[13] Source: Sofrecom (EIB workshops).

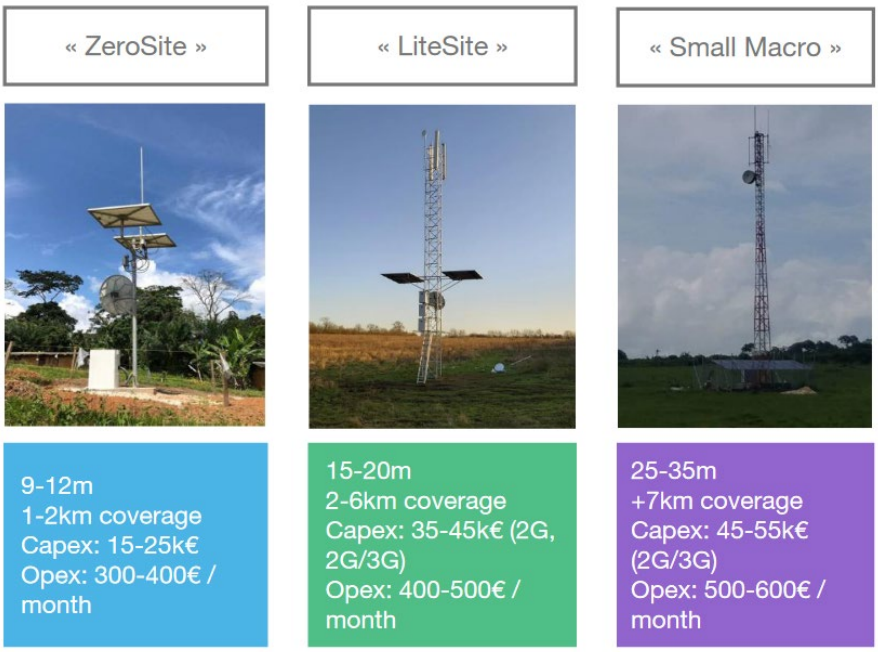
Case study: Ideal - Orange's ultra-rural initiative[14]

Ideal is the name of a set of solutions launched by Orange for ultra-rural coverage in sub-Saharan Africa, delivered by a full ecosystem of partners.

In the first stage, target population locations were identified using Facebook and GSMA data on connections. Orange then launched a call for tenders, asking bidders to describe the best solution for each location. Three types of solution have been selected, each suitable for particular geographical characteristics.

Each solution requires particular providers (ESCOs, NaaSCos, or TowerCos). The LiteSite model provider has obtained its own funding and assumes the financial risk.

Assets will revert to Orange after the contract period.



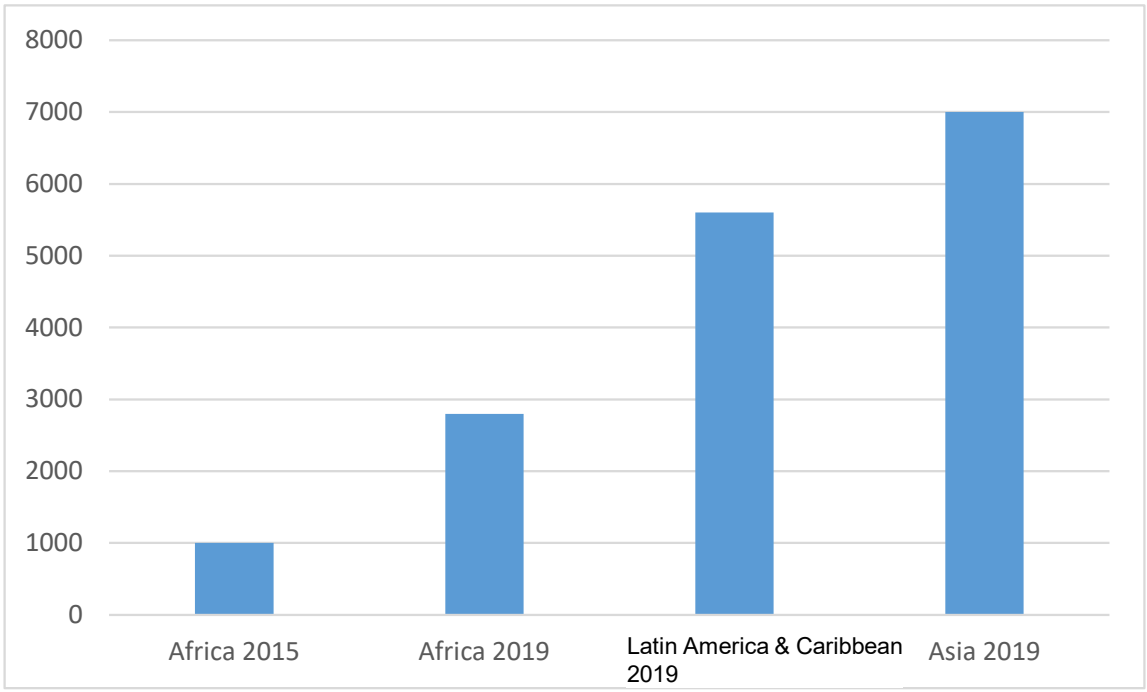
[14] Source: Orange at EIB workshops, 2021.

Delivering reliable connectivity to isolated areas

First-mile improvements need to be enhanced

Major investments in undersea cables across the African continent in the last ten years have significantly increased the capacity per user in the first mile. However, the capacity per user remains below global standards and, for landlocked countries, connectivity to coastal gateways is still complex. Some countries are served by a single cable, resulting in the complete loss of internet access when a cable cut occurs.

The current international bandwidth per user is a barrier to facilitating access to content as it remains limited and not adapted to video/streaming/online meeting usages. This is compounded by the fact that a number of countries do not have internet exchange points (IXPs), and thus their internet traffic uses international roads even when carrying local exchanges.



INTERNATIONAL BANDWIDTH PER USER (KB/SEC)[15]

While existing and emerging operators have invested in new backbone projects, a large number of projects to install fibre optic cables have not yet been completed. A high number of coastal deployments have been carried out in recent years, but inland connectivity, and particularly transnational backbones, remain underdeveloped.

[15] Source: GSMA, 2019

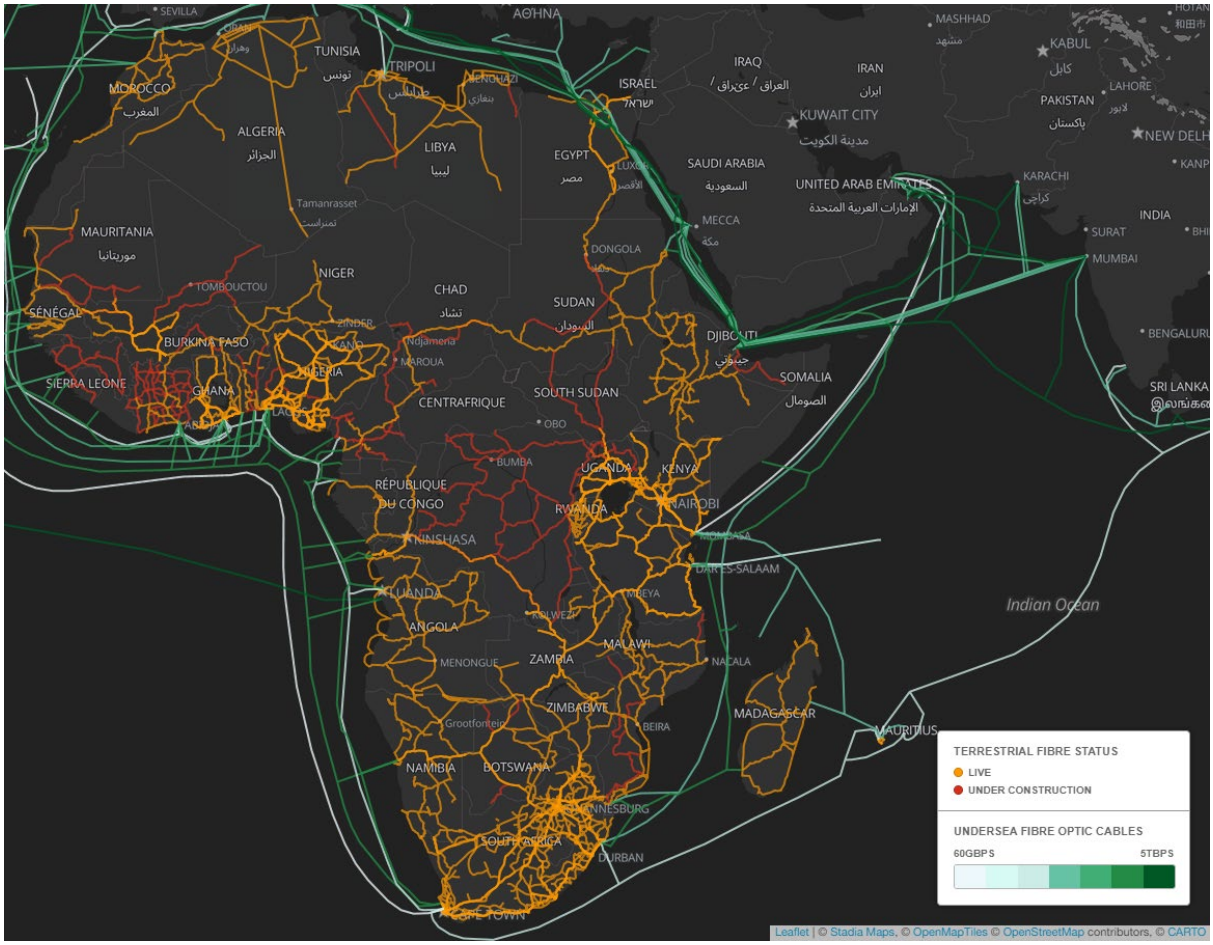


FIGURE 3: UNDERSEA AND TERRESTRIAL FIBRE OPTIC CABLES[16]

Fibre optic backbone: A difficult target

Most African countries have deployed or are willing to deploy a fibre optic central backbone (core network). This backbone often crosses the country, connecting the main city to an undersea cable (in the country itself or a neighbouring country) and/or the closest internet exchange point.

