Recommendations to the
Ministry of Digital Transformation,
Government of Ukraine

A National Broadband Development Strategy and Implementation Plan

2020 → 2025

European Commission | EaP Eastern Partnership | EU4DIGITAL | THE WORLD BANK

Report No: AUS0002018

Europe
EU4Digital Broadband TA

Recommendations to the Ministry of Digital Transformation, Government of Ukraine on A National Broadband Development Strategy and Implementation Plan 2020-2025

2020

DDT

Document of the World Bank

Project Objectives

This document has been prepared as part of the World Bank (WB) analytical program to support the Eastern Partnership (EaP) countries development of broadband services (hereinafter "the Project") supported by the European Union (EU) through the EU4Digital programme, in partnership with the WB. The EU4Digital is a regional initiative, launched in 2016, which aims to deliver the benefits of the Digital Single Market (DSM) beyond the EU MSs, extending to the EU's Eastern neighborhood countries the potential of the digital economy and society, to bring economic growth, generate more jobs, improve people's lives, and help businesses.

The WB supports Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine (EaP partner countries) in the development and early implementation of their national broadband strategies, in line with relevant EU strategies, by providing technical assistance and capacity building support. The extent and nature of the WB's support is tailored to the status of each EaP country's strategy development and implementation.

The goal of this Report on "Policy Notes for a National Broadband Development Strategy and Implementation Plan for Ukraine, 2020-2025" (the Report) is to identify those approaches and best global practices that have been proven successful in helping to realize broadband strategy goals and that could be adapted and transposed specifically to Ukraine.

Under the Component E, namely Report 5, of the WB project within the EU4Digital initiative, where this Report represents the final deliverable, the team identifies the key areas in the market, legal and policy environment aimed at developing broadband in Ukraine.

The analysis conducted by the WB team highlights the current gaps derived by a comparative exercise between the best practice model in the EU MS and other international good practices via-à-vis Ukraine's current status quo and framework. On the basis of the findings resulted from the gap analysis, the WB team has created a tailored roadmap identifying achievable targets and a related action plan for Ukraine to develop or update its national broadband strategy.

The choice of those specific actions and policy notes delivered to support Ukraine in its development of a broadband strategy outlining a roadmap leading towards its broadband development in the short, medium and long term, also were formulated taking into account the needs and priorities of Ukraine as they resulted in the series of meetings and overall interinstitutional dialogue that the WB team has conducted with key interlocutors from the Government and National Regulatory Authority.

Acknowledgements

The preparation of this report was led by Natalija Gelvanovska-Garcia, under the guidance of Nicole Klingen, Arup Banerji and Baher El-Hifnawi. Contributors to and co-authors of the report were Zhenia Viatchaninova Dalphond, Maksym Girnyk, Vitalii Mosiichuk and Oleksandr Shcheglov. The analyses for the report were conducted by Marta Khomyn, Mykhailo Koltsov and Vitalii Mosiichuk.

The peer reviewers for the report were Anastasia Golovach and Charles Pierre Marie Hurpy.

The following World Bank colleagues have provided their support during the preparation of this report: Juan Navas-Sabater, Siddhartha Raja, Valeria Dessolis, Tamta Nutsubidze, Reyn Christine Anderson, Himmat Singh Sandhu, Dmytro Glazkov, Sandeep Kohli, Olena Doroshenko, Holly Krambeck and Rajalakshmi Kanagavel.

Inputs and suggestions were received from many stakeholders working in and with Ukraine, including Oleksandr Ananiev (Huawei Ukraine), Volodymyr Babiichuk (Kyivstar), James Carroll and Katherine Macdonald (Ookla), Development Data Partnership team of the World Bank, Dmytro Hnatiuk (Global Logic Ukraine), Petro Hordiievych (GPO Technologies), Olena Hryhorenko (State University of Telecommunications), Mykola Kolesnyk (Ukrainian Scientific and Research Radio Equipment Institute), Roman Kravchenko (Qualcomm), Oleksandr Kuzminskyi (BKM Company), Andrii Kuluiev (OMO Systems), Nataliia Lado (National Commission for the State Regulation of Communications and Informatization of Ukraine), Igor Ladovych (EcoNet), Volodymyr Matiushko (Consultant), Lena Minitch (Eurotel Communication), Oleksandr Mitin (Wi-Fi in Ukraine), Andrii Nabok (Ministry of Digital Transformation of Ukraine), Yaroslav Nitsak (Ericsson Ukraine), Mykhailo Omelianenko (Igor Sikorsky Kyiv Polytechnic Institute), Vasyl Onyshchenko (Kremenets WDS), Vasyl Pantov (Kyivstar), Oleksandr Parfenov (Avia-radio servis LLC), Yevhenii Preobrazhenskyi (URAN Association), Oleksandr Shelest (Ministry of Digital Transformation of Ukraine), Volodymyr Shpak (Homenet), Stas Yarmolenko (Avia-radio Servis LLC), Volodymyr Yarovyi (EPAM Ukraine), Dmytro Yovkhymenko (Pautyna). The report was edited by Patricia Carley.

We would like to acknowledge the collaboration of European Union (EU) institutions, in the context of EU4Digital, in particular Martin Bailey (European Commission), Jorge Castro-Pardo (European Commission), Jorge Remuinan-Suarez (European Commission), Vassilis Kopanas (European Commission), Hoa-Binh Adjemian (European Commission), Steven Reijersen (European Commission), Viola Calabrese (European Commission) and Svitlana Didkivska (EU Delegation in Kyiv, Ukraine).

Administrative support from Julia Samoslied, Christine Howard, and Marisol Ruelas is gratefully acknowledged.

The print version of the report was designed by Maria Jimena Vazquez and proofread by Patricia Carley under the guidance of Marta Khomyn.

Recommendations to the Ministry
of Digital Transformation,
Government of Ukraine

A National Broadband Development Strategy and Implementation Plan

2020 --> 2025

CONTENTS

BOXES

TABLES

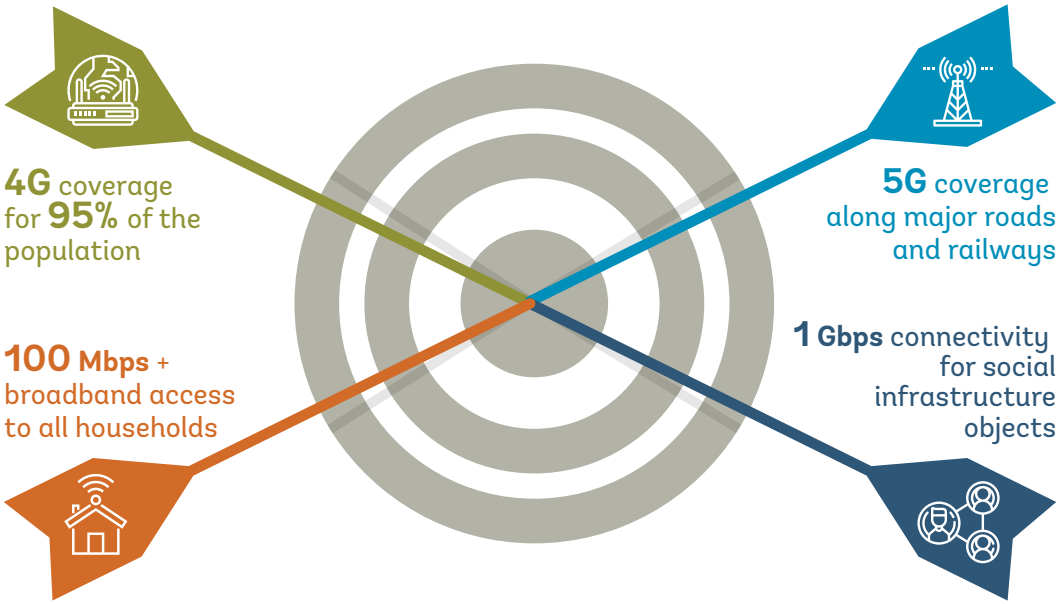
FIGURES

LIST OF ACRONYMS

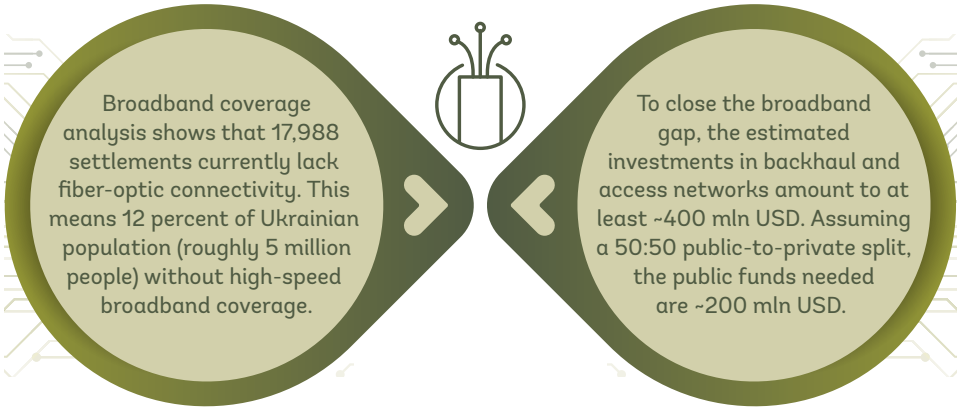
ARPU	Average Revenue per User
ATC	Amalgamated Territorial Communities
CAPEX	Capital Expenditure
DBO	Design, Build, Operate
DCF	Discounted Cash Flow
DSL	Digital Subscriber Line
DSO	(Electricity) Distribution Operators
DWDM	Dense Wavelength Division Multiplexing
EaP	Eastern Partnership (Countries)
EC	European Commission
EECC	European Electronic Communications Code
EU	European Union
EUAA	Association Agreement with the European Union
FBB	Fleet Broadband
FTTH	Fiber to the Home
FTTx	Fiber to the x
GIS	Geographic Information System
GoU	Government of Ukraine
GPT	General Purpose Technology
HCI	Human Capital Index
HDM	Harmonization of Digital Markets
HHI	Herfindahl-Hirschman Index
ICT	Information and Communications Technology
ISP	Internet Service Provider
IoT	Internet of Things
IRR	Internal Rate of Return
ITU	International Telecommunication Union (UN)
IXP	Internet Exchange Point
KPI	Key Performance Indicators

LSA	License-Shared Access
M&E	Monitoring and Evaluation
MDT	Ministry of Digital Transformation (Ukraine)
MEDT	Ministry of Economic Development and Trade (Ukraine)
MES	Ministry of Education and Science (Ukraine)
MNO	Mobile Network Operator
MoU	Memorandum of Understanding
NB	Narrowband
NBDS	National Broadband Development Strategy
NCCIR	National Commission for the State Regulation of Communications and Informatization (Ukraine)
NGA	New Generation Access
NGN	Next Generation Network
NPV	Net Present Value
NR	New Radio
NRA	National Regulatory Authority
OFC	Optical Fiber Cable
OPGW	Optical Groundwire
OSA	Oblast State Administration
PoP	Point of Presence
PPP	Purchasing Power Parity; also Public-Private Partnership
PwD	People with Disabilities
SDH	Synchronous Digital Hierarchy
SME	Small and Medium-Sized Enterprise
SOE	State-Owned Enterprise
SRDF	State Regional Development Fund
TSO	Transmission System Operator
UIA	Ukrainian Internet Association
URAN	Ukrainian Research and Academic Network
USF	Universal Service Fund
USO	Universal Service Obligations
WB6	Western Balkans Six
WEF	World Economic Forum

BROADBAND TARGETS - 2025

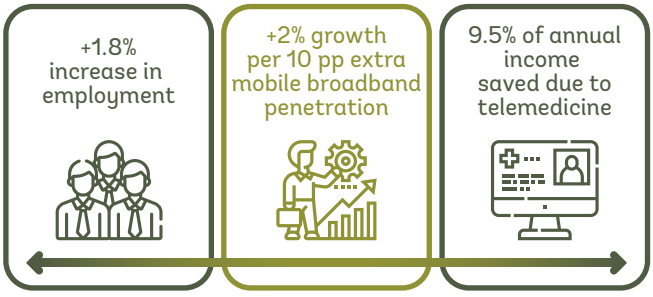


THE BROADBAND GAP



THE BROADBAND BENEFITS

THE BROADBAND INVESTMENT RETURNS



EXECUTIVE SUMMARY

This document provides recommendations on a National Broadband Development Strategy (NBDS) for the Government of Ukraine. The recommendations aim to support the country's vision of making high-speed broadband available to every citizen, business, and public institution in Ukraine by the year 2025. As part of the discussion, the report also considers Ukraine's ongoing integration into the European Union (EU) and the socioeconomic impacts of the COVID-19 pandemic in the country.

The key suggested broadband targets under the NBDS for 2025 are:

- **4G coverage for 95 percent of the population[1]**
- **Uninterrupted 5G coverage along major roads and railways**
- **1 Gbps connectivity available to all objects of social infrastructure involved in social service provision**
- **High-speed (100 Mbps+) broadband network access for all households**

These targets have been established to close the broadband coverage gap at the level of public institutions and individual households and to improve broadband affordability and penetration. The analysis suggests that roughly 18,000 settlements currently lack access to high-speed fiber-optic networks, representing 12 percent of the population. The infrastructure investments designed to provide broadband coverage to these areas would generate significant economic benefits, particularly in the education and health care sectors and in public services provision.

The recommended policy actions rely on three key pillars: demand-side interventions, supply-side interventions, and regulatory framework upgrades. On the supply side, the strategy should include offering incentives to (i) mobilize private investments in broadband network expansion and (ii) reduce the costs of network deployment. On the demand side, full coverage for the education and health care sectors is a crucial enabling factor for "demand pull" to materialize. Further, close alignment with digital skills strategies is critical to translating the growth of broadband usage into productivity gains. On the regulatory side, the recommended steps include upgrading the regulatory reporting obligations for internet service providers and building a fair and transparent institutional framework.

Supporting analysis in this report considers international best practices in broadband development, including competition policies, a comparative analysis of the broadband market in Ukraine and the EU, and a value chain analysis. The report also provides an in-depth overview of the current status of broadband connectivity at the settlement level, maps the unconnected "white areas" that lack connectivity, and assesses the economic impact of broadband infrastructure investments. The long-term economic benefits of broadband significantly outweigh the costs associat ted with network expansion. However, the positive externalities (e.g., the improved health care, education, and productivity outcomes) pertain to society rather than to private entities. This necessitates that public funding go hand in hand with market forces.

SUMMARY OF RECOMMENDATIONS

Sector Governance	Priority*
Design a National Broadband Development Strategy (NBDS), including: - a monitoring and evaluation plan - a set of broadband goals, which are aligned with the EU Broadband Strategy - a collection of broadband connectivity forecasts from the public sector - a plan for data collection by the State Statistics Service of Ukraine, incorporating the EU's DESI indicators	High
Strengthen the institutional mandate and capacity of the national sector regulator (the National Commission for the State Regulation of Communications and Informatiƶation, NCCIR).	High
Align the legal framework governing Ukrainian Broadband sector with the EU Directive 61 and EU Aquis.	Med
Strengthen the reporting standards of the NCCIR to require data from all stakeholders.	Med
Mobile (4G) and Fixed Broadband	
Ensure granular data collection by NCCIR, including the state of 4G connectivity.	Med
Accelerate the 4G deployment through strategic spectrum management, infrastructure sharing, and regulatory streamlining.	High
Adopt a legal framework for dispute resolution in the area of fixed broadband regulations.	Med
Implement real-time GIS-based Broadband Atlas to allow relevant stakeholders the access to coverage data, as well as infrastructure information.	Med
5G	
Facilitate the 5G deployment through spectrum reframing in the 700-900 MHƶ band, auctioning the spectrum to mobile operators, and implementing the license sharing agreements.	High
Diversify the sources of international connectivity by attracting Tier 1 and Tier 2 networks and by joining the Three Seas Digital Highway and the Balkans Digital Highway initiatives.	Med
Commercializе the fiber-optic infrastructure of Ukraine's state-owned enterprises (SoEs) in the transport and energy sectors to boost the broadband network capacity and enable redundancies for emergency usage.	Med
Strengthen national cybersecurity capacity by transposing and implementing the relevant EU aquis especially related to 5G roll-out.	High

*Note: This table includes only high- and medium-priority items from the list of recommendations. For the full list of recommendations, please see Annex 1.

1 INTRODUCTION AND SCOPE

This document offers recommendations to the Government of Ukraine (GoU) as it develops a National Broadband Development Strategy (NBDS). The recommendations, which aim to inform the debates and discussions around the strategy, were prepared by the Digital Development Department of the World Bank Group, with support from the European Union (EU) through the EU4Digital program for Eastern Partnership (EaP) countries.

VISION OF THESE RECOMMENDATIONS:

To make high-speed broadband connectivity universal, robust, and affordable for every citizen, business, and public institution in Ukraine by 2025

Broadband connectivity (or broadband)[2] is a critical foundation for socioeconomic development in today's global and increasingly digital economy. It is a general purpose technology (GPT)[3] that accelerates the pace of economic growth and reduces income disparities, thus contributing to poverty alleviation. It is also a powerful mechanism for addressing information asymmetry in order to accelerate long-term growth by improving the allocation of resources across the economy and enhancing market performance. The adoption of broadband also helps to compensate for geographic isolation and broadens the spatial scope of labor markets. For instance, some impact assessments suggest that more people decide to move to (or remain in) rural areas where broadband coverage has been improved than opt to leave, indicating that improved broadband coverage makes rural communities more livable places.[4] Overall recent study has found that an increase in 10% of mobile broadband penetration triggest 2% growth of GDP.[5]

The development of robust and future-proof national broadband infrastructure reaching every household, institution, and business in any country has a clear financial benefit for the state and especially for rural areas. For instance, the cost of providing utility services, such as water or sanitation, and social services such as health, are generally from 30 to 50 percent more expensive in rural than urban areas. It has also been estimated that face-to-face services for citizens cost government 50 times more than the provision of the same service online[6] and contribute to environmental inefficiencies that could otherwise be avoided.[7]

Due to the efficiencies and innovation that could be enabled in the transport sector[8] and other industries, territorial broadband coverage with advanced technologies such as 5G is as important as population coverage. Smart technologies can reduce road deaths by 8–10 percent and travel times by 15–20 percent.[9] The transportation, logistics, and automotive industries have one of the highest potentials for disruption because of digitalization and innovation.[10] Certain services, such as real-time fleet management and in-transit monitoring of perishable products using sensors and the Internet of Things (IoT), are seeing greater adoption in the industry, while such innovations as autonomous transport are also developing at a rapid pace. Supporting these transport-related industries demands the development of a variety of digital services and adequate digital infrastructure through which these new services can be delivered.

Small and medium-sized enterprises (SMEs) can particularly benefit from broadband by ensuring the continuity of business during a crisis, facilitating access to online platforms to enter new markets (domestic and international), and helping to source materials, manage operations more effectively, and communicate efficiently with suppliers and customers. Broadband's industry applications are numerous. As global value chains become more deeply connected because of falling information and economic transaction costs, the volume and speed of the information flow has increased exponentially. Indeed, global supply chains would not have emerged without the support of broadband and its applications.

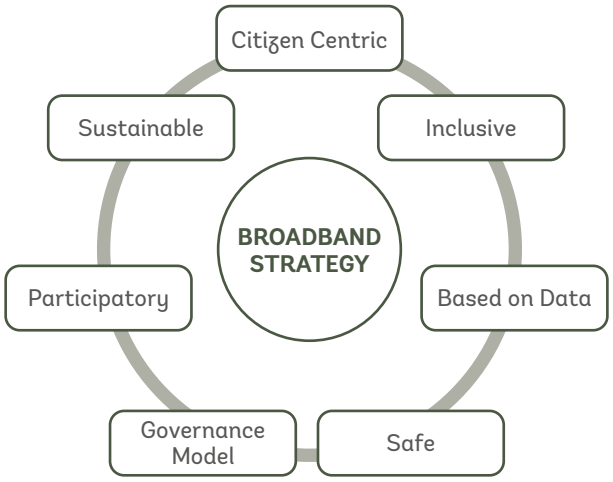
The educational opportunities associated with broadband access are tremendous, not least its

ability to offset educational losses during school closures by enabling remote learning. Massive Open Online Courses are now widely available, often competing with proper university degrees in certain fields. Electronic libraries and efficient search engines are literally the foundation of modern research. However, the COVID-19 pandemic has starkly exposed the persistent digital divide in much of the world as some children who must suddenly "attend" school remotely lack the digital tools or bandwidth needed to keep up with their more privileged classmates.[11]

In health care, the internet offers opportunities for electronic health records as well as remote communication and patient monitoring for health care professionals, thus enabling, among other important services, telemedicine in rural areas. During crisis situations, police and emergency personnel are assisted by broadband networks in accessing critical information quickly and securely. As a result, emergency response time can be decreased by 25–30 percent.[12] Telemedicine is becoming incleasingly important; for example, virtual health or telemedicine companies have experienced a more than 50 percent increase in consultations in the United States alone.

Given all of the benefits outlined here, and particularly considering the current context of a global health crisis, the development and implementation of a comprehensive broadband strategy could not be more timely for Ukraine. **Figure 1.1** illustrates that such a strategy should be built on certain core values and principles to ensure that it is: (1) citizen centric; (2) inclusive; (3) based on data; (4) safe; (5) built on an effective governence model; (6) developed with the broad participation of relevant stackeholders; and (7) sustainable.

FIGURE 1.1.
Core Values and Principles of Broadband Strategy Development



Source: Authors

The global and ubiquitous nature of the internet also implies new risks, such as personal privacy concerns, cybercrimes, or scams, to which many users, especially young children or older people, are susceptible. It is therefore critical to ensure that measures to expand the benefits of more affordable access to the internet go hand in hand with steps to mitigate against the risks that may arise.[13] The recommendations in this report recognize the need for holistic and complementary actions to accomplish this, especially with regard to cybersecurity. Equally important is the need to build "analog complements," that is, skills, regulations, and accountability in the sector. It is widely recognized that the productivity impact of GPTs (including broadband) is strongly dependent on complementary investments in other factors such as human capital.[14] In 2017, the Human Capital Index (HCI) ranking for Ukraine was higher than what would be predicted for its income level,[15] the highest, in fact, among EaP countries. The development payoffs of broadband-enabled technologies are thus expected to be higher. Various initiatives are already underway that will continue to increase the use of e-government services, promote the development of the innovation ecosystem, and improve digital skills.

2 CONTEXT FOR THESE RECOMMENDATIONS

These recommendations are positioned within a framework set up by the following documents. These works recognize the transformative role that broadband and internet-enabled technologies can play in boosting regional development and bridging the urban-rural divide necessary for more inclusive economic growth:

- *The Program of the Activities of the Cabinet of Ministers of Ukraine*,[16] which sets out three key information and communications technology (ICT) goals around access to e-government services, the use of ultrafast internet along all major information highways and in all settlements, and the development of digital skills
- *The Concept of Development for a Digital Economy and Society in Ukraine in 2018–2020 and Digital Action Plan (January 2018)*,[17] which outlines 10 measures related broadly to digital economy development
- *The Ministry of Digital Transformation's Strategic Broadband Goal: the Concept of State Policy on Digital Infrastructure (December 2019)*, which establishes three priorities for public consultation on citizen access to fixed and mobile broadband, the affordability of broadband services, and the stable accessibility and quality of broadband service
- *State Program of Economic Stimulation to Overcome the Negative Consequences Caused by Restrictive Measures to Prevent the Occurrence and Spread of Acute Respiratory Disease COVID-19 Caused by the Coronavirus SARS-CoV-2*, for 2020–2022,[18] which describes a number of key actions to stimulate the ICT sector in the areas of digital infrastructure, the IT industry, and skills development
- *The World Bank's Country Partnership Framework*,[19] which identifies (i) better governance, anticorruption, and citizen engagement; (ii) more effective markets; (iii) fiscal and financial sustainability; and (iv) efficient, effective, and inclusive service delivery as the pillars of Ukraine's further progress toward a sustainable and inclusive economic recovery
- The European Commission's (EC) strategy on *Connectivity for a European Gigabit Society*, adopted in September 2016[20]

In addition to guiding the development of broadband in the country, these recommendations recognize that the formulation of an NBDS will be a positive step in Ukraine's partnership with the EU. Article 394 of the Association Agreement with the EU[21] (EUAA) aims to facilitate access to a Digital Single Market and promote investment and competition in the sector to provide higher quality services at affordable prices. Additionally, the development of this strategy is a significant step toward fostering cooperation on the digital agenda with the EU as part of the Harmonization of Digital Markets (HDM) program for EaP countries. The NBDS should also align with and support other strategies or laws being formulated by the GoU, including online protection of minors, e-commerce, and innovation promotion.

The strategy is also timely. During the health and economic crisis that countries are currently facing due to the spread of COVID-19, broadband connectivity and the digitally enabled services that it supports are essential not only to mitigating against and containing the spread of the virus but also to coping with social distancing measures and ensuring the continuity of government and the private sector. Based on models developed for the recent SARS epidemic in 2002–04, countries with an advanced connectivity infrastructure were able to mitigate approximately 75 percent of the economic losses triggered by that event.[22] COVID-19 is provoking much

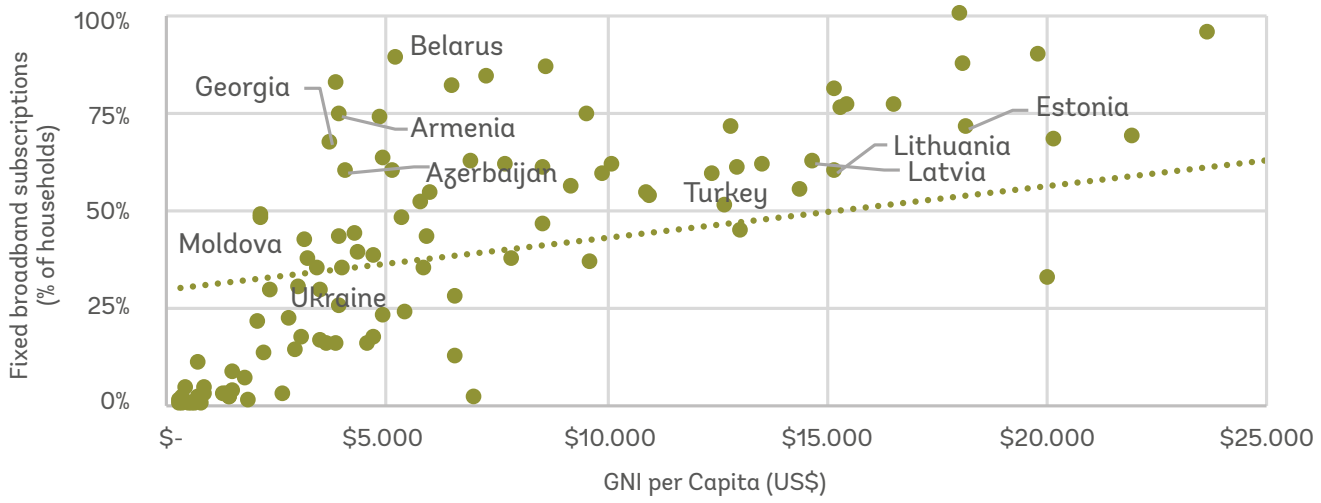
greater economic devastation, making the positive mitigation impacts that broadband could offer that much more significant. In fact, digital infrastructure has been identified as one of the very first priorities for governments hoping to emerge from the crisis stronger than before.[23]

Enormously competitive, Ukraine's broadband market has resulted in one of the most affordable broadband services in the EaP region (and globally), though in recent years the market has seen only a moderate growth in terms of access and adoption. Today, fixed broadband subscriptions are at 31.7 percent of households, and 4G connections account for roughly 37 percent of total mobile subscriptions.[24] This positions Ukraine among the average within its income group but with considerable scope to catch up with regional peers and especially the EU (see **figure 2.1**).

Notably, Ukraine's private sector has taken the lead in adopting the latest technologies, including "fiber to the x" (FTTx) and 4G networks, to roll out broadband networks, and the public sector has adopted some initiatives to improve the connectivity of public institutions such as schools. The continued growth of the fixed broadband market has seen fiber internet overtake xDSL (using more traditional copper wire technology) and now account for 52.6 percent of all household broadband subscriptions. Again, this positions Ukraine (with 16.6 percent of all households subscribing to fiber internet) slightly above the average globally and suggests that further effort is required for the country to catch up with its regional peers (see **figure 2.2**). Advanced economies are investing significantly in FTTx technology for last mile connectivity and have been aiming at extremely high quality of service over the past decade.[25] For example, South Korea plans to adopt connectivity services of 10 Gbps with 50 percent population coverage by 2022.[26]

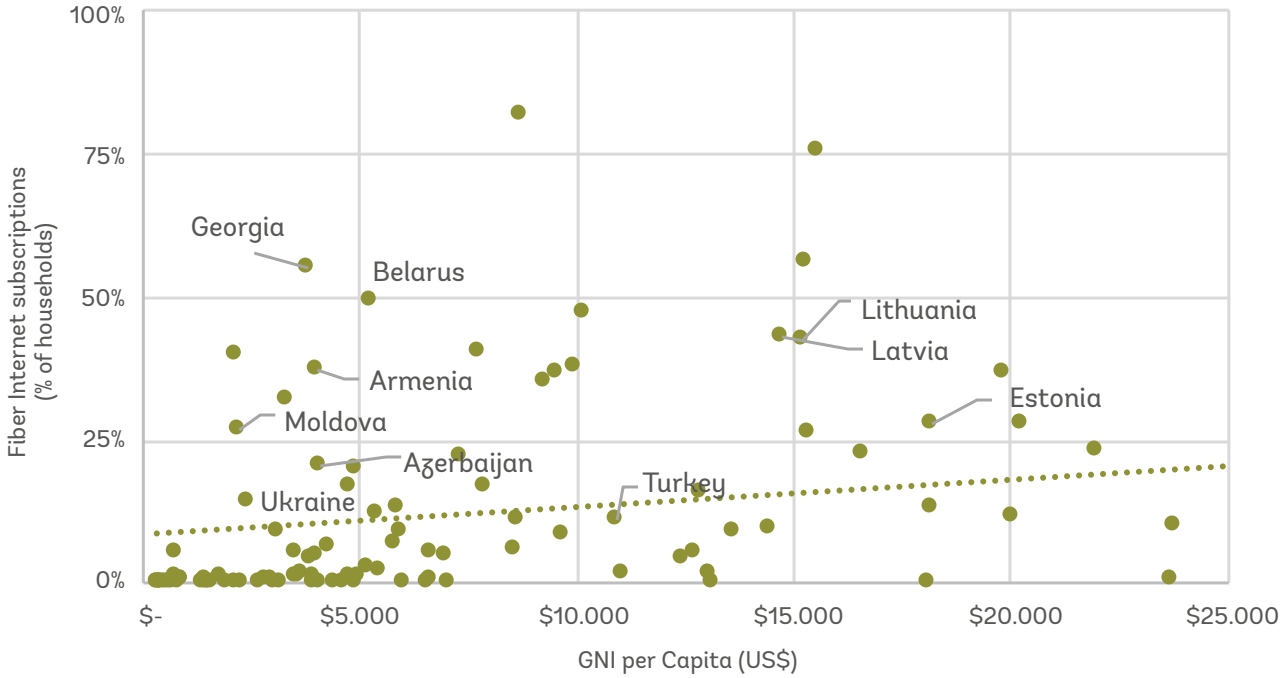
One caveat is that the interventions recommended in this report assume that the state should assume the role of an arbiter in a free market space whenever possible, especially when market forces alone can deliver the desired outcome. Public investments are therefore needed only in cases of market failure, that is, when market forces alone cannot deliver an outcome that would be socially desirable from the point of view of maximizing public welfare as a whole.

FIGURE 2.1.
Percentage of Households with Fixed Broadband Subscriptions, Globally by GNI per Capita (US$), c. 2017



Source: Authors' analysis, based on TeleGeography GlobalComms data, 2018, and World Bank data, 2017.

FIGURE 2.2.
Percentage of Households with Fiber Internet Subscriptions, Globally by GNI per Capita (US$), c. 2017



Source: Authors' analysis, based on TeleGeography GlobalComms data, 2018, and World Bank data, 2017.

2.1 Preparing the Recommendations

The recommendations for the NBDS were elaborated within the framework described above. The World Bank team, with support from the EU and in collaboration with Ukraine's Ministry of Digital Transformation (MDT), embarked on a process of supporting the MDT in developing its broadband strategy. The objective of the **first phase** (from January to May 2020) was to produce the recommendations for the NBDS, while the **second phase** (from June 2020 onwards) includes support for the development of the actual strategy document.

Given international best practice and considering the particular Ukrainian context, the strategy recommendations identify: (1) the potential market gaps and associated failures; (2) public sector interventions to address those market failures through supply- and demand-side measures; and (3) the actions needed to increase private sector participation in achieving those targets by fostering an enabling environment.

The first phase of the process started with a diagnostic assessment of the broadband ecosystem in Ukraine. The World Bank team conducted a comprehensive analysis of the broadband market, existing policy, and legal framework to identify gaps. Throughout the diagnostic phase, the team conducted extensive policy consultations with the MDT and market stakeholders. Most of the written and verbal feedback and suggestions provided by the stakeholders were reflected accordingly in the final recommendations.

3 GLOBAL BEST PRACTICE IN SUPPORT OF BROADBAND DEVELOPMENT

Global experience and best practice highlight certain common themes that underpin well-functioning broadband markets, most notably:

- **Competitive pressure** on service providers in different subsegments of the value chain—from first to last mile through markets or policy actions[27]—to improve market outcomes for consumers
- Attraction of private sector **investment** to expand networks and improve quality of service, including through strategic use of public financing to de-risk private investment where necessary
- Increases in the digital **skills** of users to stimulate demand, build knowledge about the productive uses of broadband, expand digital inclusion, and maximize economic impact

These key themes, or best practices, are also aligned with the approach adopted across the EU member states in the development of broadband services toward the EU's Digital Single Market.

Globally, greater competition is associated with stronger market performance in terms of more robust market development and lower prices. As noted in the World Bank's "World Development Report 2016: Digital Dividends,"[28] the EC's 2014 "Guide to High-Speed Broadband Investment,"[29] and a review of national broadband plans across EU member states,[30] the public sector can serve as a facilitator in creating an enabling environment for sector development through a pro-competition and investment-promoting *policy and regulatory regime*, and through the targeted *financing of investments* to address specific market failures. Ukraine's experience has underscored the role of the private sector in driving the growth and expansion of the broadband market.

Digital skills are a prerequisite for a well-functioning digital economy. The broadband market is an ecosystem comprised of supply- and demand-side actors and forces.[31] Without adequate skills, demand for broadband, and the availability of internet-based services, supply-side efforts to develop broadband networks will not have much impact. The impact of technology depends on its use.

Developing a robust talent pool with the requisite digital skills can help economies navigate the wave of transformation currently taking place across sectors, with technological advances changing the nature of work and demands from the job market. To safeguard against the negative impacts of technological advances and digitalization, a concerted effort is needed to equip the labor force with the right skills to compete in the economies of the future.

4 MARKET OVERVIEW

The broadband market in Ukraine has grown at a rapid rate over the past 10 years, as is the case in many developing economies in the region and globally. This section outlines the institutional framework and strategic context and then presents an overview of the market status quo.

4.1 Strategic context

Ukraine has yet to produce a comprehensive ICT strategy. A possible reason why an ICT sector strategy has not been produced could be the siloed approach toward ICT development in the country, with each ministry having a separate mandate to digitalize its procedures and services. Furthermore, before the establishment of the MDT, there was no permanently functioning line ministry responsible for telecommunications and IT sector development. One had to look to the Ministry of Transport and Communications (2004–10), then its successor the Ministry of Infrastructure (2010–present) and, finally the Ministry of Economic Development, and Trade of Ukraine (MEDT) (2010–19).

A vision for an ICT strategy was, however, produced in 2018 by the MEDT, according to which Ukraine's key performance indicators (KPIs) on telecom and ICT infrastructure development for 2020 were set as: (i) broadband for all; (ii) 50 percent of all broadband connections to be greater than 30 Mbps; and (iii) 20 percent of all broadband connections to be greater than 100 Mbps.[32] The strategy, known as the Digital Agenda for Ukraine, was supposed to supplement the High-Tech Strategy that had also been developed by the MEDT. Although neither document was adopted at the central executive level, parts of their vision was reflected in the *Concept of Ddevelopment for Digital Economy and Society in Ukraine in 2018–2020 and Digital Action Plan*, adopted by the Cabinet of Ministers.[33] It should be noted that implementation status reports of the latter document are not in the public domain.