When addressing unserved areas, the cost of fibre deployments and maintenance is an additional constraint as quite often there are no roads and civil work is very costly.

Furthermore, fibre is a point-to-point solution which needs other deployments to serve surrounding areas, while multipoint solutions can be more effective for connecting sparse populations. Although fibre optic technology offers the highest capacity and scalability for backbones, alternative solutions have been deployed to meet short-term coverage requirements and the need to serve broad areas with multipoint connection.

To achieve sustainable coverage in the mid-mile, a global approach is needed that integrates all segments of the network and considers technology meshing, construction sharing and operating models for both operators and infrastructure owners.

[16] Source: NSRC (https://afterfibre.nsrc.org/).

Improving backbone deployments

Traditional core network deployment methods are often difficult to implement to reach unserved areas. Alternative solutions to traditional digging have been found by operators: meshing technologies, or deploying without digging (co-construction, underwater, sharing).

Deployment evolutions

- **Aerial fibre:** Although underground fibre is commonly the most suitable solution in terms of security and infrastructure protection, aerial fibre is used for densification and even for connectivity between metropolitan area networks. In Africa, where some regions are affected by sandstorms and the security of assets needs to be reinforced, aerial solutions allow digging to be avoided while also reducing security costs.
- **Underwater:** To reach some larger underserved areas, backbone operators such as Liquid and BCS adopt underwater methods of fibre deployment by leveraging navigable rivers and lakes.

Benefits and constraints of "dig once" policies

"Dig once" policies aim to reduce excavation costs, minimise disruption to public rights of way, and encourage broadband deployment. "Dig once" encompasses several approaches to installing conduits in conjunction with other compatible construction projects.

To maximise efficiency, a number of conditions need to be respected:

- Reduce the overall costs of all underground work, both utility- and telecommunications-related, for public and private parties; this often means restricting the number of parties involved in construction. When digging in difficult/remote areas, a high number of subcontractors might participate in the project, thus increasing costs and challenging the final quality of service;
- Facilitate the deployment of a private communications network by reducing construction costs;
- Leverage construction by third-party entities to deploy a public communications network or a conduit that can be made available to other entities.

Coordination between companies using the digging works

For "dig once" policies to be effective, there must be strong coordination between the companies aiming to deploy the network (water and telecoms for example, or electricity and telecoms) and accurate information on existing and envisaged networks. Without such information, the excavator might damage existing networks, as illustrated by very many examples of telecom networks being broken during road construction and water pipes being ruptured by digging for telecoms. Existing infrastructure cannot generally accommodate the deployment of additional ducts.

Although empty ducts might appear the most suitable solution for unserved areas in Africa, very few have been constructed in practice, mainly because there is no clear framework.

Costs of unused infrastructure cannot be assumed by a single player

"Dig once" policies in sub-Saharan Africa are mostly put into practice by sharing and/or constructing bigger ducts to be shared when demand arises.

Often the spare capacity in the ducts remains unused for long periods of time either because there is no other provider interested in deploying in the available infrastructure, or because the costs of accessing the ducts are too high.

In Africa, governments cannot afford to bear high construction costs and there are few examples of multiservice networks being deployed by African governments. Meanwhile, private companies struggle to find suitable economic models to sustain these deployments; for cost reasons, they do not construct empty ducts and rarely install dark fibre for potential future usages.

Infrastructure management

Finally, ownership of the infrastructure has strong implications for pricing. Usually, the single duct is owned by the government or the national telecom operator. With a lack of clear wholesale pricing rules, some

infrastructure owners demand unaffordable prices from other players for deploying their passive or active infrastructure in the duct. Thus, non-incumbent players seek other solutions, such as deploying microwave or renting infrastructure from other players (e.g. rail, electricity).

Adapted sharing solutions

Sharing appears to be the most common solution for addressing efficiency in the backbone, given the costs of construction. To be effective, the sharing model needs to be implemented in a clear regulatory framework, thus avoiding the creation of unbalanced competition.

Traditional sharing vs. mutualisation

Network-sharing usage differs significantly between a national backbone generally managed by the former incumbent, and transcontinental networks (even at the local level) owned by wholesale operators. When there is a single wholesale operator at the national level, it is often able to exploit this strong position by demanding extremely high prices to access its ducts or to rent dark fibre. This results in MNOs deploying their own network segments in unserved areas or renting passive infrastructure from utility or railway networks, when available.

Successful network-sharing solutions often entail exchanges between operators, called mutualisation. For example, aiming to increase the geographical extent of its coverage, Orange Tunisie allows other operators to access its remote sites in exchange for these operators opening their own networks to allow Orange to access cities.

There are still very few examples of Layer 2 network-sharing solutions in Africa, particularly at the national level.

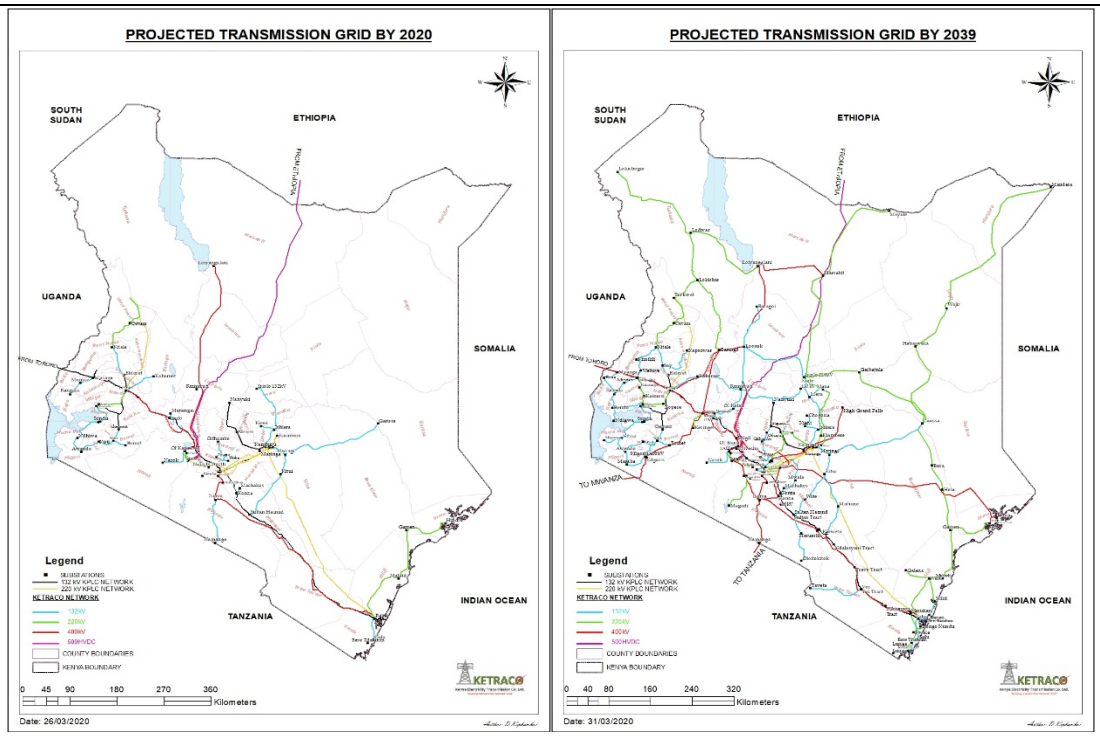
Co-construction

Co-construction of infrastructure by two operators or an operator and a utility player is one solution deployed to achieve cost-effective networks. As telecom companies strongly depend on power while electricity companies need to increase their revenues, particularly when covering rural areas, these partnerships are beneficial for both parties.

Case study: Ketraco sustains backbone and network deployment in Kenya

Ketraco is an electricity company with the founding mission to deploy fibre optic for operators within its own ducts.

Ketraco's model is innovative in that it aligns deployments with backbone providers in a win-win approach. Instead of proposing their existing ducts to operators, Ketraco invites operators to express their interest in deploying infrastructure in an identified area before construction. This approach makes it easier for both players to optimise investments and extend coverage, and for Ketraco to generate more revenue.



EXTENSION OF KETRACO'S TRANSMISSION GRID AND OPTICAL GROUND WIRE NETWORK IN KENYA[17]

Backhaul: Enabler of capacity growth

Backhaul has a strong impact on operators' business model

According to the World Bank, 45% of Africans live more than 10 kilometres from a fibre core network[18]. Backhaul has strong implications for access network capacity and operators' operating costs. As backhaul aggregates traffic from a limited number of sites, particularly in unserved areas, and a number of backhauls are connected to the backbone, the mobile backhaul puts much more pressure on mobile operators' costs than the backbone.

From a technical point of view, although fibre remains the technology with the highest carrying capacity, microwave is the most deployed, particularly in Africa, and new satellite solutions can effectively address current backhauling needs to serve widely dispersed customers.

Traditional solutions need improvements to efficiently cover unserved areas

The technology choices for the access network are highly correlated with backhaul capabilities. For example, when backhaul capabilities are low, only 2G might be deployed.

Backhaul availability also affects operators' business models and retail offerings. The cost of bandwidth is a significant recurring operating expense that has a major impact on the final cost of the service.