Learning from this legacy, the MDT, since its foundation in September 2019, has set out three key ICT goals:

- **Ukrainians should have access to all government services online** (KPIs: 100 percent of government services delivered online; 60 percent of Ukrainians using e-services; high level of citizen satisfaction after using these services)
- **Ukrainians can use ultrafast internet along all major highways and in all settlements** (KPIs: percentage of international highways and settlements with coverage of ultrafast internet with a speed of no less than 30 Mbps)
- **Ukrainians who are willing to obtain digital skills should be freely able to do so** (KPIs: over 6 million Ukrainians are covered by the digital skills development program; 70 percent of citizens who finish the program should possess skills at a basic level)[34]

At the international level, through its EUAA, Ukraine has pledged to gradually approximate the EU's laws and regulatory framework in the sphere of the information society and electronic communication (Article 394 of the EUAA).[35] In light of the Agreement, even though national specifics would need to be taken into account, the EU's strategic and regulatory framework applicable to broadband should essentially define Ukraine's strategic approach toward broadband infrastructure development. Starting with its first single EU-level Digital Agenda in 2010, which was followed by the major digital initiative of the Digital Single Market in 2016, the EU has since developed separate specific strategic documents for its many digital priorities to better focus its members states' efforts. One such strategic document for broadband development in the EU is the European Gigabit Society,[36] and one separate action is the 5G action plan.[37] Preparation by Ukraine of a national broadband strategy fully aligned with similar EU strategies is a deliverable under its commitments reflected in the "20 deliverables for 2020."[38] It should be noted that current ICT goals related to broadband and established by the

MDT in its position paper[39] are not aligned with the EU approach (see **Annex 2** for more details on current broadband-related goals in Ukraine and the EU).

To realize these goals, as well as those related to euro-integration commitments, Ukraine's executive and legislative branches have worked in concert with the National Commission for the State Regulation of Communications and Informatization (NCCIR), the national regulatory authority (NRA). For example, a number of presidential decrees were issued in 2019 with the aim of improving the state of mobile broadband communications, such as the Decree of the President of Ukraine "On Ensuring the Conditions for the Implementation of the Fifth Generation Mobile (Mobile) Communication System" (May 2019) and "On Some Measures to Improve Mobile Internet Access" (July 2019). In December 2019, the GoU issued an order on measures toward the development of mobile broadband (officially supported by the NCCIR through a separate decision) and in early 2020, it confirmed that it would allocate the spectrum needed for the development of 5G. Finally, in February 2020, the Cabinet of Ministers approved long-awaited amendments to the national frequency plan to support the expansion of 4G LTE mobile networks. That same month, the "Diia" application and portal were launched by the MDT, a first step toward realizing President Volodymyr Zelenskyy's ambitious vision of "Ukraine in a Smartphone."

Government action is taking place in concert with the private sector. The GoU has signed several Memoranda of Understanding (MoUs): with telecom vendors Ericsson and Huawei and mobile operators Kyivstar, Vodafone Ukraine, Lifecell, and Intertelecom for the development of 4G networks; and with Kyivstar for the development of digital literacy. Importantly, the MDT is in frequent contact and coordinates its activities with all key market players, as well as the Ukrainian Internet Association (UIA), an important voice in Ukraine's vibrant IT sector.

Collaboration is happening within the public sector on both the central and local levels. For example, the GoU, through the Ministry of Education and Science of Ukraine (MES), has channeled funds to connect primary and secondary schools across a number of the recently formed amalgamated territorial communities (ATCs). As part of this effort, the ministry worked with oblast (regional) departments of science and the online procurement system "Prozorro," a state-of-the-art solution widely embraced by the public sector and local self-government bodies.

Even though digital development is a multi-faceted effort encompassing many complementary development areas and engaging many actors across the public and private sectors, it is recommended that the NBDS remain a separate effort. This is because of the: (1) technicality and specificity of broadband issues; (2) limited number of stakeholders involved; and (iii) need to focus the effort due to the high-priority and high-level investments required for the strategy's implementation.

In terms of the strategic directions for legal and regulatory framework development, through its EUAA, Ukraine has also pledged to gradually approximate the EU law and regulatory framework in the sphere of the information society and electronic communication (Article 394).[40] The Agreement, in Articles 115–124, lays out the basic rules for a competitive and well-regulated telecommunications sector. The obligations of the EUAA concern the regulatory authority, principles for the authorization of licenses to service providers, the rights of access to interconnections with other service providers, principles for governing the allocation of scarce resources, and so forth.

Although the EUAA does not outline the stakeholders implementing the Articles on the Ukrainian side, a stakeholder mapping exercise yields the following key bodies from the standpoint of policy making and regulation in ICT:

- MDT (central executive body/policy maker)
- NCCIR (NRA)
- Ukrainian State Centre of Radio Frequencies (state enterprise responsible for radio frequency spectrum monitoring under the NCCIR)
- National Council of Television and Radio Broadcasting of Ukraine (a stakeholder for the analog-to-digital switchover)
- State Service of Special Communication and Information Protection of Ukraine (policy making and implementation in the protection of state information and resources in telecom systems)
- General Staff of the Armed Forces of Ukraine (regulation of special users of defined spectrum bands)

Over the years, the development of a new sectoral Law on Electronic Communications, in alignment with EU standards, has been a priority for Ukraine. Several draft laws were introduced in parliament but failed to comply with the EUAA.[41] The most recent draft law No. 3014 "On Electronic Communications," registered by the parliament of Ukraine on February 5, 2020, passed the first reading in June 2020. This new law aims to transpose the EECC with the objective of promoting modern and effective regulation of the electronic communciations market, although some key players, such as the NCCIR, find a number of major flaws in it.[42]

The adoption of a new sectoral law is ongoing, which is a step in the right direction but which should be complemented or followed by a separate law on the NCCIR and amendments to a number of legal and regulatory acts affected by the law. For instance, the establishment of the NRA is currently regulated by presidential decree No. 1067 from 2011 (with the latest amendments dating back to 2014), which is not sufficiently comprehensive in outlining the mandate the NCCIR needs to have as a sector regulator and does not ensure its financial independence. **Developing a modern regulatory environment and institutions should be a priority for sustainable sector development in Ukraine. International best practice affirms the need for a sufficiently funded, skilled, and rewarded NRA, capable of intervening on key competition issues, especially when market failures occur.**

The major recommendations based on the strategic context discusssed in this section are the following.

Recommendation 1:

Given the vital importance of broadband connectivity to economic and social functioning and the many specifics of its advancement, prepare a separate strategic document dedicated to broadband connectivity and its development (the NBDS).

Recommendation 2:

Define and include a monitoring and evaluation plan as part of the NBDS to ensure the timeliness and diligency of its implementation and accountability.

Recommendation 3:

Align the high-level stategic broadband goals of the NBDS and other relevant strategic documents with those of the EU to comply with the EUAA.

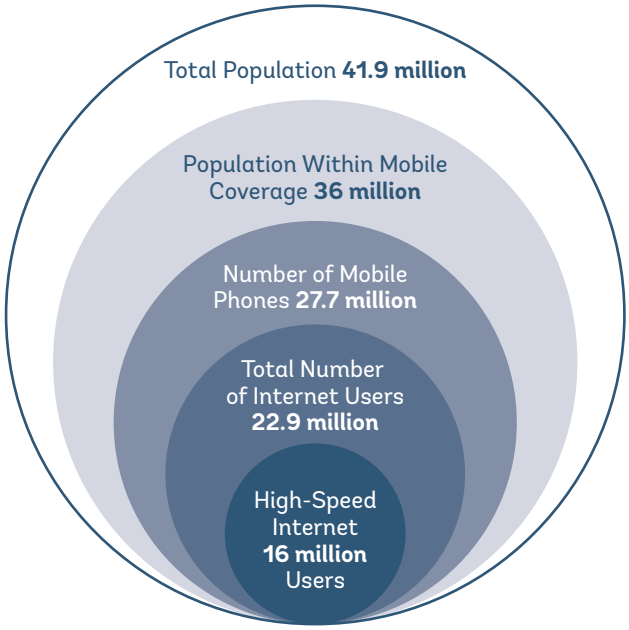
Recommendation 4:

Strengthen the institutionality, mandate, and responsibilities of the national sector regulator (the NCCIR) through the alignment of the relevant legal framework with the EECC.

4.2 Market Status Quo

The population's access to ICTs in terms of coverage and adoption is visually presented in **figure 4.1.** Optical fiber cable (OFC) has been the driver of broadband access in semi-urban and rural areas, along with 3G and 4G. Fixed broadband networks have saturated urban and semi-urban centers and are beginning to expand into rural areas. At present, roughly two-thirds of the country's households are said to possess an internet connection, although official statistics show half that number, likely due to underreporting by micro-entrepreneurs as well as gaps in regulatory reporting obligations. The vast majority of enterprises have computers and access to the internet.[43] The following two sections review the status quo in terms of retail.

FIGURE 4.1.
ICT Access by Population

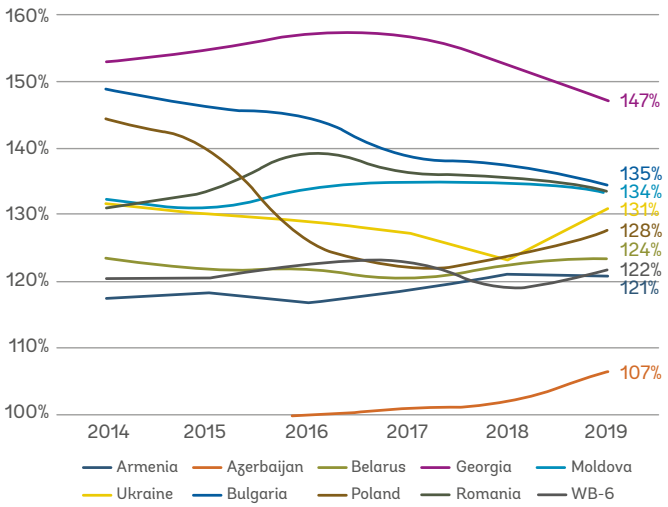


Sources: Authors, based on data taken from Ukrcensus;[44] a Factum Group Ukraine study on internet penetration in Ukraine;[45] and the Concept of State Policy in Digital Infrastructure.

4.2.1 Mobile Broadband

Wireless communications are widespread in Ukraine. As of December 2019, the wireless penetration was 131 percent per capita,[46] which is the second-highest performance in the EaP neighborhood, behind only Georgia with 147 percent. The figure is higher than in all Western Balkans Six (WB6) countries, behind only Montenegro at 184 percent, and similar to the penetration in new EU member states selected for the benchmark, oscillating between 127 percent in Poland and 134 percent in Bulgaria (see **figure 4.2**).[47]

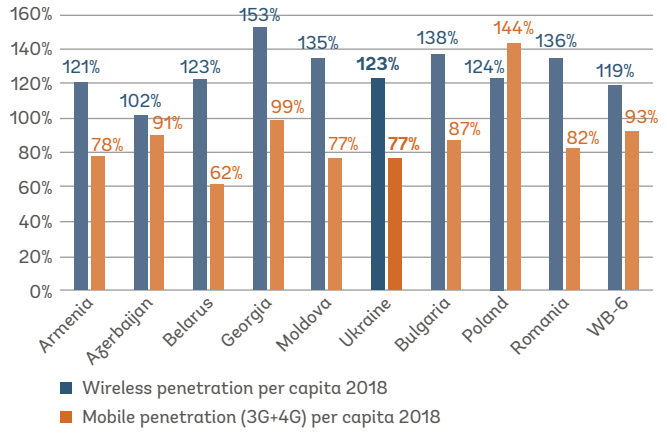
FIGURE 4.2.
Wireless Penetration per Capita, 2014–19



Sources: TeleGeography GlobalComms; World Bank (2020).[48]

The share of users of mobile broadband (3G+4G connections only) out of all users reached 77 percent in 2018. This means that the broadband market has potential for growth in the coming years, as close to a quarter of wireless users are not yet using 3G or 4G. As can be seen from **figure 4.3** below, mobile broadband has saturated wireless markets in some EaP countries (Azerbaijan, Georgia), in the WB6, and in Poland, but not yet in Ukraine, where 4G LTE networks went live only recently in 2018.

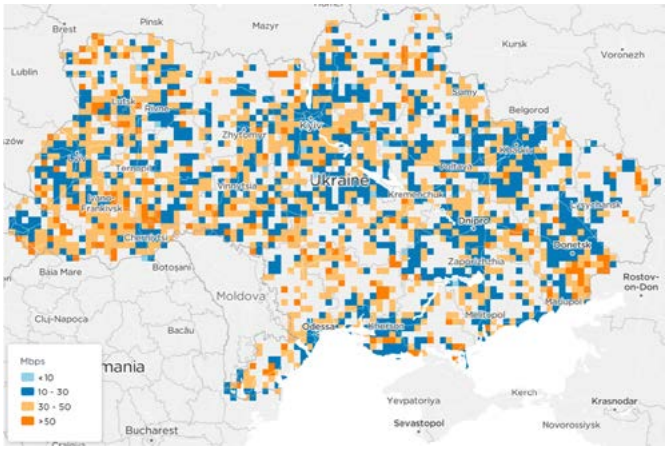
FIGURE 4.3. Wireless vs. Mobile Broadband Penetration per Capita, 2018



Sources: TeleGeography GlobalComms; World Bank (2020).[49]

The quality of mobile broadband remains insufficient for communication needs, especially in less populated oblasts and in rural and remote areas. As can be seen from the coverage map of 3G/4G broadband access, as measured by the speed tests of mobile network operators (MNOs), only the largest cities have good coverage, whereas the rest of the country is severely underserved (see **figure 4.4**).

FIGURE 4.4. 3G/4G Mobile Broadband Coverage, 2019



Source: Based on an analysis by Ookla® of Speedtest Intelligence® data for May 20, 2020. Ookla trademarks used under license and reprinted with permission.

The wireless market in Ukraine is dominated by three major operators (in descending order of market share): Kyivstar (owned by VEON), Vodafone (owned by Azerbaijani Bakcell), and Lifecell (owned by Turkcell). Three smaller national players, Intertelecom, Ukrtelecom (TriMob), and Telesystems (PEOPLEnet), cumulatively control less than 3 percent of the market. The Herfindahl-Hirschman Index (HHI) calculations reveal that the mobile market in Ukraine is competitive (HHI index 0.38)[50] and that market concentration is similar to the markets of other EaP countries, such as Moldova (0.39) or Azerbaijan (0.35), but less competitive than in Poland (0.2), Bulgaria (0.33), or Romania (0.28).

The largest revenue in the wireless market comes from data transfer and access to the internet (roughly 57 percent). As expected, this share has been continuously growing since 2016 and represents one of the key drivers of the evolution of communications networks because of the substitute effect of voice-over internet protocol (VoIP) applications over mobile telephony, which has been observed in other markets also.

Despite the decline in the national subscriber base due to the annexation of Crimea and a breakout of armed conflict in the country's east, MNOs have rebounded since 2015, as evidenced by the growth in their average revenue per user (ARPU), boosted by the launch of 3G and 4G services. The introduction of 4G services alone increased operators' ARPU by approximately 18 percent in 2019 compared to 2018.[51] That said, the revenue dynamics of MNOs do not seem to suggest that the companies will continue to reinvest in their networks as actively in the years ahead, as they are waiting to recoup their initial investments in 4G networks in the next five to 10 years.[52]

Mobile broadband prices are competitive and affordable for the average Ukrainian but are above the adopted affordability standard for the bottom 40 and 60 percent of the population by income distribution. In the fight for customers, MNOs are actively using promotional prices. Tariffs for mobile broadband are the same for all regions and are generally considered affordable. On the cost of mobile cellular tariffs, the World Economic Forum (WEF) ranked Ukraine 48th out of 139 economies in 2016.[53] However, for the poorest in Ukraine, the bottom 60 and 40 percent of the population, the broadband mobile package constitutes 4.2 and 4.9 percent, respectively, of the average monthly income, which is more than two times higher than the established 2 percent standard.[54]

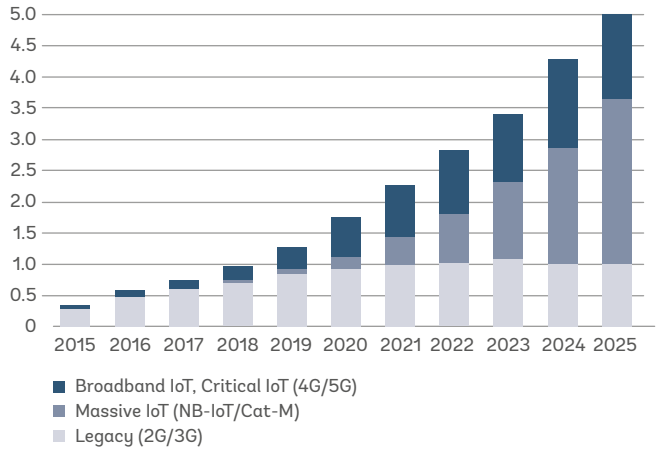
Market development has been stymied because of spectrum management policy. In 2007, without any auction or tender, then state-owned incumbent Ukrtelecom (TriMob) was issued a 2100 MHz license, enabling it to launch the country's first 3G services and cover around half of the population. Kyivstar, Vodafone (then MTS), and Lifecell were awarded with 2100 MHz licenses only in 2015, which helped break TriMob's monopoly[55] (by then privatized[56]). In 2018, Ukraine completed 4G LTE license auctions in the 2600 MHz and 1800 MHz spectrum bands, one of the last countries in Europe to do so. The rollout of networks has been swift so that by mid-year, Kyivstar, Vodafone, and Lifecell had all launched commercial 4G services,[57] resulting in well-observed penetration growth (see **figure 4.2**).

To meet the goal of covering the entire population with wireless services, it is essential that operators have access to spectrum, especially in the 700–900 MHz bands. The reason is that at those frequencies, signal attenuation is significantly lower and base stations can reach further, thus a larger geographic area can be covered with fewer base stations, that is, at significantly lower cost. Moreover, the existing towers and masts deployed for 2G and 3G could be reused.