Fibre backhaul

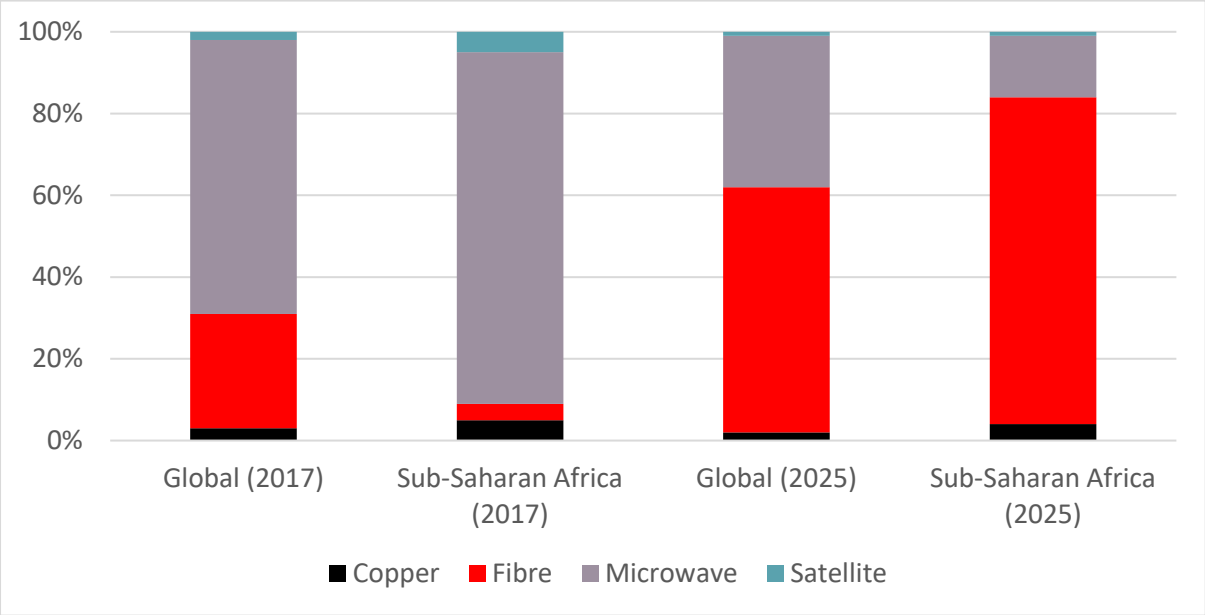
Fibre technology is the mainstay wired backhaul in MNO networks. The traffic generated by 4G in some cities has accelerated the demand for Fibre to the Tower (FTTT) and will require MNOs to upgrade many aspects of

[17] Source: Ketraco presentation, "KENYA ELECTRICITY TRANSMISSION CO. LTD.", EIB workshops, June 2021.
[18] https://blogs.worldbank.org/digital-development/africas-connectivity-gap-can-map-tell-story

their backhaul networks to fibre-based carrier ethernet. For cost reasons, fibre backhaul in Africa is mainly deployed to connect densely populated urban areas to the backbone.

Several countries have few secondary connections to the core fibre network, which often do not reach larger unserved areas. Consequently, such countries experience major bottlenecks in aggregation and backhaul, as the access network is not adequately connected to the core.

Although GSMA forecasts that most backhauls in sub-Saharan Africa will be fibre within the next five years, the latest developments show that the mid-mile remains underdeveloped even in suburban areas, and current investment plans will not fill the coverage gap in the short term.



TOTAL BACKHAUL BY METHOD, GLOBALLY AND IN SUB-SAHARAN AFRICA (2017 AND 2025)[19]

Microwave remains the most common solution

Microwave backhaul is the most used technology owing to the combination of its capability and relative ease of deployment: with no need for trenches or ducts, it is a low-cost option that can be deployed in a matter of days. Although microwave once had limited capacity, developments mean that it is now capable of attaining 10 Gbps to 25 Gbps data throughput capabilities (V- and E-band). It is also possible to combine low-frequency and high-frequency microwave bands to achieve high capacity over long distances with enhanced availability. The main drawback is that microwave backhaul usually requires a licence.

At the same time, the operating costs of microwave are especially high, thus raising the global cost of connectivity. Each microwave site requires power, maintenance and security to protect assets in high-risk locations.

Satellite

In areas where no terrestrial point of presence (POP) is available (including most unserved areas), satellite backhaul may be the only technology available to interface between different access solutions. Satellite backhaul is commonly provided by independent satellite operators, which commercialise bandwidth.

Usually, satellite is used as back up or to serve selected areas located far away from the backbone, as it is considered costly.

[19] Source: ABI Research in "GSMA Connected Society — Closing the Coverage Gap: How Innovation Can Drive Rural Connectivity."

New solutions: Technologies adapted to cover backhaul in unserved areas

- **Long-term evolution (LTE) solutions** are used for the densification of suburban areas where 4G is highly deployed. On a small scale, long-term evolution is also used as a backhaul for remote areas.
- **New satellite solutions** are being implemented even in very remote areas. For a long time, the cost and latency of satellite solutions limited the expansion of this solution. However, satellite companies have developed new technologies enabling cost-efficient connectivity for underserved areas. Satellite now appears to be the most appropriate technical solution for rapid deployment in remote areas (broad coverage, multipoint, no maintenance).

Example: SES unlocks remote Chad regions[20]

Chad is landlocked country with a high number of regions lacking good power supply and transportation infrastructure. When SES, the country's main MNO, decided to extend its coverage to remote areas, the lack of roads and the energy needs prompted the selection of satellite solutions.

Based in O3b[21] MEO[22], SES installed a new teleport and deployed satellite backhaul solutions under dual C- and Ku-band to ensure high availability.

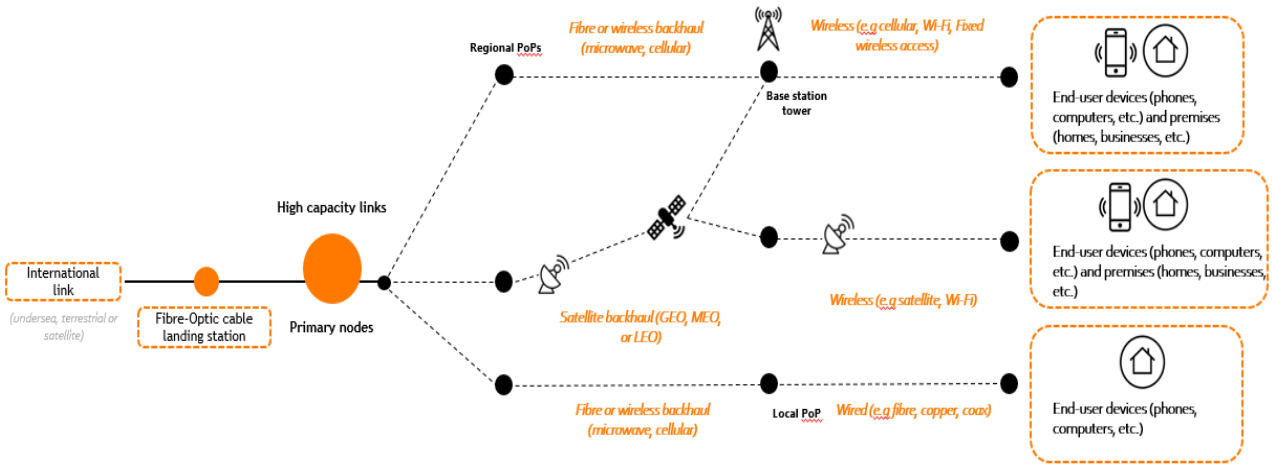
The project was financed by SES and carried out with the support of local teams trained to install the equipment.

Technology meshing

As explained above, a number of factors explain the lack of end-to-end fibre networks in Africa.

Meshed solutions are used to cover unserved areas and allow broadband deployment. Meshed networks combine satellite, fibre optics and microwave to provide broad coverage to the target areas.

Satellite and microwave appear to be more suitable for short-term deployments as they enable the coverage of broader areas, whereas fibre optic is a point-to-point solution that needs extensions to reach each location.



MESHED SOLUTIONS TO REACH THE LAST MILE[23]

This multitechnology approach reduces short-term capital risk in lengthy and expensive build projects.

[20] Source: SES (EIB workshops).
[21] O3B: Other 3 billion, Google satellite network
[22] MEO: Medium Earth Orbit
[23] Source: ITU, 2018.

Example: Liquid Telecom's multitechnology network roll-out strategy[24]

Liquid Telecom, one of the first players in Africa's fibre backbone, has adopted the multitechnology approach for addressing remote areas.

For Liquid, this approach reduces capital risk in lengthy and expensive projects by enabling short-term satellite solutions with geotagging recognition allowing hotspot identification of the villages.

Satellite is used in combination with fibre or microwave to provide high-availability backhaul.

Depending on the location, distance from the core network, and costs of construction, different technologies are available to deliver backhaul and backbone capacities. The table below summarises the backhaul solutions and their adaptation to different geographical contexts.

Technology	Where?	Pros	Cons	Evolutions
Fibre optics	Core network Backhaul to connected populated areas	Reliable Scalable High capacity	Costs of construction Cost of the asset Difficult to deploy in unserved areas Point-to-point	Lightweight fibre for aerial solutions New deployment methods (under rivers)
Microwave	85% of backhaul in Africa	Easy to install Low maintenance Cheaper than fibre	Point-to-point Power costs Need for line of sight More difficult to scale up capacity	Millimetre wave
Satellite	Ultra-rural backhaul and backbone connectivity	Low maintenance Quickest to deploy Capability to cover broad geographical areas Point-to-multipoint Used to expand data networks at low cost	Latency	New satellite solutions reducing latency and cost of equipment adapted to unserved areas, other than ultra-rural Light teleports
Long-term evolution	Suburb backhaul	Densification	Costs (energy, maintenance) Need for available spectrum frequency	Ethernet evolutions

[24] Source: Liquid Telecom (EIB workshops), 2021.

Mesh (satellite/microwave)	Rural Ultra-rural backhaul	Coverage extension Easy to deploy Cost reduction Cost efficiency	Lower capacity than fibre optic	Capacity increased by new satellite solutions
Mesh (satellite/fibre optics)	Peri-urban Rural	Coverage extension	Lower capacity than full fibre optic	Capacity increased by new satellite solutions

TECHNOLOGY USAGES DEPENDING ON CONTEXT[25]

[25] Source: Sofrecom (EIB workshops), 2021.

Efficient network roll-out

ICT and digital infrastructure projects are aligned with the decarbonisation objectives of increased energy efficiency (to decrease energy consumption).

Unlocking new energy solutions is a structural issue for successfully upscaling networks and providing a new sustainable approach towards the whole economic ecosystem built around them. New access models often integrate green solutions to avoid high operational expenditure.

Sustainable energy solutions are competitive when considering mid-term gains and amortised capital expenditure. The operational expenditure reductions of solar are also significant, given the challenges associated with regularly transporting diesel fuel to remote locations.

In some countries, even on-grid production is often inefficient, which has a very strong impact on MNOs' revenues through lack of service continuity, low quality of service, impossibility to use the network, and other adverse effects.

As shown in the table below, the level of national electrification in several countries supports the need for alternative solutions.

Country	**National electrification (population connected to national electricity network)**	**Population (million)**	**Density (pop/km^2)**	**3G population coverage**
Burundi	11%	11.8	435.2	40%
Chad	11.8%	16.4	12.3	60%
Burkina Faso	14.4%	20.9	72.2	65%
Niger	17.6%	24.2	17.7	71%
Malawi	18%	19.1	192.4	95%
Democratic Republic of the Congo	19%	89.6	37.1	65%

NATIONAL ELECTRIFICATION AND 3G COVERAGE RELATED TO POPULATION AND DENSITY[26]

Energy service companies (ESCOs): The key players

ESCOs are the new players in energy, representing an extension of the most applied model.

ESCOs have historically been engaged in managing diesel energy for MNOs and renewing sites. Some of them have also advanced to providing renewable energy offers.

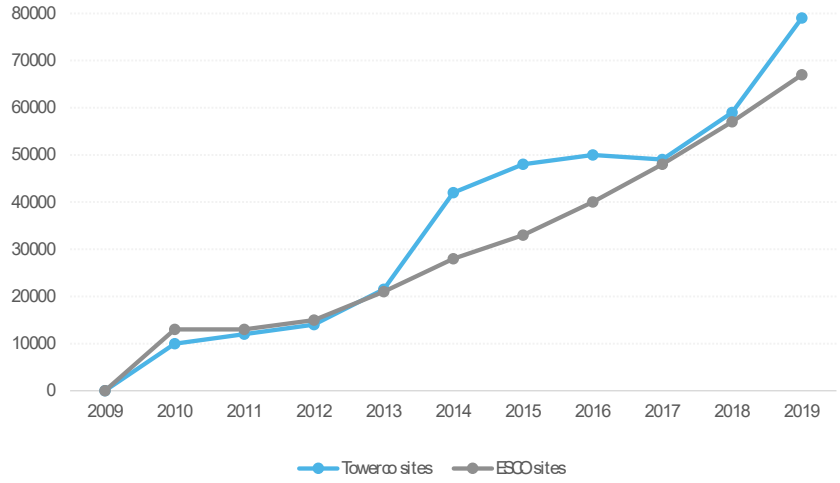
In the T-ESCO model, the energy company installs all the equipment needed to provide electricity at the bottom of the towers, bought by the MNO or the company itself.

ESCOs also train their customer MNOs to ensure they become autonomous at the end of the contract.

[26] Source: GSMA, 2018.

ESCOs can either replace energy solutions or install solutions in greenfield projects.

In all cases, contracts between ESCOs and MNOs integrate service level agreements (which might vary for rural areas).



ESCO GROWTH[27]

Case study: IPT Powertech's efficient energy production[28]

IPT Powertech is testing new energy-efficient infrastructure (electrical and photovoltaic supply, batteries) for existing and new cellular towers across Guinea, aiming to improve the energy efficiency and reliability of the power supply, while also increasing renewable energy consumption. The purpose of the project is to upgrade facilities to be partly or fully powered by solar panels, increase storage capacity and install free-cooling equipment. These upgrades will decrease electricity consumption and significantly reduce both diesel consumption and the associated maintenance costs (by 30–50%). The project has been financed by the EIB and its European partners.

The share of sustainable services across the ESCO market continues to rise. This is seen as a positive evolution by ESCOs and MNOs, resulting in reduced emissions, greater cost efficiency and easier maintenance, which is particularly relevant for rural areas.

Indeed, most green energy solutions aiming to cover isolated areas in Africa are solar, reflecting its status as the most predictable energy source (compared to wind, for instance), as well as the maturity of the technology and the decreasing price of solar panels.

For ESCOs, the move to solar ensures a predictable source of energy and no price fluctuations, while the demands of security and maintenance are lower as solar energy needs much less physical presence on site than diesel. For MNOs, the cost of energy is also predictable, risks of energy cuts are overcome, and service quality is improved. ESCOs propose a number of sustainable solutions in accordance with their customer MNOs.

ESCOs offer a 70–80% carbon emissions reduction by renewing MNO sites.

- **Solarisation of sites (off-grid)**

[27] Source: TowerXchange, Q4 2019.
[28] Source: IPT Powertech (EIB workshops).

Full solar solutions mainly cover ultra-rural areas. Solar needs space to be developed, and it is difficult to install solar solutions in cities.

- **Hybrid energy provision (on-grid)**
  Hybrid models combine fuel and solar solutions, with the aim of fuel being slowly replaced by solar.

- **Solar farms (on-grid)**
  This solution involves the ESCO building a solar farm on a field bought by the MNO. The ESCO sells energy to the MNO at a discounted price (the discount is equivalent to the loan of the field) and can also sell to neighbouring communities.

At the end of the contract, the operator can recover the assets.

The MNO and the energy supplier jointly decide on which solutions to use when renewing a site's energy provision or deploying in new territories (solar, hybrid, fuel).

A number of factors influence the choices:

- Reducing costs
- Availability of energy from the national electricity company
- Area characteristics (see table below)

	Solar panels	Hybrid	Fuel	Solar farms
Ultra-rural	X	X		
Rural (mid-distance from roads and energy networks)	X	X		
Dense cities			X	X
Unserved suburbs		X	X	X

TYPE OF SOLUTION DEPENDING ON AREA CHARACTERISTICS[29]

ESCO business models

ESCOs provide innovative business models for telecoms. The monetisation methods are very diversified and still evolving. MNOs consider ESCOs as business partners, and thus support their transformation and growth in the value chain.

MNOs mainly benefit from the relationship through off-grid deployments enabling them to reach new customers, and through the reductions in capital and operational expenditure brought by sustainable energy solutions.

An ESCO can deploy different models depending on the site characteristics and MNO demands. For example, if the MNO aims to reduce its carbon footprint, solar will be installed, even if more expensive in terms of capital expenditure.

ESCOs also provide NaaSCos in energy for their deployments in rural areas.

In the various business models presented below, energy costs can be agreed on a fixed or pass-through basis.

[29] Source: Sofrecom (EIB workshops).

- In the fixed model, the MNO pays a predetermined sum for energy for one, two or six months, regardless of how much energy is consumed.
- In the pass-through model, the MNO pays for the energy it consumes.

Recent years have seen a strong shift to the fixed model as this allows better management of energy and pushes ESCOs and MNOs to use resources more effectively.

The full operational expenditure model

In this model, the ESCO owns the assets and takes the financial risk of contracting loans. ESCOs' business models are favourable to renewable energy investments as contracts with MNOs and TowerCos have a duration of 10–15 years. This allows them to depreciate renewable energy equipment over a longer period and to generate good financial returns.

The ESCO deploys its own capital to acquire energy equipment for telecom cell sites.

This model allows strong control of costs and good EBIDTA[30] margins for both sides.

The ESCO has visibility over revenue and sustainable cash flow, mainly because of the length of contracts and low tenant turnover.

Contracts usually cover inflation risk and fuel price variations.

If the MNO shares its passive or active infrastructure it can also share the electrical provision with other operators.

The supplier invoices the MNO on a quarterly or half-yearly basis for capital expenditure (generators, batteries and location) and operational expenditure (maintenance, energy and security)

Revenue-sharing model

Revenue-sharing contracts are also 10–15 years in length and generally renewable. ESCOs secure the cash flow stream from the basic renting revenues and benefits are shared on predefined bases (e.g. 50/50, 60/40).

For investors, cash flow is based on a pool of sites (and not per site as in other models).

This model may also be suitable for equity investors.

Hybrid model

The hybrid model addresses the commercial part of the business model. The MNO pays a fixed amount to the ESCO and the two parties share the remaining revenue.

In some cases a threshold is established, with the MNO committing to pay a guaranteed minimum amount to the ESCO even if the site does not generate the expected revenues.

In other cases, the MNO can establish a limit for the revenue received by the ESCO.

Anchor-Business-Community (ABC) mini-grid model (off-grid)

In remote rural areas unlikely to be connected to a national electricity grid in the near term, access to mobile connectivity is often provided through "small cell sites" — low-capacity, low-power-consuming sites designed to bring services to small niches of the population.

Small cell sites are increasingly considered ideal for renewable energy systems such as solar, as they consume less than a quarter of the energy required by larger towers.

[30] EBITDA: earnings before interest, taxes, depreciation, and amortisation.

These sites present an opportunity to install and operate renewable energy-based mini-grid systems that supply electricity to not only towers but also local businesses and community households. MNOs or TowerCos are the "anchor customer," generating enough revenues to ensure equilibrium in the financial model, while ESCOs enable the power system to be scaled to provide electricity to communities.

As in most rural areas in emerging countries, monetisation is a challenge when deploying the ABC model as rural populations have lower income than the national average. For the ABC model to be viable, it needs to reach a sufficient scale to ensure the service level agreement for the main customer (the MNO) can be implemented. Scale is also necessary to lower costs, as the local population will not be able to pay the current price for solar KW.