However, the 700–800 MHz bands are currently being used for, among other services, television broadcasting. Nevertheless, the National Television and Radio Broadcasting Council (the media regulator) has agreed to release bands 694–862 MHz in favor of the rollout of 4G LTE.[58] The **NCCIR has also agreed with the major MNOs on a roadmap to redistribute the licenses for the 700–900 MHz bands for LTE and on specifications for converting spectrum from military to civilian use.**[59] The corresponding changes are projected to take place in 2020, a little behind the schedule set by the EU for its member states (June 30, 2020).[60] **Although Ukraine is on the right track, it is recommended that it apply EU best practice in addressing spectrum coordination issues in the country. The GoU should initiate the actions needed to implement the roadmap for 700 MHz frequency band reassignment, including those dealing with cross-border coordination.** A more comprehensive analysis of spectrum management for 4G/5G, as well as more detailed recommendations on this subject, can be found in **Annex 3.**

An increase in the number of users of machine-type communications (MTC) and IoT services by 17.5 percent throughout 2019[61] was a major trend in Ukraine's mobile broadband that ties directly to the issue of spectrum release for 5G. The major operators have started to launch narrowband (NB) IoT services in Ukraine.[62] The demand for IoT is expected to grow further, in line with global IoT trends (see **figure. 4.5**), fueled by 5G operationalization. To satisfy the demand for IoT in Ukraine, proper technology should be in place (4G/5G). An overview of 5G technology, as well as major recommendations related to its promotion, is provided in **Annex 4**, and high-level recommendations on cybersecurity measures related to the preparation and planning of 5G rollout can be found in **Annex 5.**

FIGURE 4.5.
Forecasted Cellular IoT Connections by Segment and Technology



Source: Ericsson mobility report.

With the development of IoT and other types of smart infrastructure technologies, the understanding of broadband universality has shifted from population to territorial coverage. Some time ago, population coverage was considered an ultimate goal for ICT policy makers; now, however, ensuring the coverage of the entire national territory (including major infrastructure routes) has become as, if not more, important. Coverage of the territory with high-quality mobile broadband allows for a range of cutting-edge projects in real sectors of the economy, such as agriculture, energy, transport, and forestry, and in cross-cutting areas, such as environmental protection and climate change adaptation and mitigation, among many others. **The new opportunities arising from technological advancement need to be considered and enabled through the NBDS, especially in its provisions related to mobile communications.**

The major recommendations based on the analysis of the status quo of the mobile market are formulated below.

Recommendation 1:

Improve data collection and reporting by the NCCIR to obtain a more objective picture of the state of mobile broadband connectivity with a higher granularity in time.

Recommendation 2:

Accelerate the deployment of 4G for consumers and businesses by removing barriers to operators, such as spectrum allocations.

Recommendation 3:

Ensure full connectivity to remote areas by performing spectrum refarming in the 800–900 MHz band, based on the principles of technology neutrality and efficient resource uitilization.

Recommendation 4:

Promote the introduction of IoT services through a shift in coverage requirements from the share of the covered population to the percentage of geographic territory.

Recommendation 5:

In line with the EU Gigabit Society, as soon as 5G becomes available, ensure that the service is accessible along major highways to facilitate 5G pilots and applications for transport, including digital transport corridors (DTCs).

4.2.2 Fixed Broadband

Overall, Ukrainians have access to low-priced, high-quality (as measured by speeds) broadband, especially in urban and semi-urban areas. The coverage, however, remains uneven, particularly in rural and remote areas, either located in the mountainous part of the country or characterized by depopulation and a high concentration of the poor.

The affordable price and a high share of coverage with high-speed technologies (especially based on OFC) is driven mainly by the high number of internet service providers (ISPs) on the retail market, many of which are not officially registered as providers of electronic communication services[63] and the majority of which are microentrepreneurs, especially in rural areas. According to the register of telecommunications operators and providers,[64] as of April 17, 2020, there were 1,192 entities actively[65] operating in the sector. Out of those, close to three quarters (72 percent) were individual entrepreneurs/natural persons (microentrepreneurs) who conduct business in a mode of preferential taxation (single tax of 5 percent on income[66]) and who offer low costs. This allows ISPs registered as individual entrepreneurs/natural persons to compete effectively against larger operators, especially in villages. By end-2019, there were 7,265 microentrepreneurs registered in the same register, of whom 1,173 were operating in rural areas, an increase of 18 percent compared to the preceding year. It may appear that the huge competition overheats the market, with certain providers dumping prices to extend their client base, especially in multi-storied apartment buildings in major cities.[67] And indeed, typically smaller ISPs frequently operate as part of the shadow economy (e.g., oftentimes ignoring legal provisions) and offer a cheaper (and possibly, at times, suboptimal) service to end users.[68] However, at the same time, the high number of ISPs stems from the fragmentation of corporate ISPs into hundreds of ISPs run by microentrepreneurs and operating as a single undertaking. The real number of ISPs (single undertakings) is therefore much lower.

The HHI index value (measuring market concentration) reveals that **in Ukraine, market concentration is very low (HHI index 0.12),[69] which would normally denote fierce competition and a fragmented market. In the case of Ukraine, however, this may not present the whole picture as the real number of ISPs is likely lower.** A more granular analysis of the retail market is therefore needed on the oblast level to observe market concentration at varying levels of geographic aggregation.

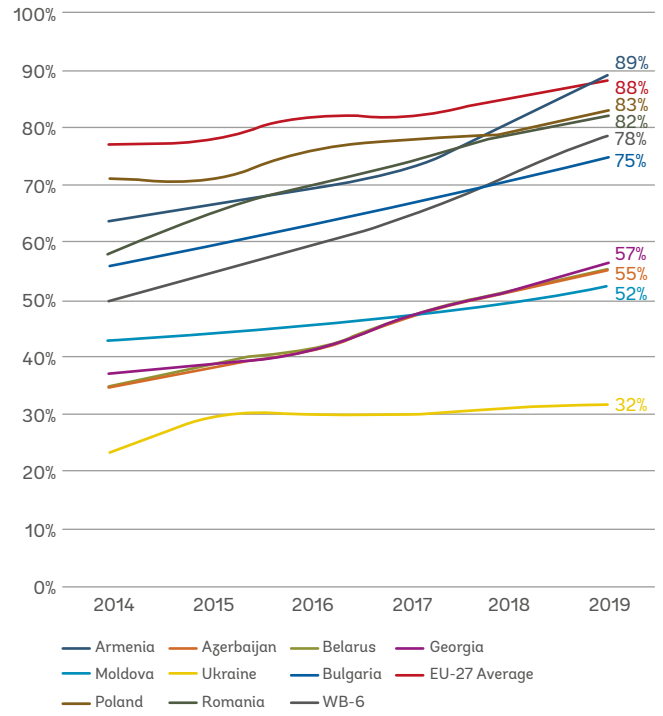
Still, the large number of operators in the market indicates that market entry is not a challenge but operating sustainably and scaling operations are. **Consultations with industry stakeholders have pointed to the fact that ISPs lack the financial resources to roll out networks and do not have the bargaining power to get fair access to the national backbone networks of dominant operators.** As a result, areas with lower demand and less purchasing power to afford broadband services tend to be less competitive.

Judging from the official statistics, the level of fixed broadband penetration on a household level in Ukraine is the lowest in the EaP neighborhood or among the countries selected for the benchmark (see **figure 4.6**): the EU-27, new EU member states with similar geographic and population characteristics (Poland, Romania, Bulgaria); and aspiring member states (the WB6). **This positioning of Ukraine compared to the benchmark has not substantially changed since the World Bank prepared a report on the state of the ICT industry in 2005.[70]**

However, a recent survey from Factum Group at the request of the UIA found that 65 percent of Ukrainians actually had internet at home in 2019, two times more than official figures indicate.[71] The below fixed coverage map based on the speed measurements of ISPs by Ookla supports the assumption that the actual coverage of households could be as high as two times the official number (**figure 4.7**). As one would expect, the white areas can be found in the mountains in the country's west, depopulated north (including the Chornobyl exclusion zone), alongside the Dnieper river, and the low-populated (steppe) of the Crimean peninsula.

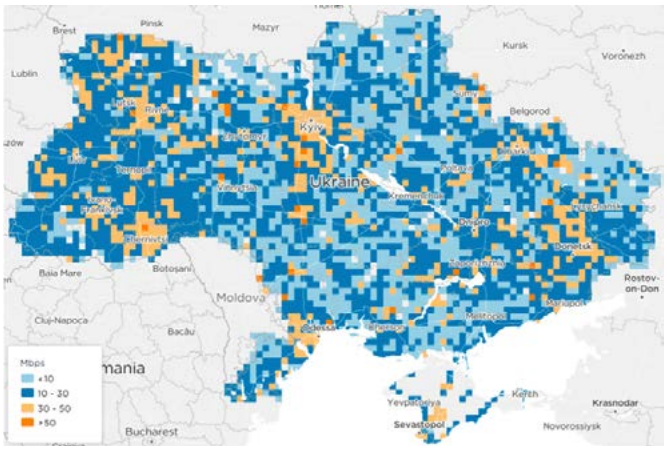
The penetration trend and projections until 2025 (using official statistics) show that without active market intervention, the number of households connected to fixed broadband will not increase in the near future (**figure 4.8**). Although some data discrepancies are possible on the level of real household penetration, the trend is accurately demonstrating the situation on ground, that is, that this submarket is saturated, with urban and suburban areas fully covered. This was also confirmed during public consultations with the market players conducted by the MDT.

FIGURE 4.6.
Fixed Broadband Household Penetration in 2014–19



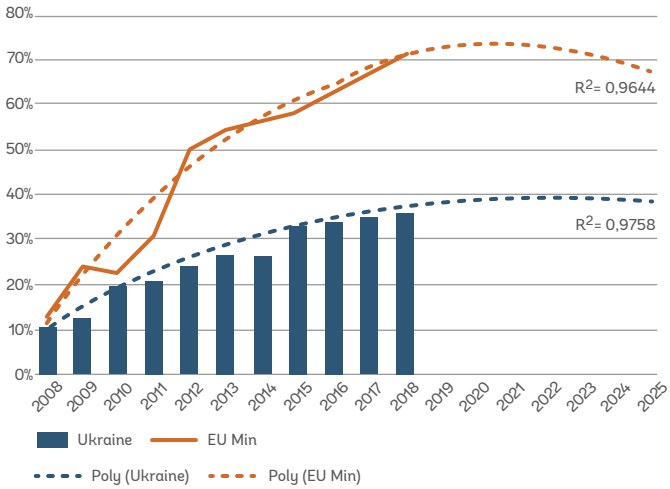
Source: Eurostat, TeleGeography GlobalComms (2020).[72]

FIGURE 4.7.
Fixed Broadband Coverage of Ukraine, 2019



Source: Based on analysis by Ookla® of Speedtest Intelligence® data for May 31, 2020. Ookla trademarks used under license and reprinted with permission.

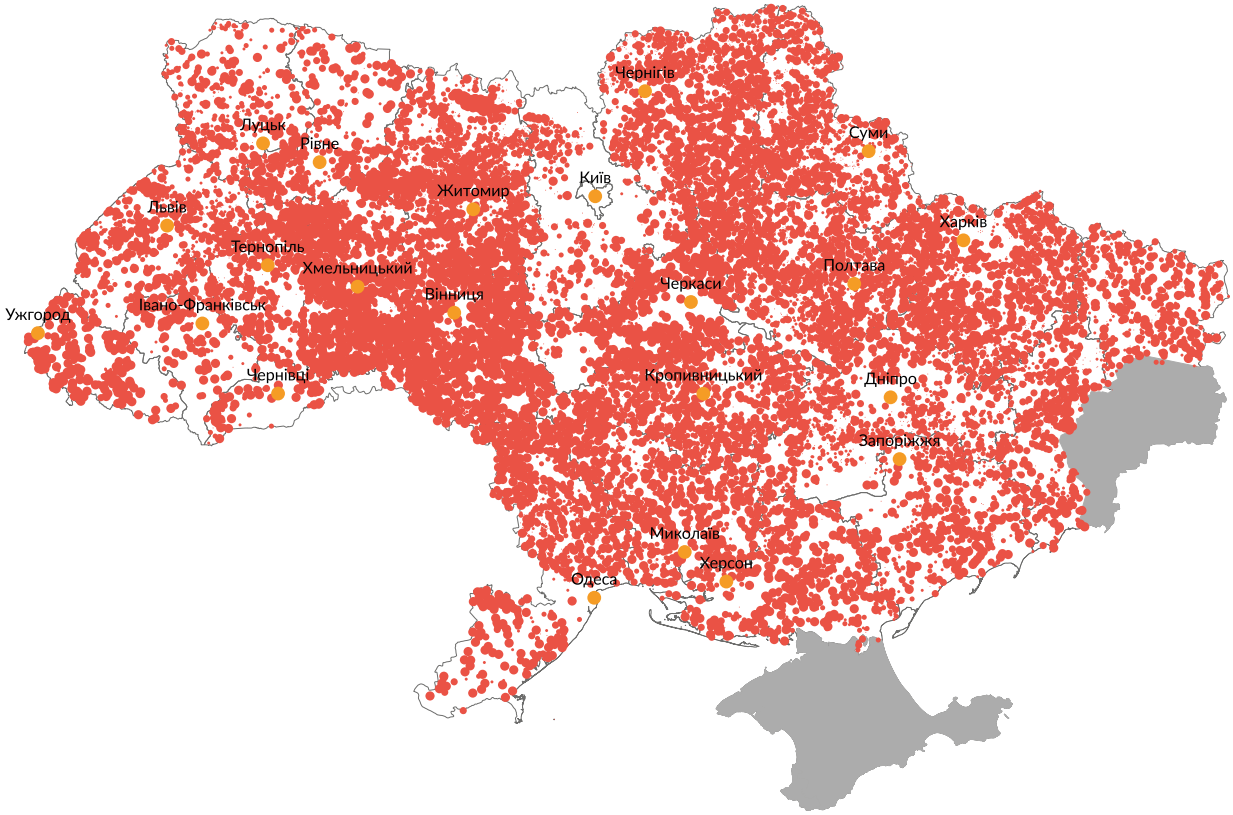
FIGURE 4.8.
Fixed Broadband Household Penetration Trend and Projections in Ukraine vs. EU-27



Source: World Bank estimates based on TeleGeography GlobalComms and Eurostat (2018).[73]

As a result of the market saturation, the pace of broadband infrastructure expansion has considerably slowed, leaving behind 12 percent of the Ukrainian population (roughly 5 million people) living in 17,988 settlements.[74] **Box 1** outlines the methodology applied to conduct this analysis, while the aggregated results are presented in **figure 4.9.** The estimated range of the investment gap is between US$344.9 and $444.4 million; additional investments will be required to connect the unconnected public institutions. It is further estimated that the entire investment gap cannot be bridged by the private sector alone and that approximately US$200 million would need to be (co)invested by the public sector (see **box 2**). A detailed cost-benefit analysis of this investment can be found in **Annex 6**.

FIGURE 4.9.
Settlements without Fiber-Optic Connectivity, 2020



Note: Unconnected settlements are marked in red; the size of the circle for each settlement is proportionate to its population.
Source: World Bank, based on multiple data sources (see box 1 for methodology).

BOX 1
Estimating High-Speed Broadband Coverage in Ukraine

To estimate the coverage of high-speed broadband in Ukraine, four different data sources were used to identify and cross-check the status of coverage at the settlement level. The core data on connection speeds are from Ookla.[75] Three additional data sources were used to complement and cross-check the data using official statistics from the GoU and the telecommunications regulator, NCCIR: (i) MES data on broadband coverage in schools, (ii) regulatory data from the NCCIR survey of ISPs as of January 2020, and (iii) official speed testing data from broadband.gov.ua.

In the data visualization, the settlements without fiber-optic coverage were mapped, using a red dot for each settlement with 0 confirmed speed tests at 30 Mbps or above. **A settlement was defined as having no coverage if all four data sources described above suggest that no user in a given settlement had access to internet connection speeds above 30 Mbps during the period January 1, 2020–May 30, 2020. As there are 17,988 such settlements (accounting for 12 percent of the overall population), the map was made more tractable by plotting only settlements with a population of 1,000 or more.** In the visualization, the dot size is proportional to the population of the settlement. The temporarily occupied territories and Crimea were excluded from this analysis.

Source: Authors.

BOX 2
Estimating Investment Costs to Bridge Investment Gaps in Ukraine

The total required investment amount is estimated as the sum of backhaul investments (the cost of connecting settlements currently without fiber-optic connectivity) and the access network investments (the cost of connecting specific objects within a settlement, including schools, health care institutions, and other objects of social infrastructure).

The conservative estimate of backhaul investments is US$344.9 million. This estimate uses the number of unconnected settlements (17,988 settlements with no speed tests at or above 30 Mbps)[76] and the estimated cost per settlement (US$27,750). The cost per settlement estimate relies on the broadband rollout project undertaken by the MES in 2019.

The estimate of access network investments (conditional on backhaul connectivity) is US$54.3 million. This estimate takes into account the number of unconnected schools (6,544) and primary health care institutions (7,565), according to the data provided by Ministries of Education and Healthcare of Ukraine, as well as the number of unconnected rural households (1.6 million). The estimated cost per building (at US$34.04) is calculated from the ground up, taking into account the cost of material and labor for ISPs.

Hence, **the lower bound of the total required investment amount is estimated at US$399.2 million.** Recognizing that part of the required investment amount can be covered via private means, **the baseline case was considered at 50:50 public-to-private investment, which would result in a required public investment of US$199.6 million.**

Source: Authors.

Given the necessity for public sector action, it would be relevant for Ukraine to strengthen its capacity to apply the EU broadband state aid framework[77] and establish a legal groundwork for broadband state aid rules.[78] The state aid framework regulates the financing of many broadband deployment projects in the EU, including new-generation access (NGA) projects, when providing public support to broadband projects using, for example, direct subsidies, matching grants, or other form of state aid allocation. State aid is an integral part of EU competition policy. Although it is generally prohibited when it distorts or threatens to distort competition or affect trade between member states, there are a number of exceptions: the use of state aid needs to be justified by reasons of an economic nature, and projects should demonstrate a beneficial developmental impact. Thus state aid represents a common approach to correct market failures (market power, information asymmetries, inefficient allocation of resources, public services) and contribute to the achievement of specific state objectives, for example, on broadband development.

Examples of state aid programs in broadband market development include a range of cases considered in the EU: from direct investment in publicly owned and operated networks, to demand-side efforts to connect more businesses or households to broadband, to municipal network development.[79] Three examples of different state aid models from Romania, Sweden, and Lithuania are outlined in **Annex 7**.

To this end, the **MDT is actively pursuing broadband mapping initiatives** that should be instrumental in stimulating the use of shared infrastructure and implementing the provision of Law No. 1834-VIII. The MDT is also considering service, demand, and investment mapping opportunities aiming to stimulate investments. These could also be used as an assessment tool for the application of state aid. At the moment of this writing, the MDT was defining the overall framework for broadband mapping initiatives and its coordination on the national level.[80] This process is taking place as a part of the concept development of the multifunctional platform broadband.gov.ua, which should become a more comprehensive and universal tool for public authorities and other stakeholders (see **box 3**). The approach toward infrastructure and service mapping currently under development is discussed in more detail in **Annex 8**.

Although broadband coverage needs to be improved, no intervention appears to be required on the affordability side. An analysis of the prices of entry-level broadband plans in Ukraine shows that they are under the established threshold of 2 percent of monthly average income—actually the lowest among EaP countries and selected EU member states. The latest Networked Readiness Index of the WEF ranked Ukraine 2nd in the world on the affordability of fixed broadband tariffs, and some other industry sources have equally ranked it in recent years either second or first, aided by, among other factors, the national currency devaluation since 2014.[81]

BOX 3
Broadband.gov.ua as a Multifunctional Platform for Broadband Development in Ukraine

In accordance with the MDT's model, all services and information about broadband should be available in one place. It is planned that the broadband.gov.ua portal should become this single access point that will ensure the participation of all stakeholders in the implementation of the State Policy on Digital Infrastructure. Ultimately, this platform should consist of seven modules: (i) infrastructure mapping, (ii) a coverage and penetration map of fixed and mobile broadband, (iii) the submission of data and reporting to state authorities, (iv) feedback from citizens and quality of service monitoring, (v) simplification of public procurement in broadband, (vi) a comparison of the tariffs and services of operators and ISPs, and (vii) Interoperability and open data.

When implemented, the portal will assist the GoU in monitoring and facilitating broadband infrastructure development in the country. At the same time, one of the main components of the portal will be broadband mapping and data collection modules that will provide valuable information to market participants and ease the submission of statistical information for regular market reports. These and several other issues are explored in **Annex 8**.

Source: Authors, based on consultations with the MDT.

According to Ukraine's Statistical Office UkrStat, in 2010–18, a typical household in Ukraine spent, on average, around 2.3 percent of its monthly income on communications (including fixed and mobile). This consumption share has been more or less stable, especially since 2014, with a slight downward trajectory. In comparison to other household expenditures, Ukrainians spend approximately six times more on utilities and over 40 percent more on transport, while communications consumption is similar to expenditure on restaurants and hotels.[82]

An affordability analysis of fixed broadband is presented in **box 4. The analysis suggests that typical fixed broadband packages cost no more than 2 percent of average household income in rural or urban areas.** These estimates rely on data from 2019 and compute the affordability proxies using average monthly income for householdls in urban and rural areas. It should be noted that recent income shocks related to the COVID-19 crisis are likely to adversely affect affordability due to significant drops in disposable income.

BOX 4
Estimating How Many Households Can Afford High-Speed Broadband in Ukraine

How many of Ukraine's households might comfortably afford a 100 Mbps broadband connection? Analysis based on the consumption groups used by UkrStat provides a view of affordability. If an affordable broadband connection is set up to cost less than 2 percent of monthly consumption,[83] at current prices (UAH 180 for Kyiv and UAH 150 used as a proxy for outside the capital), average households, both urban and rural, can afford it, as shown in the table below.

Even if prices increase in line with recently observed market tendencies, only the bottom 10 percent of households by income would not meet this affordability criterion. Prices are not expected to remain stagnant or fall, given the market trends.

It should be noted, however, that due to the negative effects of COVID-19, the level of income, including its disposable portion, is likely to drop in Ukraine. This means that new affordability analyses should be conducted by policy makers later in 2020 and 2021 to determine whether and how the affordability picture has changed and whether additional demand-side measures may be required.

Affordability Estimates of 100 Mbps Connection Based on Consumption Groups

Consumption Group	Estimated per household income in 2019 (monthly UAH), first 9 months	Affordability in 2020 (100 Mbps as % of monthly household income, UAH) Kyiv prices			Affordability in 2020 (100 Mbps as % of monthly Prices outside the capital (proxy)		
		180	207	234	150	173	195
Average	11930	2%	2%	2%	1%	1%	2%
Average (Urban)	12368	1%	2%	2%	1%	1%	2%
Average (Rural)	11024	2%	2%	2%	1%	2%	2%

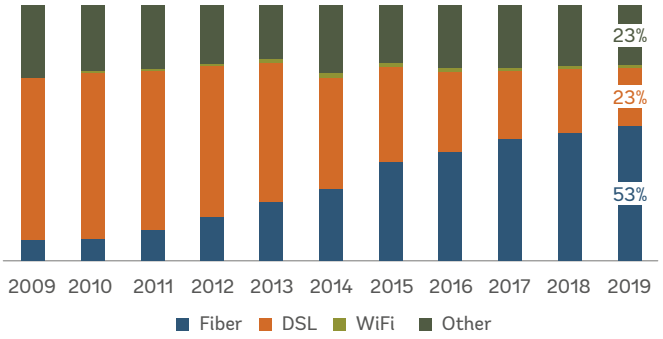
Notes: These estimates of household income per consumption group were derived from a survey of Ukraine's households conducted by UkrStat—called the Expenditures and Resources of Ukrainian Households (according to a sample survey of household conditions) in the first nine months of 2019—prepared by World Bank staff.
Prices for packages for Kyiv are based on the analysis of the cheapest (100 Mbps download) fixed internet offerings of the top three ISPs by market share as of July 11, 2020.
Source: Authors' analysis, based on UkrStat data and World Bank staff estimates, 2019–20, and projections.

Furthermore, broadband packages appear to be affordable for the average Ukrainian, including the bottom 40 and 60 percent by income distribution. Fixed broadband packages take up a somewhat larger share of one's disposable monthly income than basic (prepaid) mobile, although it has to be noted that the tariffs analyzed (by Ukraine's ISPs with the top market shares) are provided only for the residents of Kyiv, which may imply that the same ISPs offer lower-priced packages outside the capital. Furthermore, the analysis performed was on a per capita basis, whereas fixed broadband connectivity is typically used on a household level, meaning the cost of a service is spread among household members (the typical number of household members in Ukraine is 2.58). Finally, this likely means that alternative ISPs provide even lower-priced packages, especially in the settlements outside Kyiv, and may have particularly tailored offerings in terms of price for the areas with a high concentration of low-income households.

Interestingly, ISPs in Ukraine do not usually impose restrictions on any kind of subscription sharing between customers due to multiple devices that might potentially be used by a user. The earlier practice of assigning a media access control (MAC) address to each subscription is no longer in practice. In some cases, when price per connection is high, radio relay links users share internet access with their neighbors. Another relevant case is university campuses with a local ISP monopoly, where students often share their unlimited subscription.[84] This subscription sharing, while a dubious practice, in the particular context of Ukraine undoubtedly boosts internet access among low-income strata of the population, thus explaining the higher number of internet users compared to the statistics on official household coverage.

Not only is fixed broadband connectivity affordable in Ukraine, it is also of decent quality (high speed). The quality is determined by the type of access technology. In 2019, the largest share of fixed-line subscribers (53 percent of total annual subscribers) accessed the internet via fiber-optic home/residential (fiber to the home, or FTTH), followed by more or less an equal share of digital subscriber line (DSL), and cable and other technologies. Since 2014, the number of subscribers receiving fixed broadband services through FTTH has been increasing, on average, by 20 percent due to consumers' transition from DSL (see **figure 4.10**). The FTTH Council places Ukraine in the bottom middle of 39 European countries on the FTTH/B ranking on household penetration, considerably behind Romania, Bulgaria, and North Macedonia but ahead of, for example, Poland, Germany, and the United Kingdom.[85]

FIGURE 4.10.
Technological Mix on the FBB Submarket of Ukraine, 2009–19

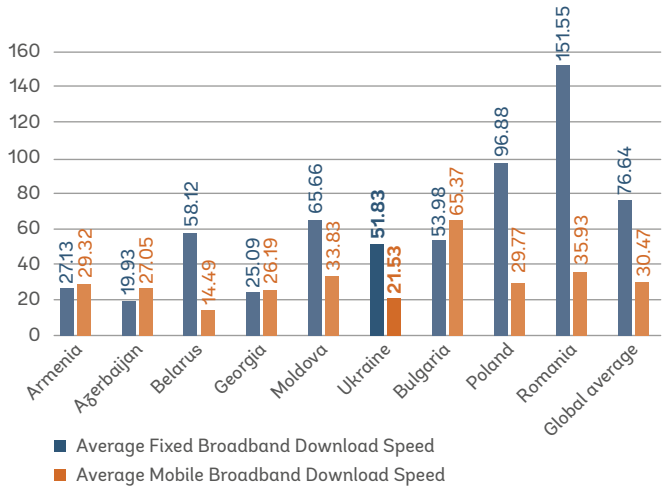


Source: Ukraine Broadband. GlobalComms Database TeleGeography (2020).

Average speeds of fleet broadband (FBB) access are relatively high, although improvements are needed. The data for the February 2020 Speedtest Global Index from Ookla show that the average download FBB speed in Ukraine increased to 50.51 Mbps, which is ranked first, albeit four times lower than in Singapore. Overall, the country is ranked 59th out of 176 economies (see **figure 4.11**). In its analysis of the evolution of speeds worldwide in 2017–19, Ookla[86] placed Ukraine in the "Speed Laggers" category, juxtaposing its potential against Speed Leaders from the EU (see **figure 4.11**).

On the FBB speed indicator, Ukraine is performing well relative to the benchmark selected for this report: although its download FBB speed is lower than that of the EU-28 and new EU member states (such as Bulgaria, Romania, and Poland), it is well ahead of the majority of the WB6 (with the exception of Serbia, which is ranked 58th) and EaP countries (with the exception of Belarus, which is ranked 56th, and Moldova, ranked 46th).

FIGURE 4.11.
Mobile and Fixed Broadband Average Speeds in Ukraine vs. Benchmark Countries, March 2020



Source: Ookla® Speedtest® Global Index March 2020, https://www.speedtest.net/global-index.

Despite the positive effects of affordability on end users from the standpoint of service adoption, there is another side of the coin. The low price of internet service packages (despite recent price increases) and low ARPU, coupled with the national currency volatility, hinders investment in the construction and upgrade of broadband networks. For example, connecting and providing broadband access in many villages is not economically feasible for private telecom operators due to the particular socio-demographic profile of the local population (the poor, the elderly) or specifics of the terrain (in mountainous areas). Furthermore, in a large share of Ukraine's 28,376 villages,[87] there is no legacy copper infrastructure due to the lack of basic telephony. As of January 2019, there were almost five times as many wireline (basic telephony) residential connections in cities than in villages.[88] Only the largest ISPs thus have the possibility of rolling out networks in multiple hard-to-reach rural areas, as evidenced, for example, by a recent announcement that incumbent Ukrtelekom will connect "hundreds of thousands" of village residents across 200 settlements in 13 regions through its 2,000 kilometer fiber network under a UAH 200 million investment.[89]

The major operators of FBB access by market share are Ukrtelecom (also the largest by revenue and coverage), Kyivstar, Volia, Triolan, PJSC Datagroup, and other players. Out of this list, Kyivstar and Volia are owned by foreign investors. The former is a wholly owned subsidiary of Russian-backed VEON Ltd. (formerly VimpelCom Ltd.), while the latter has U.S.-based Providence Equity Partners as the largest shareholder.[90]

Ukrtelecom is an ADSL2+ and fiber provider covering 2,300 cities/towns/villages whose main competition is now represented by mobile and fiber operator Kyivstar, which caters exclusively to apartments, not single dwellings, in 118 cities/towns. Volia is the largest cable TV operator in the country (present in 33 cities), followed by Triolan (HFC cable and fiber provider in 11 main cities). Multi-regional facilities-based fixed line operator Vega is a sister company of Ukrtelecom (part of the same industrial and financial conglomerate SCM), with a presence in 90 cities/towns. Until recently, Vega had been focusing on the business segment, similar to Datagroup, the last of the "big six," with its own extensive network. Kyivstar and Vega account for a significant share of data transmission and corporate services markets, while cable company Volia has put an effort into growing its presence in the corporate data/wholesale sector and data center market.[91]

In 2019, income from fixed internet services amounted to the equivalent of UAH 11,688 million, which is 14.4 percent of the total income of telecommunications services. The bulk of this income came from fixed (wired) broadband internet access, accounting for 83.2 percent. Compared to the preceding year, the income of ISPs increased by almost 44 percent in 2019, a solid jump from a more modest increase in 2017–18.[92] Equally important, **the ARPU increased by 21.8 percent in 2019 compared to 12.7 percent in 2018.**

Sharing the passive and active physical infrastructure of various utilities, such as energy, water, and transport, has not been widely used to lay optical cable due to a lack of legal and regulatory obligations, although this is expected to change with the transposition of the EECC into Ukrainian legislation. The adoption of the Law on Access to the Objects of Construction, Transport, Energy for the Purpose of Development of Telecommunication Networks (No. 1834-VIII) in February 2017 was a step in the right direction. Supported by telecom sector players, the bill has significantly streamlined access to the passive infrastructure of electricity distribution operators (DSOs).[93] It could be still further enchanced to fully incorporate the provisions of EU Directive 2014/61/

EU, which focuses on measures to decrease the costs of broadband network deployment.[94]

Despite the progress on the legislative front, there has been little active or passive infrastructure sharing, as ISPs often face infrastructure access denial. Market players complain that local authorities and market players that are asset owners sometimes ignore existing regulations or leverage loopholes to prevent access.[95] Others complain about unrealistic requirements imposed by DSOs, such as a change of electricity poles if they would like to lay cables over them. In particular, market players have complained that some new apartment building construction sites provide access to only one or two preferred telecom service providers.[96]

To compare how Ukraine fares in relation to other countries on the rental cost of electricity poles, a high-level analysis was performed to benchmark the prices charged by DSOs. Given Ukraine's deregulated energy distribution, the average of several DSOs was used, which, as can be seen from the table below, is lower than in neighboring Poland and Romania but is 40 percent higher than in Bulgaria.

In Ukraine, infrastructure owners can set prices, although Article 17, paragraph 7, of the above-mentioned law clearly stipulates the permissible maximum price, using the calculation that access cost for the rental of one electricity pole/cable per month should not exceed 0.3 percent of the minimum fixed salary. (As of March 2020, this price could thus not be higher than approximately UAH 14.2.) **That said, some infrastructure owners do not comply with the law and set higher prices or refuse to let ISPs hang their cables over their poles, thus pushing the latter to invest in their own concrete poles.** Two more facts need to be highlighted. Since in Ukraine, electricity distribution is organized on the oblast level through energy companies that are unbundled into suppliers and DSOs, the price varies widely from one oblast to another, namely, from UAH 2.5 to UAH 15.95. (The majority of energy companies have been privatized, with significant shares belonging to five–seven individuals.[98]) In some oblasts, DSOs are owned by the country's largest energy group DTEK, which is part of the same industrial and financial group (SCM) that owns the incumbent (Ukrtelekom) as well as a smaller ISP (Vega).[99] Some ISPs interviewed for this report believe that the incumbent may thus benefit from preferential access to electricity poles, a matter that may deserve more in-depth scrutiny from the NCCIR in the context of a wholesale market analysis and the Antimonopoly Committee of Ukraine upon request from ISPs.

TABLE 4.1.
Cost of Electricity Pole Rental in March 2020: Ukraine vs. Selected European Countries

Country (DSO)	Price per 1 electricity pole per 1 cable per month, local currency	Price per 1 electricity pole per 1 cable per month, in international $	Price per 1 electricity pole per 1 cable per annum, local currency	Price per 1 electricity pole per 1 cable per annum, in international $
Bulgaria	0.49BGN	0.27	5.92 BGN	8.46
Poland	4.5PLN	1.09	54 PLN	30.33
Romania	4.36RON	1	52.32 RON	30.42
Ukraine	9.02UAH	**0.32**	108.24 UAH	**11.89**

Source: World Bank, based on transmission system operators (TSOs) and various websites.[97]

Some evidence suggests that ISPs have been settling disputes at the Antimonopoly Committee rather than the NCCIR in cases when access to infrastructure was unlawfully impeded. **It is thus recommended that the NCCIR review the existing practice of such cases being settled by the Antimonopoly Committee, and that both institutions collaborate and coordinate to develop consistent case law.** (See **Annex 4** for further details related to infrastructure sharing.)

The major recommendations based on the analysis of the status quo of the fixed market are formulated below.

Recommendation 1:

Improve the NCCIR's data collection process to obtain a more objective picture of the state of fixed broadband connectivity in the (occupied) residential buildings and on the level of public institutions.

Recommendation 2:

Undertake a more granular analysis of the retail market on the oblast level to understand the concentration at varying levels of geographic aggregation.

Recommendation 3:

Develop a publicly funded financial incentive (state aid) scheme to support broadband infrastrutcure investments in unconnected areas of the country.

Recommendation 4:

Develop an action plan for the implementation of Directive 2014/61/EU as a whole and especially its provision related to effective dispute settlement, access to residential buildings and electricity poles, and the efficiency of the permit-granting process.

Recommendation 5:

Review existing dispute-resolution procedures in collaboration with the involved parties, including the NCCIR, Antimonopoly Committee of Ukraine, and Ministry of Justice, and establish consistency in these procedures to avoid the development of conflicting practices within the Ukrainian judicial system. This could be implemented through a review of the access laws and an elaboration of the particularities of dispute settlement (for example, the dispute-settlement body, dispute-settlement timeline, price setting, and coordination procedures between the various regulators, as the case may require).