Finally, ESCOs need to deploy new commercial capabilities to move from a B2B model to a B2C model[31].

Power purchase agreement model

This model is an application of solar farms and is based on energy exchange between the MNO and the national electricity company. The MNO or energy provider deploy solar farms on-grid, managed and operated by the ESCO. The energy generated is injected into the network of the national energy provider, and the MNO takes the energy back at the bottom of its towers anywhere in the energy network.

The MNO buys the field where the solar farm is situated, then leases it to the ESCO that provides energy to the MNO.

To be implemented, this model needs a supportive regulatory environment for wheeling (injection and transport of energy) and net metering (allowing recovery of the energy injected).

NaaS: The new model

MNOs have expressed strong interest in ESCOs becoming NaaS players, as there is a strong relation between energy coverage and telecom coverage.

In the NaaS model, the ESCO provides a full service including tower installation and maintenance, while the MNO plugs itself into the all-in-one tower.

NaaS often relies on revenue or margin sharing. By adopting this model, ESCOs would become competitors of current NaaSCos as providing the same type of service. ESCOs' competitive advantage is based on the cost of energy, but they will usually need to deepen their knowledge of the telecoms ecosystem.

[31] B2B: business to business; B2C: business to customer.

Business model	Description	Service provider examples	Who is the customer?	Who owns the asset?	Who takes the risk?
Full operational expenditure	ESCOs provide end-to-end energy (capital expenditure, energy, maintenance and security)	I-ENG Camusat IPT Powertech	NaaSCos MNOs	ESCOs during the period of operation, then the MNO if the contract is not renewed	ESCOs Some cases of risk sharing with NaaSCos
Revenue sharing	Calculations (costs and revenues) based on **pool of sites**	I-ENG	NaaSCos MNOs	ESCOs	ESCOs
Hybrid	Minimum payment is guaranteed by the MNO to the ESCO; revenues "on top" are shared	I-ENG IPT Powertech	MNOs	ESCOs	ESCOs
NaaSCo	ESCOs extend their activities to tower installation and operations	IPT Powertech	MNOs	ESCOs, then passed to the MNO at the end of the contract period (depending on agreements)	ESCOs
ABC (off-grid)	Provides energy to villages surrounding towers	No example found in Africa	MNOs and inhabitants of communities close to tower sites		
Corporate power purchase agreement (on-grid)	Based on the exchange of energy; the MNO is the service provider, even when the energy is produced by a subcontractor	Orange	National electricity company	ESCOs own the energy solution MNOs own the farm site At the end of the contract, the ESCO hands over the equipment to the MNO	ESCOs/MNOs

SUMMARY OF NEW BUSINESS MODELS FOR ENERGY PROVISION[32]

[32] Source: Sofrecom (EIB workshops).

Reaching scale

At present, most ESCOs are covering off-grid areas or deploying solutions in pursuit of green energy objectives.

Although full solar solutions are only installed in off-grid rural areas, the benefits for operators in moving to renewable energies will enhance the installation of these solutions.

Drivers	Inhibitors
- MNO commitment to green energy - Revenue optimisation - Increased coverage of unserved populations through off-grid solutions - Operational expenditure reduction - Improved quality of service for MNOs, as ESCOs guarantee 99% energy continuity	- Lack of field information makes deployment complex - Price regulations can oblige ESCOs to provide energy at the same prices as the national company - Security of people and assets - The revenues are in local currency while most of the loans are in euro or US dollar.

DRIVERS AND INHIBITORS OF REACHING SCALE[33]

To be competitive and achieve geographical expansion, ESCOs need to achieve scale, but the associated costs preclude competitive prices until scale is attained. In this context, operators have an essential role as anchor customers.

Local governments can enhance the usage of solar energy by allowing the electrification of small villages close to towers using the ESCO solution, thus enhancing service deployment.

For the use of renewable energy to increase, it is necessary to consider broader bases than short-term pricing.

The telecom sector can be the game-changer in renewable energy deployment in Africa

Implementation of renewable energy solutions in Europe is often driven by regulatory obligations. However, very few African countries have renewable energy policies and regulations. When these regulations exist, they incentivise or mandate reduced diesel consumption, increased renewable energy deployments and energy-efficiency measures for tower sites. Initiating a policy-related dialogue between equipment owners (MNOs, TowerCos and ESCOs) and policymakers in the telecom and energy sectors can help to achieve a breakthrough. ICT players have the opportunity to be key players in energy migration and off-grid coverage.

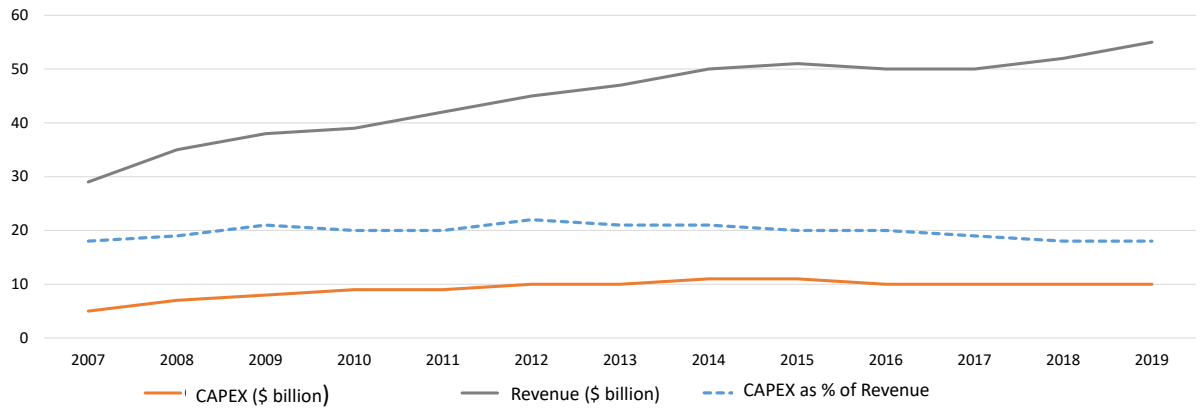
In sub-Saharan Africa, where MNOs and TowerCos do not expect to receive electricity from the national grid in the near term, the incentive to invest in renewable energy remains high.

As many rural unserved areas are off-grid and diesel energy has associated transport and security challenges, renewable solutions appear to be a viable long-term choice for electrifying network components.

[33] Source: Sofrecom.

Operators' business models

Since the most profitable areas have already been covered by 3G and 4G networks, operators' capital expenditure has been declining over recent years. Reasons include their reluctance to assume the financial risks of deploying in less developed areas, new business models that push capital expenditure to other players, and the implementation of sharing solutions.



CAPITAL EXPENDITURE AND TOTAL REVENUE IN THE TELECOM SECTOR IN AFRICA, 2007–2019[34]

The characteristics of unserved areas have a profound adverse impact on all aspects of the traditional business case for mobile network expansion — higher capital investment costs per site, higher operating costs and a significantly lower revenue opportunity.

The traditional financing approach cannot be applied with the same conditions as for urban situations. For deployments to be financially viable, it is necessary to lower the cost of equipment, find adapted energy solutions, enhance the usage of towers for other services, and consider benefits for the whole ecosystem with regard to return on investment.

A single business model cannot address all the coverage issues an operator might encounter, as the geographical characteristics, competitive situation and ICT policies differ for each case.

The government can play a particularly important role in the deployment of networks in unserved areas, for instance as the anchor customer or the network owner.

Diversified business models

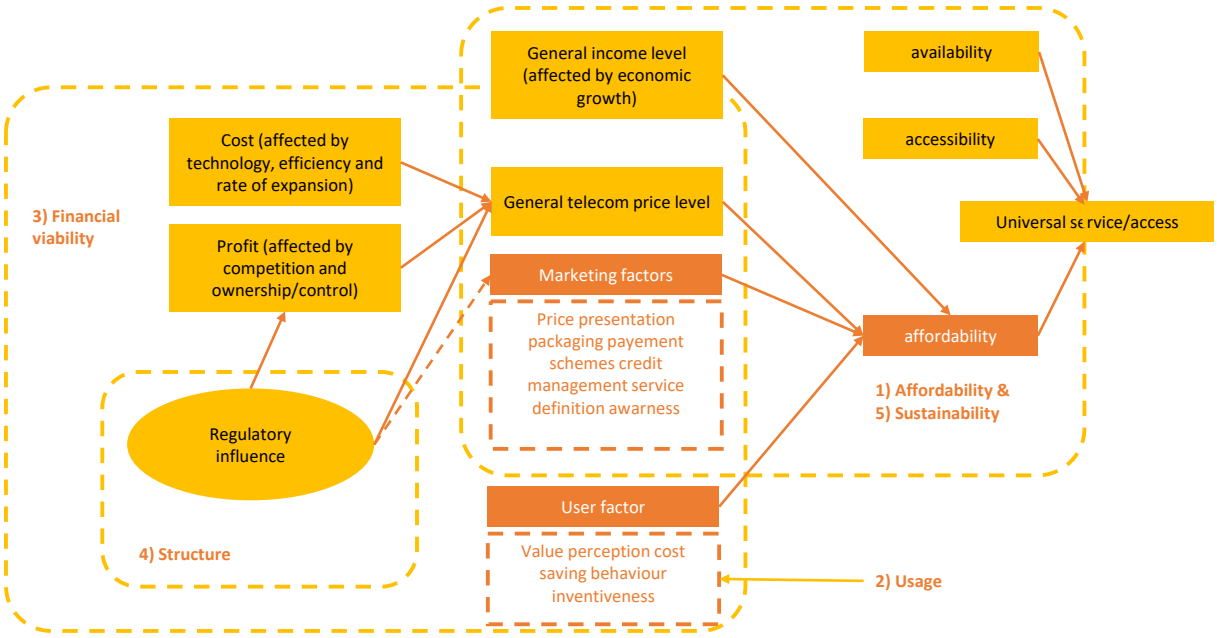
While a number of innovative business models have been adopted by traditional and new players, the ability of a single provider (of equipment or energy) to diversify business models according to its partners and the implementation location enhances overall business feasibility.

A single provider can combine a number of business models: for example, a NaaSCo can provide services under NaaS and move to lease to purchase.

Finding new solutions to traditional business models is a challenge for all players aiming to connect unserved areas.

As shown in the figure below, the viability of last-mile connectivity depends on several components: affordability, usage, financial viability, regulation and sustainability.

[34] Source: Authors' calculations based on data from GSMA Intelligence, www.gsmaintelligence.com/data/

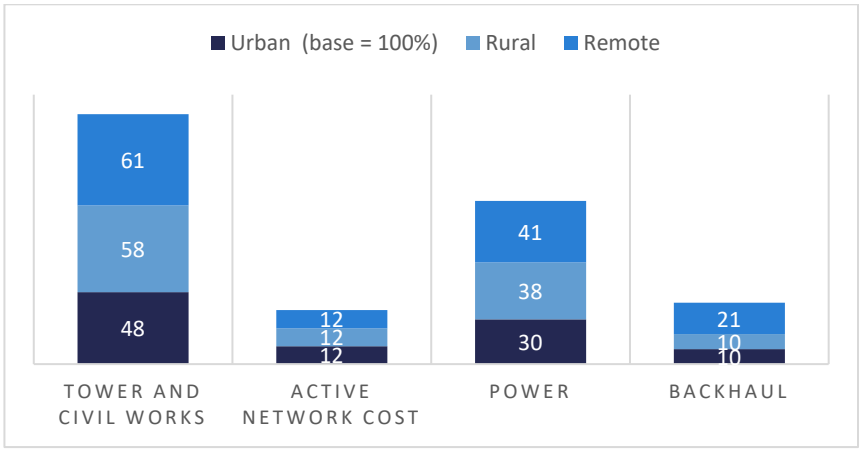


The components of an affordable last-mile connectivity solution[35]

Reducing costs

As explained in the first three chapters of this white paper, the main requirement to achieve coverage of unserved areas is to reduce costs at all levels.

To reach this objective, MNOs and equipment providers have enhanced subcontracting to smaller, more reactive companies specialised in energy and access solutions.



ANNUALISED COST OF MOBILE COVERAGE SITES IN RURAL AND REMOTE LOCATIONS (RELATIVE TO URBAN) BY MAJOR COMPONENT (% OF OVERALL COST)[36]

[35] Source: ITU, 2020.
[36] Source: GSMA Intelligence, 2020.

To successfully implement their own business models, specialised players such as NaaSCos and ESCOs also focus on ways to achieve cost reductions. NaaSCos, for example, install software enabling the reduction of bandwidth usage from satellites and the increased efficiency of 2G networks.

Solution sharing

The cost reductions from network sharing have been discussed in the previous chapter. However, the possibilities for solution sharing in new service models are not fully clear.

Innovative sharing options can be leveraged: currently, most light access solutions (deployed by NaaSCos) are devoted to a single operator, while most ESCO models aim to provide energy to the towers of subscribing operators.

By sharing energy supply and light towers with other operators, vendors and electricity solution providers can benefit from diminished risks, including with respect to revenue, and better economic returns.

Furthermore, using electricity equipment to provide energy to surrounding communities can create new sources of revenue and attract new subscribers (by powering terminals, benefiting the ecosystem and increasing global externalities). If energy companies, which are mainly small and medium enterprises, do not envisage changing their target market, they could make use of MNOs as commercial channels.

Sharing risks

The new models of subcontracting access and the integration of new specialised players allow traditional MNOs to share financial risks with vendors, solution providers and energy players.

In all these cases, after signing a contract for a defined project, the suppliers (energy, all-in-one equipment providers) seek their own financing solutions.

MNOs can support the providers' financing efforts by agreeing long-term contracts.

- **TowerCos**
  TowerCos own their towers and assume responsibility for maintenance. They invoice service and energy costs to MNOs.

- **NaaSCo**
  NaaSCos deploy the whole solution and leverage funds for the global project. They invoice MNOs mainly on the basis of NaaS models. Capital expenditure is integrated in the amount invoiced, so at the end of the contract the MNO can renew or become the asset owner.

  When considering all-in-one solutions, it must be taken into account that the player installing the infrastructure also has relations with off-grid power providers. Accordingly, the risks can be shared between the two players or fully assumed by the all-in-one provider.

- **Energy providers**

  When an energy company contracts with an MNO to provide energy to several sites, it will take out a loan to finance the infrastructure and initial months of operations. Depending on the model (ESCO, operational expenditure, NaaS), the conditions of payment for services may change.

  The length of the contract is usually 10–15 years.

  The business models are still evolving and some ESCOs are moving towards becoming all-in-one providers, under pressure from MNOs.

Creating revenue opportunities

To achieve revenues, accessibility and affordability are the two core concepts.

Affordability is driven by not only the price of the service but also access to terminals.

Enhancing usage

Skills development is key to enhancing the usage of telecom services. Accordingly, MNOs need to create the conditions for customers to move from voice usages (still predominant in central and western Africa) to data usages. In this context, actions to develop digital skills are taken by either MNOs or the anchor customer.

Enhancing coverage

Some operators aim to provide service continuity and consider revenues at the national level and the benefits of the whole business case, rather than simply assessing the profit and loss for rural sites. In such cases, the MNO deploys with support from an all-in-one provider on a revenue-sharing basis, and agrees to concede high percentages to the deploying player.

Finding the anchor customer

For unserved areas where appetite for services is low because skills and equipment are lacking, the government and other public institutions can act as anchor customers in a connectivity deployment. By assuming this position, and thereby ensuring that sufficient revenues will be generated by the deployment, public agencies can play a significant and concrete role in expanding coverage of unserved areas.

Example: De-risking investments with an anchor customer (Liquid Telecom)[37]

When aiming to connect an unserved area, Liquid Telecom first seeks an anchor customer that will subscribe to services to cover costs and create the dynamics for growth. Generally, the anchor customer is a public body, such as a school, health institution, or government agency. With this approach, potential financiers can be satisfied that financial risks are diminished.

Liquid Telecom has used this approach to connect all government buildings in South Africa on a network of 100 Mbps capacity. A number of these buildings were in unserved areas, so this deployment has brought data connectivity to previously unconnected villages. The whole ecosystem has benefited from the new connectivity and the local economy experienced growth.

[37] Source: Liquid Telecom (EIB workshops).

Flexible, adaptable business models are the answer

Gaining efficiency in each aspect of a traditional MNO's business model can provide coverage for some unserved areas. However, changes in the overall approach of the business case are producing faster and more efficient ways to deploy networks and create broader economic opportunities.

Connectivity business model	Description	Service provider	Who owns the asset?	Who takes the risk?
Coverage as a service (capital expenditure model)	The operator provides the capital expenditure; selects and secures the equipment; and manages the operation and operational expenditure of cell sites (often macrocell, although small cell may be more relevant for rural locations), backhaul (microwave and satellite) and energy solutions (largely diesel generators).	MNO	MNO	MNO
Coverage as a service (revenue-sharing model)	A rural-focused third-party operator raises funds to deploy infrastructure in areas not covered by, and perhaps not strategically viable for, a traditional retail operator.	Projects in Benin, Mauritania	Local specific operator	Government and/or equipment providers
Asset lease model	Major TowerCos provide the tower structure on which telecom companies' radio equipment and antennas are placed, as well as value-added services such as power and maintenance.	TowerCos	TowerCos	TowerCos
Build-own-operate-transfer	This models builds on the asset lease model by adding specific hardware and letting operators plug into the solution. The provider also assumes responsibility for commercial activities, such as scratch card selling.	NuRAN, AMN	NaaSCo during the contract MNO at the end of the contract	NaaSCo
Equipment supply (RAN)	The integration of new RAN light solutions in traditional towers.	NuRAN	TowerCos NaaSCo	NaaSCo TowerCos
Lease to purchase	Contractual agreement under which the lessee leases the business for an agreed period, after which the lessee could fully own the business.	American Towers Helios Towers NuRAN I-ENG	NaaSCo TowerCo ESCO	ESCO

Network as a service	Minimum revenue guaranteed for each site or revenue sharing.	As customer: Orange, Moov	NaaSCo ESCO Transfer to MNO after 6–10 years	NaaSCo
Revenue sharing/Margin sharing	This model can be used on a standalone basis (not associated with network as a service) in situations where operators rent infrastructure	AMN, NuRAN As customer: MTN, Orange, Moov	NaaSCo ESCO Asset reverts to the MNO after the contract period	NaaSCo ESCO
Anchor customer	This model focuses on connecting a single institutional customer, thereby generating the minimum revenue needed to allow network expansion.	As infrastructure operator: Liquid Telecom	Infrastructure operator MNO	For infrastructure, the MNO takes the risk. The anchor customer can benefit from grants or loans to deploy services to other customers close to its location

SUMMARY OF BUSINESS MODELS APPLIED TO COVER UNSERVED AREAS[38]

The importance of policy and regulation in overcoming barriers

Rural communities have a high need for voice and data connectivity to overcome some of the challenges inherent in their remote location. However, they tend to be the least connected parts of a society, particularly because the economics of investments in sparsely populated areas are often unattractive to the commercial sector.

Digital exclusion of rural areas is creating a spatial divide that worsens rural populations' economic opportunities and access to productivity gains while also inhibiting their access to a major development driver.

Local governments can be an essential driver of deployment in unserved areas by clarifying policies, sustaining investment and adapting licence prices. The table below summarises the main barriers to increasing connectivity in unserved areas, together with potential solutions.

[38] Source: Sofrecom (EIB workshops).