5 BROADBAND VALUE CHAIN ANALYSIS

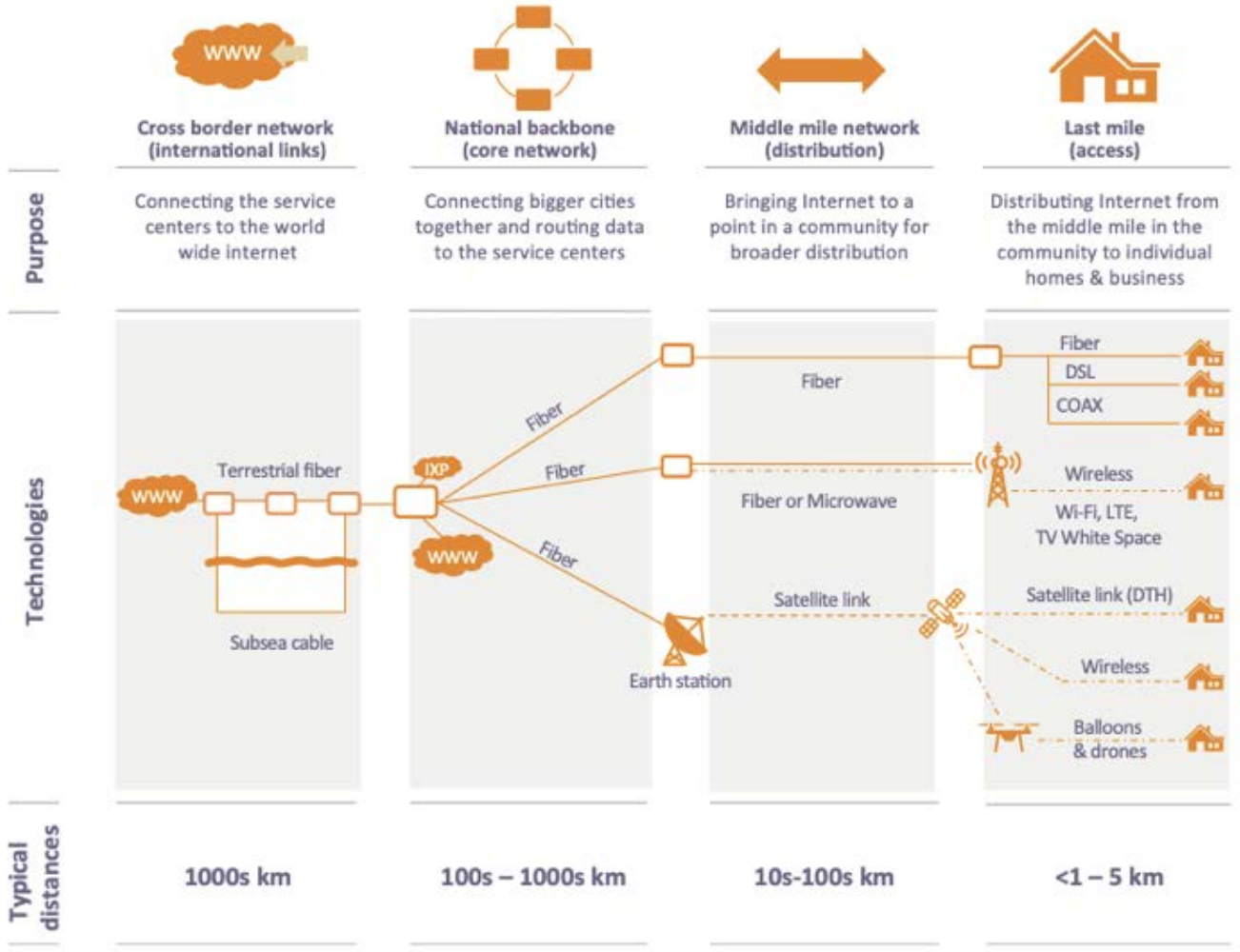
The broadband value chain is made up of three markets: international wholesale, domestic wholesale, and retail. The functional effectiveness of each market impacts those downstream, with cumulative effects falling on the retail segment, as shown in **figures 5.1 and 5.2.**

FIGURE 5.1.
Broadband Value Chain

Source: Authors' analysis.

Technical visualization of the broadband market is depicted in **figure 5.2** below.

FIGURE 5.2.
Broadband Value Chain



Source: World Bank, "Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps" (Washington, DC: World Bank, 2019).

5.1 International Connectivity (Wholesale)

Ukraine, by virtue of its geographic position, has always been a transit state between the East and West and also remains relatively interconnected with its neigboring countries. International transport corridors run through Ukraine from the EU to Russia and the Caucasus, which include not only roads and gas pipelines but also fiber backbones leading to the Baltics and Scandinavia, Western Europe, the Balkans, and Turkey (**figure 5.3**). Ukraine's international internet bandwidth had a 15 percent compounded annual growth rate between 2015 and 2019.[100]

However, major Tier 1[101] backbones stretching from South Asia and the Middle East to Europe bypass Ukraine and run through Russia and Bulgaria. Of the major carriers, Telia has multiple points of presence (PoPs) in Ukraine, but it leases fiber-optic networks,[102] and Orange has a secondary PoP but no networks.[103] Of the other major networks, one should mention the PoPs and networks of Cogent, Vodafone, and Hurricane Electric.[104] The extension of Tier 1 networks, widely present in Europe, such as Telia Carrier, Deutsche Telekom Carrier, and Telecom Italia Sparkle, would tremendously enrich the international connectivity of Ukraine and improve its resilience.[105] Attracting Tier 2 networks for internet access would also provide route diversity, while relying on reputable operators at a decent cost.

FIGURE 5.3. Global Transmission Maps with Terrestrial Fiber Links and IXP Locations

Source: UN International Telecommunication Union (ITU), https://www.itu.int/itu-d/tnd-map-public/.

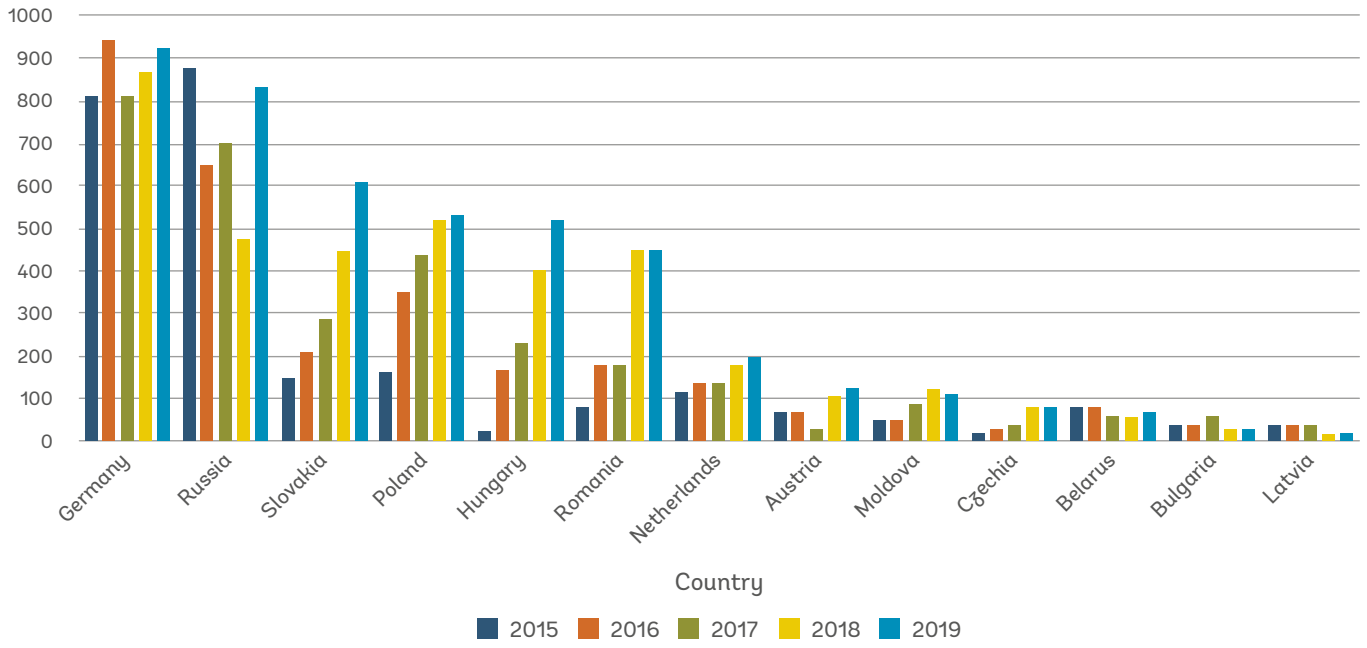
Ukraine's own international interconnectivity is quite robust, with 18 physical cross-border interconnections with, and multiple internet exchange points (IXPs) in, four diverse geographic locations. Ukraine has at least one interconnection with all seven countries it shares a border with, and with five of those countries, the interconnection is through two or more physically separate routes. **Table 5.1** depicts the number of international interconnections and major operators owning the cross-border routes, and **figure 5.4** presents a distribution of international bandwidth per cross-border connection.

TABLE 5.1. International Interconnections of Ukraine, 2020

Country	#connect.*	Locations	Operators**
Romania	3	Orlivka, Porubne (2)	Atrakom
Moldova	1	Udobne	Atrakom, RETN, Cogent
Hungary	3	Chop (3)	Atrakom, Eurotranstelecom, Datagroup, Ukrtelecom, RETN, Rascom, TurkTelecom
Slovakia	4	Palyad-Komarivtsi, Malyi Berezhnyi, Uzhgorod(2)	Atrakom, Eurotranstelecom, Datagroup, Ukrtelecom, Cogent, TurkTelecom, Hurricane Electric
Poland	5	Starovoytove, Shegyni (3), Belz	Atrakom, Eurotranstelecom, Datagroup, Ukrtelecom, UARNet, RETN, Rascom, TurkTelecom, GTS Central Europe, Hurricane Electric
Belarus	1	Skytok	Atrakom, Ukrtelecom, RETN
Russia	5	Goptovka (2), Graniv (3), Krasnodarskyi,*** Kerch***	Atrakom, Eurotranstelecom, Datagroup, Ukrtelecom, UARNet, RETN, Megafon, Rascom, TurkTelecom

Notes: *Number of connections means independent physical route crossing the border. **Operators means operator(s) owning the cross-border route. ***Currently inaccessible crossings. *Source:* Websites of operators.

FIGURE 5.4.
Internet Bandwidth across International Borders of Ukraine, Mbps.



Source: Telegeography GlobalComms, 2020.

Nationwide, Ukraine has four physical dark fiber backbones: Atracom LLC, Eurotranstelecom LLC, Naftogaz, and Ukrtelekom. Operators claim that there are surplus lines and digital infrastructure of the backbones that make international wholesale communication more resilient.[106] Nearly all of the largest Ukrainian operators, such as Datagroup, UARNet, Kyivstar, Ukrtelecom, Eurotranstelecom, Farlep-Invest, VF Ukraine, and Omega Telekom, are active in all market segments.

Networks peer by means of IXPs. Ukraine's biggest IXPs are located in the four major cities of Kyiv, Odesa, Donetsk, and Kharkiv and are connected with major international traffic exchange points, including DE-CIX in Germany, AMS-IX in the Netherlands, and others. Ukraine's largest IXPs include UA-IX (cumulative traffic of roughly 800 Gbps), GigaNET (1.83 Tbps), and DTEL-IX (peak traffic of over 1.90 Tbps).[107]

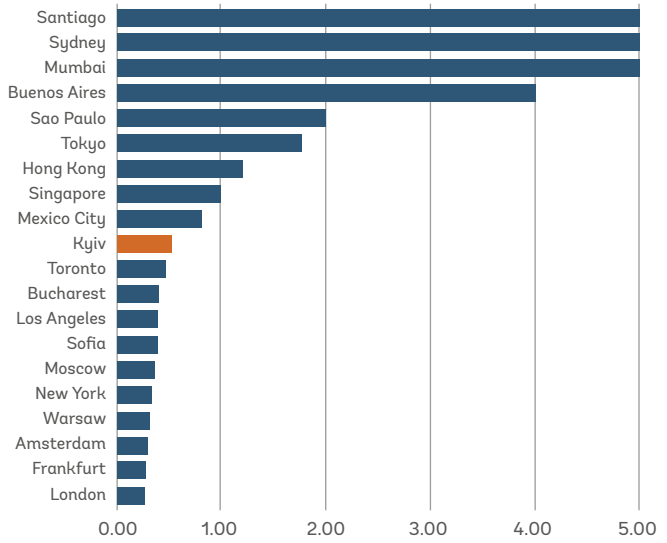
The total capacity of broadband traffic entering Ukraine is approximately 4.64 Tbps,[108] and the total bandwidth for international connectivity is roughly 4.5 Tbps.[109] **If Ukraine is to follow the EU Gigabit Society goals of providing each household with access to at least 100 Mbps, realistic assumptions suggest that the required peak total capacity should be almost two times the current level, or 7.1 Tbps.**[110] The eventual upgrade to high-quality 1 Gbps connectivity per household will require a total capacity of 181.64 Tbps (see **Annex 9**).

It should also be noted that in recent years, content providers have deployed their own international networks worldwide and have become the largest source of international bandwidth, accounting for 54 percent of international bandwidth usage in 2018. The growth in the amount of capacity they have deployed has significantly outstripped that of internet backbone operators. This trend should be taken into account, given the presence of Google network in Ukraine and the presence of Facebook, Microsoft, and Amazon in Central and Eastern Europe.[111] It is therefore important to take measures to attract these big players and to create a proper tax and regulatory climate for their operation. In addition, incentivizing them to **build data centers in Ukraine could lead to additional economic growth benefits in corresponding rural areas, new employment possibilities, and investments in renewable energy.**[112] This will enable new cloud-computing services for businesses and increase the outside-in demand for Ukrainian traffic.

Due to the high competition, the cost of international internet traffic with good "connectedness" is US$0.16–$1.3 per 1 Mbps,[113] which is among the lowest globally (see **figure 5.5**). Due to constantly decreasing prices, substantial growth—in monetary terms—of the external wholesale traffic market has not been observed over the past decade. Beyond falling prices, this could be also explained by the reduction in international traffic to Ukraine due to the measures taken by the leading social network providers (notably Facebook and Google)—that is, the installation of cache servers at Ukrainian IXPs.[114]

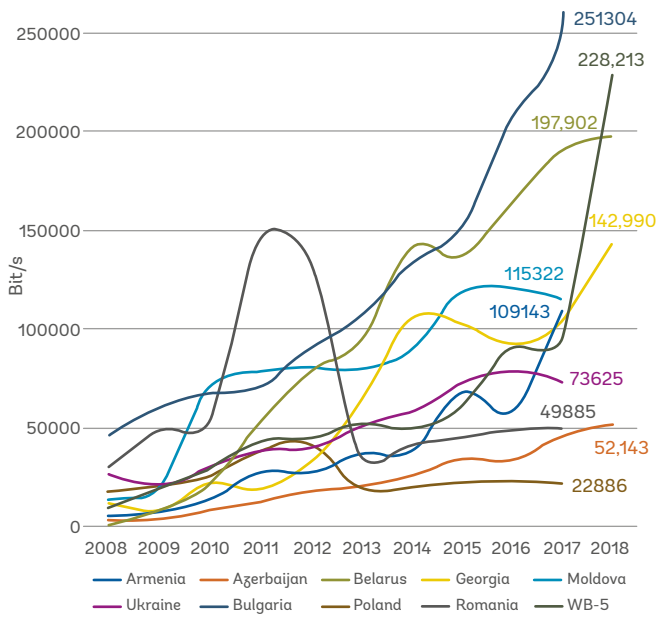
International internet bandwidth per internet user has been gradually growing in Ukraine since 2009 (**figure 5.6**). In 2017, it was 73 Kbps, which is in the middle of the benchmark set for this study, comprised of selected EU member states (Bulgaria, Poland, Romania), EaP countries, and the Western Balkans average. Historically, Ukraine has lagged far behind comparable transition economies on this indicator, and it will likely continue to do so, as EU member states are mobilizing EU structural funds for accelerated NGA development, and the WB6 are gaining access to Instrument for Pre-Accession Assistance (IPA), a funding mechanism of the EU.[115] Low international internet bandwidth is an important bottleneck for the development of the sector and should be addressed. **This requires increasing the number of connections in all directions and taking part in major traffic routes in the region.**

FIGURE 5.5.
Median Monthly International IP Transit Price for 10 Gigabit Ethernet (US$ per Mbps), Q2 2019



Source: TeleGeography GlobalComms data, 2020.

FIGURE 5.6.
International Bandwidth per Internet User in 2008–18



Source: ITU; data for 2018 are not available for all countries.

The current and anticipated increase in internet traffic demand between Eastern Europe, the South Caucasus, and the broader Europe and Central Asia region, and the overall need for greater regional network resilience, creates an opportunity for Ukraine to become a broadband connectivity bridge and regional connectivity node. Ukraine's IXP owners claim to be ready to increase the range of bandwidth options for international connectivity to the level required by the market at their own expense.[116]

There are several opportunities for Ukraine to strengthen and diversify its interconnectivity that may be further explored. For instance, a potential submarine cable connection with Bulgaria, Romania,[117] Turkey, and the South Caucasus could significantly improve Ukraine's international connectivity. In this way, its largest seaport Odesa (which already hosts an IXP cluster) could emerge as a new international point of digital traffic exchange. In addition, Ukraine could consider joining international digital connectivity initiatives, such as the Three Seas Digital Highway and the Balkans Digital Highway, to enable better and more secure data transfers from north to south and from the Balkans to the Baltics via trunk fiber-optic communication lines.

The international connectivity market in Ukraine is liberalized and appears to be functioning well, but there are several constraints to its growth unrelated to competition. The international market is not regulated by the NCCIR; during interviews conducted for this report, national operators did not express specific competition concerns in this market. However, market players name the following constraints related to growth: the volatility of the national currency;[118] the high level of cable cuts (including in major routes) due to the theft of copper, malicious intent, or accidents; the low cyber crisis management capacity at the national level;[119] and the failure to implement EU legal provisions related to cybersecurity and personal data protection (including the General Data Protection Regulation).[120] To address these concerns, Ukraine could cooperate with the EU on the development of cybersecurity guidelines for the EaP, in line with EU procedures, and then spearhead their implementation.

The major recommendations based on the analysis of the international connectivity submarket are formulated below.

Recommendation 1:

Consider diversifying sources of international connectivity by attracting Tier 1 and Tier 2 networks and by joining, initially as an observer, the Three Seas Digital Highway and the Balkans Digital Highway initiatives.[121]

Recommendation 2:

Take action to attract the GAFA tech giants and provide them with incentives to build data centers in Ukraine by creating a proper tax and regulatory climate for their operations.