Type of barrier	Description	Consequences	Solutions
Licences	High prices of licences lead to high prices for the related telecom service.	Some sub-Saharan countries do not have 4G deployments because of the licence price set by the government. The primary goal for policymakers and regulators should be to maximise use of the spectrum, rather than its short-term value. In low-income areas, money spent acquiring licences has a strong impact on the final price of services and network deployments.	Consider direct and indirect benefits of technology deployment when setting licence prices. Use policy and regulation to enhance the ecosystem potentialities.
Cost of service when network sharing carried out by a single operator	Very few countries in Africa have structured wholesale regulations that define sharing rules, provide cost caps for wholesale infrastructure or establish monetisation rules.	Double deployment of networks in the same area.	Clear wholesale regulation on network-sharing conditions and pricing.
Taxes	High taxes for towers, batteries, generators and other equipment increase the cost per site.	In rural areas, where investment and revenues are considered per site, the cost of equipment can make services unaffordable or prevent deployments and upgrades.	Tax exemption and tax cuts for equipment for rural areas.
Suppliers' compliance during construction	Construction companies often have a high number of subcontractors.	Once the margins of each subcontractor are audited, the final price of the network can increase by up to 50–60%.	Establish requirements for all suppliers to comply with established quality standards. Limit the number of suppliers.
Energy	Some countries do not allow the deployment of solar farms or apply high constraints on solar equipment installation.	Such regulations have a strong impact on the overall sustainability of the ecosystem.	Consider green energy as a sustainable goal in regulations. Letting private companies create new sustainable energy solutions might advance a country's engagement in sustainable growth without any public contribution.
Energy	Pressure to align prices of sustainable energy with the prices charged by local energy companies.	Higher cost per tower and difficulties in achieving scale.	Allow competition in energy offerings and pricing. As solar is currently only devoted to industrial customers in unserved areas, this will not have any distortion effect at the consumer level.

BARRIERS TO AND SOLUTIONS FOR INCREASING CONNECTIVITY IN UNSERVED AREAS[39]

[39] Source: Sofrecom.

Unlocking financing

With African states facing budget deficits and telecom operators witnessing the continuous erosion of profit margins and the contraction of average revenue per user, it is essential to find new models for financing digital development, especially telecom infrastructure.

To unlock financing, beneficiaries need to find ways to address financial institutions, while financial institutions need to adapt their approach to the specific characteristics of telecom businesses in unserved areas.

Overcoming barriers to accessing finance

Operators in Africa need strong investment to maintain their average revenue per user in populated areas by scaling up technologies, increasing densification and launching new services. However, they lack sufficient financing capacities to fund deployment projects to connect unserved areas. When seeking funding support, commercial players (operators, all-in-one business providers, vendors) face several barriers:

- Mismatch between the currencies of revenues and capital expenditure costs

While equipment costs are mostly in international currencies, revenues are in local currencies. A number of international operators with local operations strongly encourage their local partners to take out loans in local currencies, either from subsidiaries of international banks or development banks.

- Return on investment

Return on investment takes longer to realise in areas where the average revenue per user is around $2 and customer usages need to be enhanced to create appetite for telecom services.

- The life cycle of active equipment is much shorter than the loan tenor

Often, the loan for equipment is still being repaid when active parts of the equipment need to be upgraded (every two to three years). At the same time, the tenor for licencing duration is usually five to seven years, while amortisation can take much longer. Thus, companies (MNOs and vendors) are still paying for a previous technology while already migrating to the next.

- Players do not always know how to contact international stakeholders

The processes for accessing international funding are difficult to understand for local governments and industry players, particularly innovative small and medium enterprises in rural areas.

- Low-budget projects are difficult to finance

The novelty of connectivity solutions often means there is no historical evidence to support their business case, which may raise doubts about the company's capacity to repay debt and generate cash flow. The amount of investment required to provide coverage of unserved areas, even if relatively high in relation to the operator's revenues, may represent a relatively small loan ticket for international institutions, while still requiring similar administrative efforts to those needed for larger loan tickets. From this point of view, low-budget projects might appear less appealing for financiers.

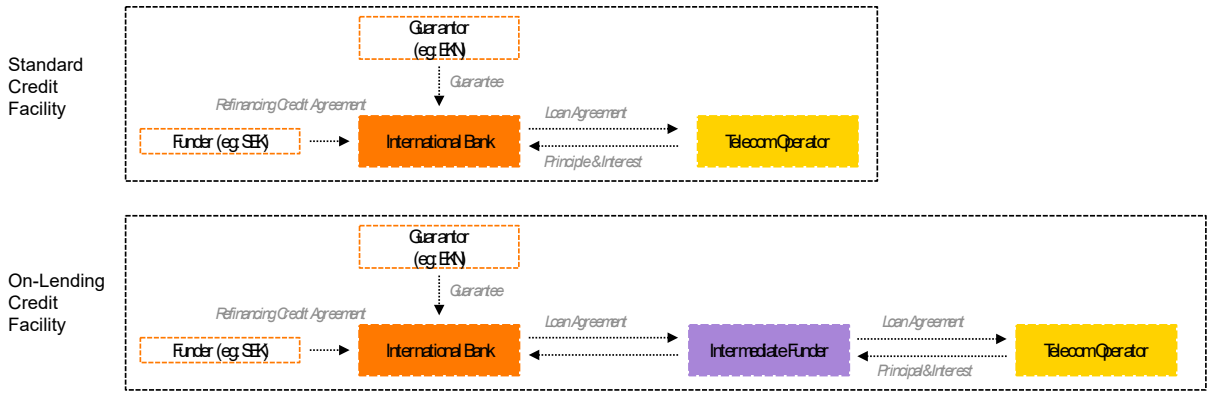
- Small and medium enterprises are insufficiently considered

NaasCos and ESCOs are of a smaller scale than MNOs and other network players (lower revenues, less assets). Although a number of these companies find investment in equity, they struggle to find financing solutions as their size and revenues can appear risky to financial institutions.

Finding solutions

Reduce currency risks

A number of international operators are reluctant to take loans in foreign currency while generating revenues in local currency. In some cases, involving an intermediary agency to guarantee the currency exchange rate can facilitate local players' willingness to take out loans.



INTERMEDIATION TO FACILITATE CREDIT FACILITIES[40]

MNOs envisage business case globally

While MNOs do not frequently shift their perspective from economy per site to economy per pool, some operators go further by considering the company's business case globally in unserved area deployments. These MNOs accept sites in unserved areas to reach equilibrium between investment and revenues without looking to create benefits at the site level. They consider that enhancing connectivity in unserved areas will positively impact their business model as a whole by creating new usages and appetite for services while also providing service continuity.

Partnerships and the role of government

The different cost components of expanding access and adoption are borne by various players — public and private sector bodies, donors, civil society and even consumers. Partnerships that enable these investments to be coordinated and that bridge the gaps between available funds and required investments can shift the burden as appropriate to different stakeholders.

Governments can play a key role by guaranteeing some loans. When an investment by private companies has strong implications for development and, consequently, GDP growth, government support provides an important guarantee of:

- Access to local currency loans;
- Access to hard currencies to repay loans;
- Funding for small-scale projects (typically less than €10 million) that is difficult to find.

Considering the full project costs from coverage to upscale might also open up new avenues for project funding.

Government as the anchor customer can unlock financing

Governments can contribute to financing the uptake of capacity and connectivity for unserved areas by paying upfront for a service subscription. In conjunction with the anchor customer approach, government agencies can subscribe to a service to be deployed, thereby ensuring sufficient revenue for the operator to balance costs while also reducing the financial risks by guaranteeing revenues.

Payment for services can be made from the government's operating budget or USF.

[40] Source: Ericsson (EIB workshops).

Extending access to funding

Regulations and national policies can require banks to diversify their customers or at least limit loans to a single customer to reduce risks (for example, a single customer cannot be loaned more than 30% of the bank's loan book). This limits risks for banks and opens opportunities for new beneficiaries.

African banks are encouraged to extend their customer base

In the West African Economic and Monetary Union, local banks and subsidiaries of international banks are constrained by a regulation to limit their loans to a single customer. Profitable operators are very important customers of local banks, and consequently account for a large percentage of their loan books. This regulation might have a positive impact on funding for small and medium enterprises and niche operators by requiring financing capabilities to be better spread between players.

Changing the market approach

To address the connectivity gap in rural areas, industrial players and financing bodies need to change their market approach in terms of how they consider return on investment and other benefits.

Extending the customer base

A high number of unserved areas can reach profitability through efficient deployments and financing in terms of tenure and pricing. In a number of recent cases, new business models based on risk sharing have achieved significant growth in the customer base (reaching an additional 3 to 5 million customers in some countries).

Expanding national coverage increases usage by existing customers

African populations often move from their villages to the cities, but frequently return to villages for visits or short stays. When villages have coverage, the use of voice and data by visiting urban customers increases. Network expansion also supports money transfers from people living in cities or abroad to their relatives in rural areas.

Consider scale-up potential when drafting the business case

Regarding network access, a number of coverage expansion projects for unserved areas focus on 2G deployments, as towers are lighter and energy consumption is moderate.

2G offers a short-term connectivity solution, allowing populations to communicate, receive information and use some vertical applications based on text, such as e-agriculture (weather information, international seed prices). By accessing technology, populations develop their skills and expand their use of ICT. Therefore, 2G certainly offers strong development benefits in the short term compared to a situation where no service is accessible. At the same time, as explained in the first chapter of this white paper, 2G can only be considered as the first step in a "cover first/upgrade after" strategy. This means that 2G deployments are very likely to be integrated in a mid-term plan which integrates technology upgrades.

For backbone and backhaul, although fibre is considered the most efficient solution in terms of capacity and latency, new satellite and other meshed solutions enable the provision of a good quality service, linking villages to national networks and facilitating usage growth.

Presenting a project for funding and providing a long-term view that integrates the planned technology evolutions to be deployed after the coverage objective is achieved has strong potential to create appetite from development banks.