Recommendation 3:

Strengthen national cybersecurity capacity by transposing and implementing the relevant EU aquis.

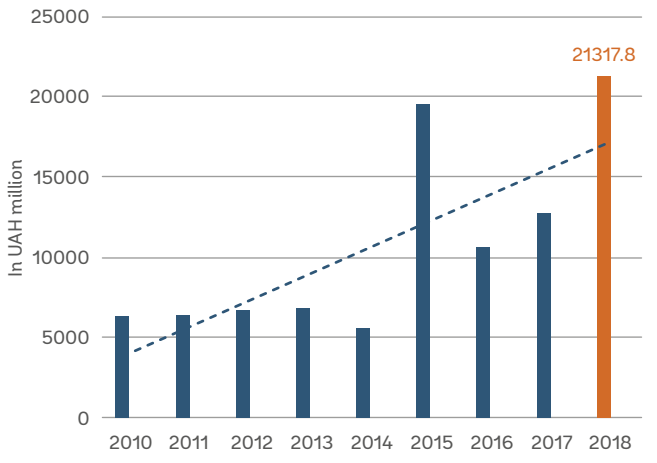
Recommendation 4:

Consider increasing the supply of submarine connectivity in the Black Sea to ensure resilient alternative connectivity between Ukraine and, for example, Bulgaria, Romania, and Turkey and with other EaP countries. This in itself will help develop Ukraine's largest seaport and IXP cluster host-city Odesa as a new international point of digital traffic exchange.

5.2 Domestic Wholesale Market

According to Ukrainian telecom operators, the volume of wholesale traffic in the country is growing rapidly. However, due to the low wholesale prices, the share of income from the service, compared to wireless communications or fixed internet provision, is not significant (12.5 percent).[122] Operators attribute the growth to the launch and development of mobile broadband in 3G and 4G networks in 2015–19. The domestic wholesale price in Ukraine is considered to be low, from roughly US$300 to $1,250 per 10 Gbps.[123] Consequently, in monetary terms, the wholesale service segment occupies UAH 8.260 million (approximately US$308 million),[124] which is lower than, for example, in neighboring Romania (at roughly US$315 million) and approximately 10 times smaller than that of the EU.[125] These aspects, as well as the low ARPU, disincentivize wholesale operators to engage in investment projects. Although the amount of investment tripled in 2018 compared to 2010, the overall investment trajectory in the sector has been uneven (note that **figure 5.7** below excludes data on investments in Crimea and the temporarily occupied territories of Donetsk and Luhansk Oblasts since 2014).

FIGURE 5.7.
Capital Investments in Telecommunications as a Type of Economic Activity in 2010–18



Source: Ukrstat, http://www.ukrstat.gov.ua/operativ/operativ2013/ibd/ibd_rik/ibd_u/ki_rik_u_e_beg.htm.

The growth in traffic, the development of national backbones, and the increasing number of wholesale operators in the market have led to an increased number of IXPs over the years. IXPs facilitate the local exchange of traffic among operators and free up the capacity of trunk communication lines for the transit of international traffic. At present, depending on the source, there are 14 such IXPs in seven cities. IXPs contribute to reductions in the domestic wholesale price.[126]

According to the NCCIR, in Ukraine there are 12 active licensed wholesale telecom operators[127] **that operate and maintain telecom network infrastructure.** Major national wholesale operators include: Atrakom, ADAMANT Ltd, PJSC "DATAGROUP," UARNet, Eurotranstelecom Ltd (ETT), PJSC "FARLEP-INVEST" (VEGA), Omega Telekom, Gigatrans LTD, PJSC "Ukrtelecom," Dataline LLC, and NetAssist LLC. Major wholesale services provided on the market are dark fiber leasing and capacity leasing. **Table 5.2** below depicts the distribution of the market share calculated based of the company's ownership of the dark fiber.

TABLE 5.2.
Dark Fiber Market Shares of Wholesale Operators

Operator	Length of dark fiber, km	Market share, perc.
Atrakom	24,000	18.3%
Datagroup*	20,000	15.2%
ETT	6,000	4.6%
Gigatrans	1,000	0.8%
NetAssist	300	0.2%
Omega Telekom	26,400	20.1%
Ukrtelecom**	42,764	32.5%
UARNet	1,000	0.8%
VEGA	10,000	7.6%

Source: Authors, based on company websites.[128]

In Ukraine, wholesale telecom operators name the bureaucracy of the construction process as the main impediment to infrastructure investments. Oftentimes, larger operators encounter long waiting times and an unresponsiveness bureaucracy from state agencies. According to the operators, it would therefore be helpful if a "silent-agreement" principle were in place: if an agency does not reply within a certain period of time as determined by law, by default the state does not object to the requested matter. While exact solution shall be well-though and discussed, addressing this issue is important as it will attract further infrastructure investments and make them more efficient. At the same time, smaller operators do not seem to experience the same problems (especially in connecting condominium owners associations), and indicate instead that infrastructure access has indeed been simplified since the adoption of Law #1834-VIII.[129]

A further expansion of the backbones would be still required to reach smaller cities and villages. This could be based on leasing the available fiber assets from state-owned enterprises (SoEs), given their considerable capacity and large footprint of fiber infrastructure, which would both speed up the process and make it more efficient.

SoEs possess around 10,000 kilometers of unutilized fiber assets, and some have international connections with peer SoEs in neighboring countries. As of February 2020, five SoEs were registered as wholesale operators on the telecom market. These include: JSC Ukrainian Railways (Ukrzaliznytsia), the Ukrainian Sea Ports Authority (USPA), the Ukrainian Sea Port "Yuzhnyi," National Nuclear Energy Generating Company "Energoatom," and the Factory named after V. Malyshev (a heavy equipment producer). Eight municipal enterprises from Dnipro, Enerhodar, Ivano-Frankivsk, Kherson, Lviv, Zaporizhzhia, and Vinnytsia are also registered as wholesale operators.[130]

The entrance to the wholesale market of non-telecom sector players with existing backbone and cross-border networks, in particular transport (especially railways) and power network infrastructure (such as electricity and pipelines), would be highly welcomed by operators and ISPs alike. This is particularly the case with regard to the commercialization of assets of Ukrenergo and Ukrtransgaz, two SoEs with wide networks and infrastructure under protection (see **box 5** for a brief overview of the fiber-optic assets of key SoEs). These assets, once commercialized, will create an additional business line for SoEs, thus generating a higher return on assets. Typically, the commercialization of dark fiber does not require any new investment. That said, a shortage of dark fiber in some directions in the SoE networks should be rectified through company-specific investment for equipment modernization/upgrade (to dense wavelength division multiplexing [DWDM] technology) that would take into account the potential market demand of telecom operators. The mapping of existing SoE optical groundwire (OPGW) assets is also required to understand which segments are in greater demand by the telecom sector.

In case it is not feasible for SoEs to install fiber optics during the construction or reconstruction of infrastructure objects in the near future, operators would greatly benefit even from installation of cable ducts. This could be leased to telecom companies with the possibility of installing their own fiber later on, and could serve as a more affordable alternative than the installation of the actual optical fiber.[131]

In the same vein, **information sharing by SoEs with the central government authorities (the MDT, NCCIR) on the state of their fiber-optic infrastructure should be streamlined.** Such requests for information should be exchanged on a routine basis to inform the decision making of ICT policy makers.

BOX 5
Spare Fiber-Optic Assets in Ukraine's Largest State-Owned Enterprises with Cross-Border Connections

Ukrenergo (Transmission System Operator)

Ukrenergo, Ukraine's transmission system operator (TSO), has in recent years been actively developing fiber-optic communication lines along the trunk and interstate overhead high-voltage power transmission lines as part of its ambitious program to integrate Ukraine's power system with the European Network of Transmission System Operators for Electricity (ENTSO-E) of the EU. The technology used by Ukrenergo is synchronous digital hierarchy (SDH), which is obsolete and has low bandwidth. The modernization of telecom equipment toward dense wavelength division multiplexing (DWDM) is being planned throughout the existing fiber-optic network, which will significantly increase bandwidth and enable capacity sharing, including with neighboring states' TSOs. According to the company's 2020 investment plan, the construction of fiber-optic lines and installation of OPGW equipment on the level of substations is being planned in the southern and eastern parts of the company's network in 2020–23, with specific segments planned for completion by end-2020 (e.g., the Kremenchuk-Zmiivka segment).[132] By 2028, the company plans to build 10,000 km of fiber-optic communications lines.[133]

Ukrzaliznytsia

The length of the fiber-optic communication lines of the Ukrainian railway operator Ukrzaliznytsia is about 8,100 km, of which 2,500 belong to Ukrzaliznytsia (24 fibers) and 5,600 are leased from third-party telecom wholesale operators, primarily Eurotranstelecom. As of February 2020, the enterprise was registered as a wholesale provider on the telecom market of Ukraine, although for effective commercialization of its assets it would need to upgrade certain segments of its communication lines from SDH to DWDM technology.

Ukrgaztekhzviazok

The branch of Ukrtransgaz—Ukrgaztekhzviazok (also referred to as Ukrgaztekhsvyaz)—now provides telecom services and radio and radio-relay communication to the gas transmission subsidiaries of Ukrtransgaz (international gas pipelines). This includes the provision of all types of communications, except for mobile, to the subsidiaries and enterprises of Naftogaz of Ukraine; implementation of centralized provision of IT services to the company; and maintenance of the complex automated control system based on SAP software. At present, Ukrgaztekhsviazok is actively building its own fiber-optic communication network along international gas pipelines (all cross-border gateways of gas pipelines of Ukrtransgaz rely on copper cable lines). In the long run, the length of its OPGW network will reach roughly 5,000 km, on a combination of SDH and DWDM equipment.

Ukrtransnafta

The existing fiber-optic communication lines of Ukrtransnafta have a total length of 4,000 km (mostly 24-fiber cables). Its network was built with the use of now obsolete plesiochronous digital hierarchy (PDH) and SDH technologies. The fiber-optic lines will be reconstructed using DWDM technology, and part of the funding has already been allocated for this goal. Given the wide range of additional services the company provides, including telephony (wireline) services, it would be a logical addition to its portfolio to launch a fiber-sharing activity.[134]

Source: Authors, based on company websites and interviews.

Although the commercialization of such alternative sources of digital infrastructure will inject additional capacity and competition into the market, the networks will still not cover all population centers across Ukraine. Remote and mountainous regions with low population densities may remain unconnected because of the limited economic viability of investment in the necessary infrastructure. Such access gaps[135] require public sector subsidies and financing assistance to be filled, for example, by state aid programs.

The major recommendations based on the analysis of the national wholesale connectivity submarket are formulated below.

Recommendation 1:

Commercialize the spare fiber-optic assets of Ukraine's SoEs in transport and energy as a short-term objective (Ukrenergo, Ukrtransgaz, Ukrzaliznytsia). Over the medium term, work with other SoEs, private and public electricity distribution companies, and municipal water and sewage providers on the same objective.

Recommendation 2:

Use the fiber-optic infrastructure of SoEs to boost the capacity of the networks servicing the GoU to organize communications during crisis events.

Recommendation 3:

Reach a principal agreement with the GoU and with donors that every new linear infrastructure upgrade or construction project should take into account internal SoE telecom capacity needs, as well as those of the telecom sector. No new pipeline or road segment should be built without laying fiber-optic cable, and/or cable ducts planned for the future, alongside it.

Recommendation 4:

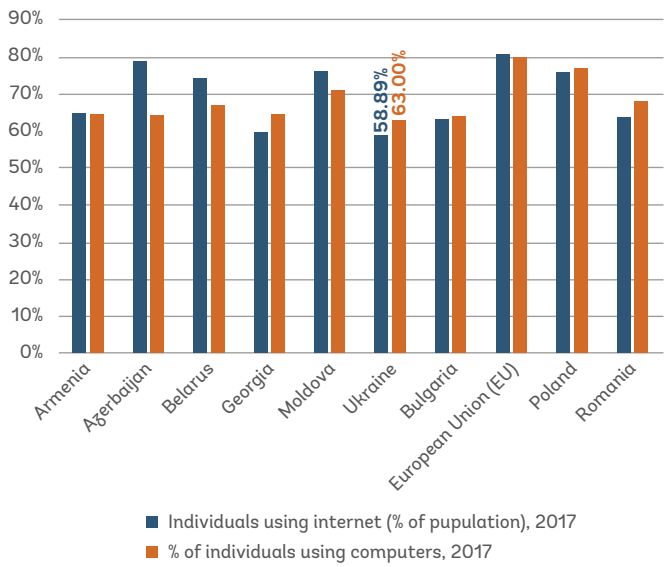
Consider increasing the supply of submarine connectivity in the Black Sea to ensure resilient alternative connectivity between Ukraine and, for example, Bulgaria, Romania, and Turkey and with other EaP countries. This in itself will help develop Ukraine's largest seaport and IXP cluster host-city Odesa as a new international point of digital traffic exchange.

5.3 Demand Side

Unlike some other countries in the benchmark, consumers in Ukraine typically use both fixed and mobile broadband. The share of individuals using internet as such was 63 percent in 2018, which is lower than in the EU (84 percent) but higher than the average for countries in a similar GDP bracket of lower-middle-income countries (35 percent).[136]

The level of internet usage strongly correlates with computer ownership. Per ITU data from 2017, the share of individuals who use computers is roughly 63 percent of the population, lower than anywhere else in the benchmark countries (see **figure 5.8**). This data align with the results of the statistical survey of Ukrainian households, according to which the share of personal computers owned by households increased only slightly from 25 percent in 2010 to 37 percent in 2018. The growth has been much higher for notebooks, however, from 6 to 35 percent in the same reference years.[137] Per 2019 data from UkrStat, rural households are much less likely to own a computer (which is associated with poverty) than urban households: almost 20 percent of rural households, compared to 7.3 percent of urban ones, lack access to a PC.[138]

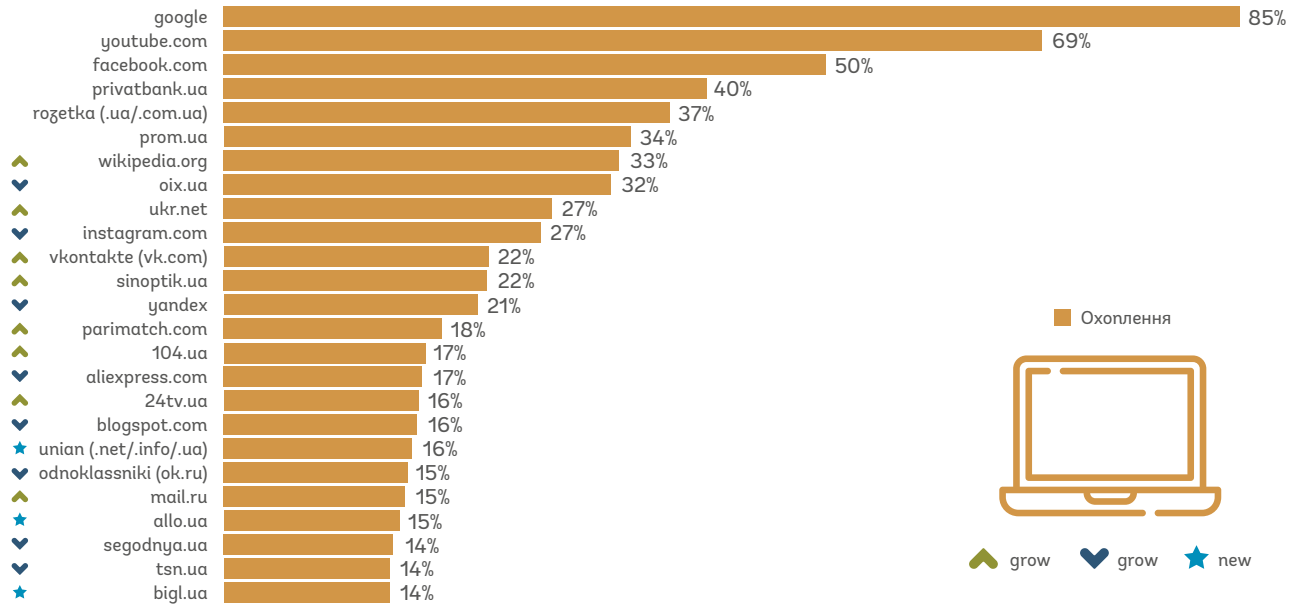
FIGURE 5.8.
Computer Ownership, Ukraine vs. Benchmark Countries



Source: World Bank and ITU.

According to research conducted for the UIA, the share of regular internet use in villages is much lower than in cities, which is due to the lack of access to commercial broadband (or its price) and insufficient digital skills. Figure 5.9 shows the 25 most visited internet sites/domains in December 2019, according to their coverage of Ukrainian internet users.[139]

FIGURE 5.9.
Top 25 Domains in Ukraine, December 2019

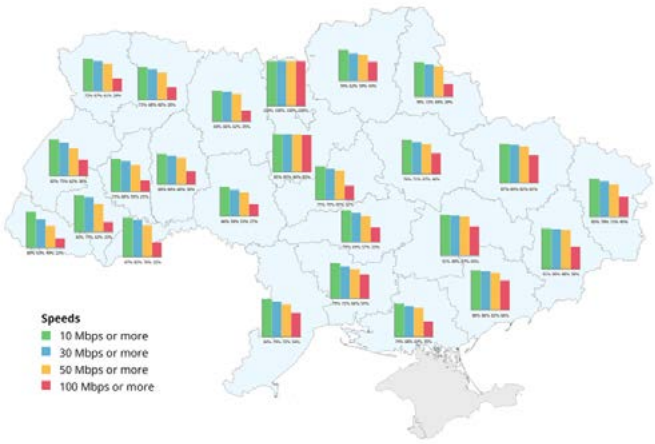


Source: Factum Group for UIA.

As can be deduced from this research, Ukrainians mainly use the internet to search for textual and visual information, send and receive e-mails, visit social networks and wiki sites, and utilize mobile banking and e-commerce. Interestingly, the fourth domain is that of a state-owned Privatbank, which has top-shelf mobile banking applications that allow users to not only wire funds to individuals and businesses, but also pay for utilities, communication bills, and more. Another observation is that government websites with the GOV.UA domain or other digital services in the fields of e-education, smart cities, e-democracy, and so forth are not on the list of top 25 sites.