Considering all beneficial externalities

The economics of investments in sparsely populated areas are often unattractive to the commercial sector as the amortisations periods are much longer than in populated areas. The take-off of demand needs literacy enhancement, content availability and new digital business implementation.

The transition to a digital economy through greater use and adoption of digital-enabled services across economic sectors generates strong positive externalities, such as increased investments, new addressable markets, improved efficiency and cost savings.

The expansion of networks into unserved areas and the densification towards higher data rates are equally important and closely related. The digital economy is based on scale: the reach of digital services is national and their affordability increases with market uptake[41].

Economic impact[42]

Entrepreneurship	More inclusive access to entrepreneurship through lower capital investment requirements and new business models across several sectors.
Financial inclusion	Use of ICT to drive financial inclusion by providing access to banking and digital financial services, such as mobile money, to expand payment, insurance, savings and credit options to all. Digitalisation has emerged as the main driver for improved financial inclusion, starting with retail electronic payment systems and expanding to insurance, savings and credit servicing. This evolution has had a major impact on previously unbanked medium- and low-income households, as well as small and medium enterprises.
Productivity increase	The use of digital solutions is a major driver of increased productivity in sectors such as agriculture, financial services and transport, as well as in public services.
Access to jobs	The emergence of Africa's digital economy, bringing new products and services, has the potential to create jobs, particularly among young people.
Access to goods and services	Digital solutions are reducing the cost of serving consumers across industries, allowing products and services that were traditionally only accessed by the privileged few to reach a wide pool of customers.

[41] EIB, "Areas of intervention of the EIB's Africa digital economy financing" in "The rise of Africa's Digital Economy," 2021.
[42] EIB, 2021.

Social impact[43]

The adoption and use of digital solutions generate social benefits through improved quality of life. Those benefits generate political support for transitioning to a digital economy and attract impact investors and entrepreneurs.

Education	Improvements to the education curriculum through access to information, interactive training materials, e-learning and distance learning.
Healthcare	Technological innovations and the increased affordability of equipment support the proliferation of e-health solutions, from the dissemination of basic prevention information to e-health record platforms and telesurgery.
Gender equality	Digital technologies increase women's inclusion in socioeconomic life through first-time access to legal identity, financial inclusion, information and dedicated services delivered through innovative business models.
Government services	Facilitating the online dissemination of essential public information, accountability, online citizen engagement and streamlined processes, including payment services, generates strong gains in the efficiency and transparency of governance.
Democracy	Access to information and diversified sources of communication enhance democratic participation and awareness.
Climate action	Smart and efficient technologies or ICT-enabled services bring indirect benefits in other sectors. Next-generation technologies also tend to be more energy efficient.
Inclusion of rural population	Network extension in rural areas provides the infrastructure to deliver first-time access to services such as finance, insurance, information and electricity to unserved populations.
Conservation	Digital technologies are used to increase operational efficiency and open market opportunities across the food security, climate technology and domestic nature tourism sectors. In the challenging environment faced by most African countries, the use of modern technology can greatly unlock market potential and provide solutions for better use of resources. Enhanced communication also makes it possible to raise awareness of Africa's conservation challenges.

[43] EIB, "The rise of Africa's digital economy," 2021.

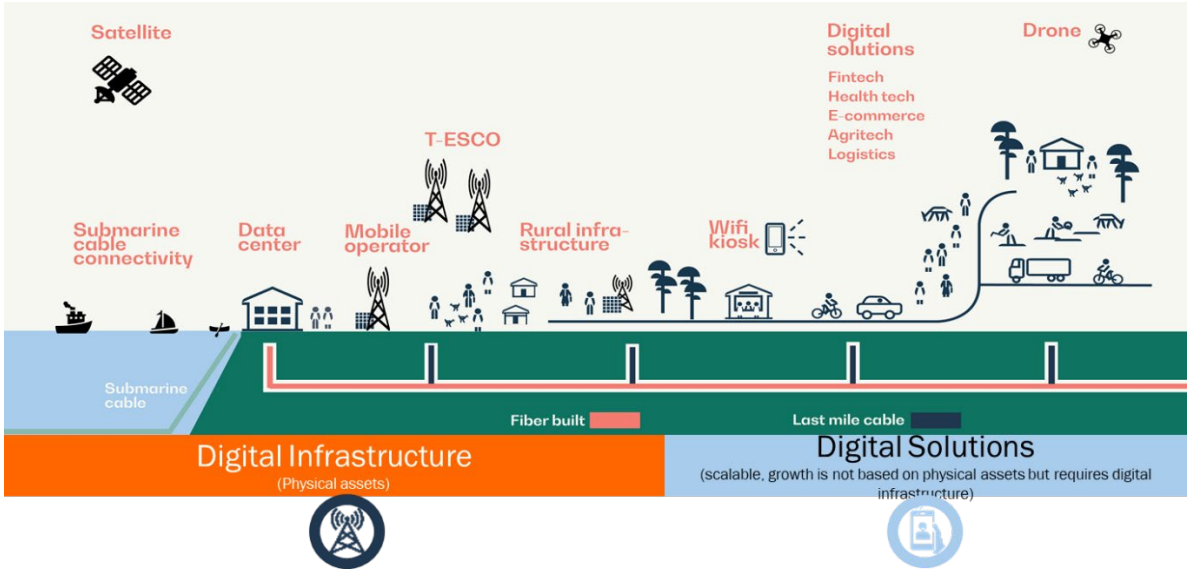
A holistic approach to benefits

As shown in previous chapters, one key to a successful innovative approach is the integration of new players in equipment and energy, as well as an integrated approach to benefits.

For example, a network operator/internet service provider can offer a connection that delivers coverage and other services, such as solar battery recharging, access to administrative services or cached content (such as for schools), and a voice interface for those who cannot read or write. The target is to encourage people to use the different services, including data, thereby fostering private investment.

Development banks have a major role to play by orchestrating relations between players and coordinating projects for the same region or location.

The ultimate aim is to create the cooperation needed to achieve service accessibility, not solely connectivity.



THE DIGITAL ECONOMY ECOSYSTEM[44]

Case study: Vodafone Group takes a holistic approach in Ethiopia[45]

A consortium of major players including Vodafone (United Kingdom), Vodacom (South Africa), Safaricom (Kenya), Sumitomo (Japan) and CDC (United Kingdom) has won the first private licence to offer telecom services in Ethiopia, historically only operated by Ethio telecom.

Vodafone Group will combine two types of networks — terrestrial mobile and LEO. The aim is to cover the whole country with 4G/5G and to create 1–1.5 million jobs.

To reach the objective of moving from 6% data penetration to 98% data penetration with 4G, the consortium has adopted a holistic approach aiming to foster overall development to achieve service affordability. Vodafone Group worked on vertical markets (education, agriculture, health, manufacturing, tourism) to find the path of global development and invest in industrial growth.

While the mobile licence cost $850 million, the global investment carried by the consortium amounts to $8.5 billion, which will be funded by different sources.

[44] Source: Finnfund.
[45] Source: Vodafone.

The essential role of development banks[46]

Development banks are committed to boosting financing for the Sustainable Development Goals and inclusion. Besides seeking to mobilise finance from public and private financers, multilateral development banks finance projects that respect best-in-class standards, are financially viable and generate impact. Targeted outcomes include environmental, social and governance effects; the best strategic use of scarce concessional finance resources; and helping the poorest and most vulnerable.

Infrastructure remains a top global priority. Most development agencies have digital economy as a key sector in their agendas for the coming years. This support is essential given the market failure to provide enough financing to achieve connectivity in unserved areas. Development banks often finance high-risk infrastructure investments, filling the gap left by the commercial community. When a market failure occurs, development agencies are often the only solution. They provide the starting investment to create an ecosystem and unlock usages. The EIB works with various national and multilateral development agencies to support Africa's digital economy, funding governments and private companies to sustain activities in the digital field. Examples of the EIB's involvement are presented in the table below.

Multilateral development agency	**Project description**
African Development Bank	The EIB co-invested with the African Development Bank in several venture capital funds, including TLCom and Partech. The two institutions also jointly set up the Boost Africa Initiative.
European Bank for Reconstruction and Development (EBRD)	The EIB and the EBRD Digital Transformation Platform and Broadband Investment Programme was selected under the European Fund for Sustainable Development. The programme aims to increase the use of digital technologies and widen rural access to broadband in the neighbourhood.
World Bank	The EIB and the World Bank have supported digital identity (e-ID) infrastructure in Nigeria and the supply of a biometric identity to all Nigerian citizens.
National development agency	
Agence Française de Développement (AFD)	AFD is a co-financer of the e-ID infrastructure in Nigeria, alongside the EIB and the World Bank. The project aims to facilitate education, health and social safety, transportation, the sale of industrial and agricultural goods, financial inclusion and elections by creating trustable identification applications.
Finnfund	The EIB co-invested with Finnfund in M-BIRR, a mobile banking services platform operating in Ethiopia.
Private company	
IPT Powertech	The EIB and European partners DEG, Proparco and Finnfund have co-financed the efforts of the Lebanese company IPT Powertech to roll out sustainable electricity in Africa.
Tunisie Télécom	The EIB has financed €100 million to support 4G deployments for Tunisie Télécom.

[46] EIB, "The rise of Africa's digital economy," 2021.

List of abbreviations

AFD: Agence Française du Development

Backbone: in *networking* is the part of your *network* that ties different departmental *networks* into a single whole

Backhaul: the physical part of a communications network between the central backbone and the individual local networks

CAPEX: capital expenditure

EIB: European Investment Bank

ESCO: Energy services company

FTTT: Fibre to the Tower

GDP: Gross domestic product

ITU: International Telecommunication Union

GSMA: GSM Association (Global System for Mobile Communications)

MNO: Mobile network operator

NaaSCo: Network as a Service Company

OPEX: operational expenditure

SME: Small and medium-sized enterprise

TowerCo: Tower Company

UEMOA: West African Economic and Monetary Union

USF: Universal Service Fund

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