On the level of primary and secondary educational institutions, only a few schools are connected to broadband access with optimal speeds of 100 Mbps and with the possibility of upgrading to 1 Gbps. As can be seen from **figure 5.10**, based on information collected in fall 2019 through an MoU with Chinese company Huawei, only schools in the capital Kyiv have universal future-proof connectivity. Similarly, schools in Kyiv Oblast and in eastern oblasts have better connectivity compared to the rest of the country (over 50 percent of all subscriptions are 100 Mbps+). Schools in the western and central parts of the country have the worst connectivity. For instance, the share of 100 Mbps+ school connections in Western Ukraine ranges from 22 percent in Zakarpatska and Ivano-Frankivska Oblasts to 36 percent in Lvivska Oblast. In Central Ukraine, the share of such connections ranges from 27 percent (Vinnytska Oblast) to 46 percent (Poltavska). At the same time, it should be noted that over half of Ukraine's schools have subscriptions of at least 50 Mbps, with the exception of Zakarpatska Oblast (49 percent). The range of such subscriptions, again, varies per region in line with 100 Mbps+ dynamics, with the higher subscription rate found in the country's east (over 72 percent +) and Kyiv Olbast (84 percent). **The low level of school digital connectivity does not allow for the effective implementation of key initiatives of the MES, such as access to/adoption of YouTube MON Ukraine online classes during the COVID-19 pandemic, e-books for secondary education, the electronic scientific-informational system URIS, or the scaling up of a national educational e-platform.[140] Similarly, the current state of affairs will not help achieve the decentralization goals of the primary and secondary education sector (currently, 46 percent of hub schools and their branches fall under the managerial mandate of ATCs).[141]**

FIGURE 5.10.
Connectivity in Primary and Secondary Schools, first quarter of 2020



Source: World Bank analysis based on data from the MDT.

Tertiary education institutions seem to be, for the most part, connected to high-speed broadband internet, bolstered by a functioning 230-kilometer Ukrainian Research and Academic Network (URAN) integrating over 80 research and educational institutions in 15 cities and operating an 80-kilometer international fiber-optic communications line from Lviv to the Ukraine-Poland state border (see figure 5.11). URAN was built in 1997, thanks to infrastructure grants from NATO and a state order of the MES that established the six biggest universities as an association.[142] URAN is non-profit public organization with several offshoot limited liability companies.[143] A member of the pan-European network GÉANT, URAN was quick to deploy its simple, easy-to-use functionality web conferencing tool eduMEET during the COVID-19 pandemic for its member institutions.[144]

All vocational educational institutions are connected to the internet. Fifty-six percent of professional (to include professional-technical) education institutions are connected to broadband (wired and wireless), including 24 percent in rural areas.[145] As for future-proof connectivity, it is known that 40 universities, 100 institutes and colleges, and the Academy of Sciences are connected to fiber connectivity through the state enterprise, "Ukrainian Academic and Research Network" (UARnet), a spinoff of the National Academy of Sciences. UARnet also has a direct 10 Gbps channel to the Polish NREN PIONER.[146]

It is evident that without high-speed broadband connectivity, Ukraine cannot effectively implement the Roadmap for Ukraine's integration into the European Research Area (ERA-UA),[147] take part in the projects financed under the EC's Horizon 2020, in which Ukraine is an associate member,[148] or leverage other initiatives to the full extent (such as the regional project EaPConnect[149]).

FIGURE 5.11.
Topology of URAN's Network

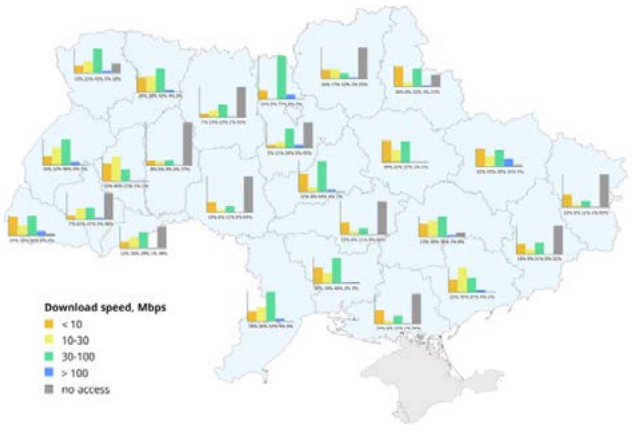
Source: URAN, http://uran.ua/~eng/net-ukraine.htm.

Health care institutions are less connected than schools, although health sector legislation mandates that all hospitals, clinics, and other health care facilities maintain electronic health records and exchange medical and financial information electronically.[150] High-speed broadband internet is also indispensible to telemedicine, which has become more important than ever with the spread of COVID-19, as well as to Ukraine's participation in a regional platform on e-Health under the "Harmonization of Digital Markets" (HDM) EC project. It is equally important to the achievement of the country's decentralization goals in health care.[151]

According to the self-reporting of primary and secondary health care system providers in December 2019–February 2020, only a few primary health care institutions have decent connectivity of 100 Mbps+ (see **figure 5.12**). Many institutions report that they have no digital connectivity at all. Out of a sample of responders, 77 percent of primary health care institutions in, for example, Khmelnytska Oblast report not having internet access. The situation is somewhat better for the secondary health care system,

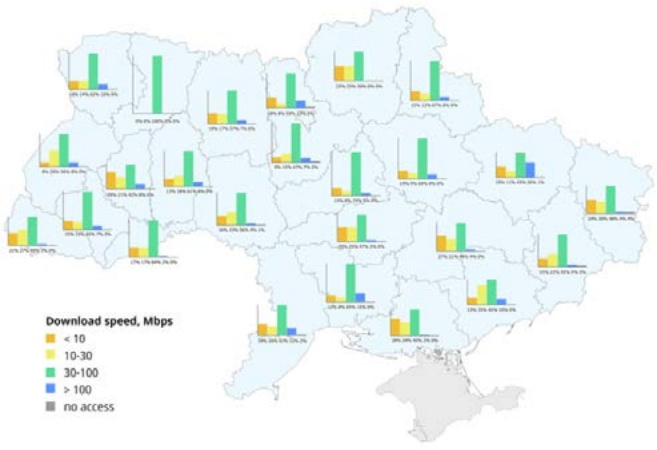
although the sample of respondents is not representative enough to draw definitive conclusions (see figure 5.13). The Ministry of Health is aware of the situation, which has been caused by a lack of financing, and is particularly concerned about the low level of internet connectivity in medical and obstetrical centers in rural areas,[152] of which over 45 percent report a lack of any internet access.[153]

FIGURE 5.12.
Access to the Internet among Primary Health Care Providers, February 2020



Source: MDT.

FIGURE 5.13.
Access to the Internet among Secondary Health Care Providers, February 2020



Source: MDT.

Central executive bodies, other state bodies, state enterprises, and other organizations that receive, process, disseminate, and store information are subject to state ownership and are protected by law.[154] **They are connected to broadband internet through UARnet,** an operator with its own fiber backbone (of 1,000 kilometers), as well as its own external channels of access to global information networks. It has full technical facilities (nodes) in all oblast centers of Ukraine, as well as in Frankfurt (Germany) and Warsaw (Poland).[155]

No major demand-side programs oriented to the population at large seem to have been implemented in Ukraine to date, although several first initiatives are appearing with the launch of the specialized educational digital skills portal "Diia." This platform is aimed at building a range of digital awareness and skills regarding online job searching; cyber safety for children; the use of computers, smartphones, and tablets; payments of utilities online; and so on. "Diia" had over 277,000 registered users as of end-July 2020.[156]

From the standpoint of digital skills development, significant potential may be found in Ukraine's roughly 166 youth centers and the MDT's network of educational hubs.[157] **Of these, the majority are connected to the internet, though less than 1 percent reported connections of over 100 Mbps as of end-April 2020.** As these youth centers are oftentimes located within libraries or other communal properties (e.g., the Soviet era "houses of culture"), their high-speed broadband connectivity will automatically benefit the larger communal building in which they located. Furthermore, their connection to future-proof connectivity will enable the implementation of the State Target Social Program "Youth for Ukraine" for 2016–2020,[158] according to which youth centers should provide access to employment and training programs, among many other activities. Importantly, one of the criterion by which youth centers are to be evaluated is access to an internet, mobile, or fixed phone.[159] On August 5, 2020, the GoU approved the State Strategy for Regional Development for 2021–2027[160] with the goal of providing all social infrastructure, such as libraries and health, sports, and cultural institutions, with broadband internet connectivity of 100 Mbps and with open Wi-Fi zones for visitors and staff by December 2023.

Under the same plan, 11,579 post offices of the state-owned UkrPoshta under the Ministry of Infrastructure will provide a digital platform to the residents of remote areas and promote the development of e-commerce.[161] There is particular potential here to help the 37 percent of the population without bank accounts to receive financial services, especially in rural areas.[162] However, these plans would be difficult to realize without future-proof broadband connectivity. Currently, only 36 percent of post offices report having connectivity to the internet. Of these, the connections are mostly through xDSL or 3G, which provide very low speeds of 2–10 Mbps (this was the case for 92 percent of the post offices that reported having a connection). **Only 2 percent of the connected post offices have at least 100 Mbps.[163]** Evidently, calls for the introduction of e-commerce or e-banking require that at least a sample of post offices be connected to high-speed connectivity or undergo a telecom upgrade.

In 2018, the Ministry of Infrastructure and MEDT were tasked with submiting proposals on the use of post office infrastructure as a digital platform for service provision, social infrastructure, and e-commerce for residents of rural and remote areas. A working group consisting of the MEDT, the NCCIR, Kyivstar, and Intertelekom has subsequently defined as a priority for this enterprise the creation of e-catalogues through which the population could order products and have them shipped to post offices.[164] It is recommended that this working group revive its activities with the leadership of the MDT.

With regard to businesses, it seems that the vast majority[165] have computers and access to the internet.[166] A proxy for the level of internet access could be tax reporting, which is mandatorily done online for all medium and large enterprises.[167]

Given the information outlined above, Ukraine needs to create a national digital skills strategy, in cooperation with the private telecom and IT sector and other stakeholders and in line with similar EU strategies. The MDT has already implemented a first step in this direction through its preparation of a methodology, in line with that used by the EC and based on the Digital Economy and Society Index (DESI), for measuring and forecasting national digital skills gaps.[168] From this study it was learned that 53 percent of the population of Ukraine have a below-average skills level and 15.1 percent do not have any digital skills at all. From this study it was learned that 53 percent of the population of Ukraine have a below-average skills level and 15.1 percent do not have any digital skills at all. Next, the GoU based on the measurements and forecasts, should be able to define a common competence framework for SMEs and microbusinesses, create a national coalition for skills and jobs, and launch new programs and initiatives. The experience of the EU in which companies, social partners, nonprofits, and education providers work jointly on the digital skills problem is highly relevant.

However, it should be noted that as access, adoption, and usage of the internet increase, so does the possibility of negative externalities that arise from it. For example, vulnerable populations, such as young children and senior citizens, may fall prey to exploitative individuals who target these groups. In addition to raising awareness among users about internet and online services, steps should be taken to protect vulnerable groups from being exploited online. Similarly, citizens and ISPs should be educated about their respective responsibilities, duties, and rights as providers and users of services. Publishing clear and transparent details and providing service and product comparison tools are simple steps that can help acquaint new users with the technology and build trust in the online ecosystem.

Special attention will also be needed to ensure that the internet is inclusive for people with disabilities (PwD). As of 2017, there were over 2.6 million people in Ukraine with a disability,[169] and the recent hostilities in the country's east have led to a steady increase in this number since 2014. The internet offers an opportunity to overcome some of the challenges in terms of access to education, services, and markets (including for employment) for PwD. Yet, there is a risk of exclusion, for instance, for people who have a visual disability. Moreover, barriers facing PwD in gaining access to education will constrain their ability to acquire digital skills, and limited employment opportunities means that many PwD may face even larger barriers to affording access to broadband. In this context, it will be critical to ensure that PwD are not left behind in, and because of, the digital revolution.[170]

A list of geo-mapped objects of social infrastructure facilities discussed in this section is provided in **Annex 10.**

The major recommendations based on the analysis of the demand side are formulated below.

Recommendation 1:

Finalize the upgrade of the telecom infrastructure supporting the education and health care sectors, including by connecting the currently unconnected facilities.

Recommendation 2:

Create a national digital skills strategy and, throughout its implementation, introduce digital awareness (including on cybersecurity) and digital skills programs to specific population groups to increase the productive usage of broadband. Leverage educational institutions, libraries, post offices, and youth clubs for this purpose.

Recommendation 3:

Encourage the GoU to facilitate the participation of URAN and possibly UARnet in the EaPConnect Project, with Ukrainian NREN's integration into the European data network GÉANT.

5.4 Summary of the Obstacles to Market Development

The need to **sustain efficient competition, attract investment,** and **build digital skills and demand** are consistent themes across market segments. Additionally, as the next phase of broadband development demands a strong focus on expansion into rural areas, the demand side of the broadband ecosystem also requires stimulation. Below are the key bottlenecks under each of the above-mentioned themes:

- **Efficient competition** in all segments of the value chain:
  - Limited mandate of the national sector regulator may lead to a lack of regulatory interventions when required to create a level playing field
  - Unreliable and incomplete statistical information
  - Informality in the market
  - High risk of inconsistency in the dispute-resolution process and a lack of a settlement body in case of inter-sectoral disputes

- **Decrease in investments** to expand network coverage and introduce new technologies:
  - Limited network expansion in rural and remote areas owing to lower economic viability; some key objects of social infrastructure remain unconnected or underserved
  - Gaps in the legal framework and transparency tools to boost investment through information and transparency measures (for example, broadband mapping)
  - Unleveraged opportunities to improve broadband infrastructure rollout through infrastructure sharing
  - Unexplored opportunities to increase international interconnectivity through utility networks and submarine network development
  - Lack of state aid to support broadband infrastructure deployment
  - Unavailability of spectrum resources to support the further expansion of 4G coverage and the deployment of 5G

- **Limited digital skills and demand** among users to improve the business case for investors and increase the productive uses of broadband to maximize the economic impact:
  - Limited connectivity of socioeconomic objects, especially outside urban areas, including schools and health institutions
  - Lower demand for broadband internet among individuals and households in rural areas
  - Lack of use and integration of digital services by objects of social infrastructure (which also connects to the access issue)

6 LOGIC BEHIND THE STRATEGY AND INTERVENTIONS

A broadband strategy for Ukraine should frame and organize the measures that will accelerate market development from its status quo in 2019–20 to the targets set for 2025.

With several million households to be connected to high-speed broadband, and with more advanced mobile technologies to be introduced, it is likely that the total investment needed to reach the recommended targets outlined above could be as high as US$2 billion or more. In line with historical and current trends, most of this investment should come from the private sector.

However, markets alone will not deliver on the strategy's targets. There will be locations and populations that may not be commercially viable enough—in any reasonable time frame—to justify private investment. It is also important that there be continued investment in technology upgrading in areas already covered, as well as investment in advanced technologies in areas only newly supplied, to avoid the emergence of digital divides due to significant differences in the quality of networks or services, for example, between urban and rural areas.

This strategy should therefore define measures that enable private investment, while expanding the market to reach the defined targets. These should be measures that:

1. Create incentives to mobilize private investment by promoting competitive markets, sharing or reducing risks in investments, encouraging demand-side interventions, or improving the business case for investors

2. Reduce the costs of network deployment to expand markets by increasing the sharing of infrastructure, simplifying rules around rights-of-way and network construction, and making radio spectrum available

These measures will create an enabling environment that will maximize the efficiency and impact of private investment. For those populations that are likely to remain underserved or unserved despite the implementation of these actions, a strategic approach will help to identify the potential or remaining gaps and define the state aid programs needed to close them.

In the specific context of Ukraine, an NBDS would frame and operationalize these measures toward providing universal, robust, and affordable broadband connectivity across the country and facilitating the development of the sector through two specific mechanisms. First, the NBDS can help strengthen the enabling environment by addressing the main bottlenecks identified and signaling the public sector's priorities for the market through **policy and regulatory measures.** Second, it can provide the public sector with a framework for **identifying and addressing the financing gaps** in the market.

7 RECOMMENDED TARGETS AND DIRECTIONS

The NBDS should highlight the priority of broadband infrastructure development for Ukraine's digital economy and define and implement an action plan to 2025.

The recommended targets for the NBDS could build on the momentum gained in the development of the broadband market and operationalize the twin policy objectives of **increasing the availability of, and promoting advanced technologies for, broadband services for all.** Given the already quite advanced market development status quo, it would be reasonable to align the NBDS with the EU's Gigabit Society objectives for 2025.[171] Given the high affordability of broadband services in Ukraine, the NBDS does not need to contain specific actions related to reasonable pricing, but it should recognize the importance of maintaining the affordability standards referred to in the UN Broadband Commission for Sustainable Development's affordability benchmark.[172]

Within this context, the recommended NBDS targets for 2025 are:

- 4G covers 95 percent of the population
- Pilots for 5G services in major urban settlements in four oblasts
- Uninterrupted wireless broadband (5G) coverage along major roads and railways
- 1 Gbps connectivity available to all objects of social infrastructure involved in service provision[173] in cities and ATCs
- High-speed (100 Mbps+) broadband network access for all households

The recommended targets are ambitious yet realizable if the accompanying set of reforms and investments is implemented. The targets need to be ambitious to reflect Ukraine's euro-integration aspiration and its will to compete in the global digital economy. Moreover, they build on existing market dynamics and focus on access—emphasizing availability and affordability—and not subscription, which remains a consumer's choice. Moreover, they factor in the technological progress that will unfold in the coming years, such as the introduction of 5G broadband networks and the declining costs of network deployment due to efficient infrastructure buildout.

Monitoring and evaluating progress toward these targets is essential, and recommendations on the output indicators and monitoring mechanism are outlined below (see **section 8**).

The MDT and NCCIR have recently taken significant steps toward the development of a positive enabling environment for the sector and the harmonization of sector policies with the EU. In recent years, the NCCIR has conducted market analyses of three domestic wholesale markets, based on which the fixed telephony and mobile markets are regulated, and six relevant retail market analyses are forthcoming in 2020.[174]

The bottlenecks highlighted can be addressed through remedies focused on the categories identified. Hence, the GoU may choose to design the NBDS to address the bottlenecks by:

- **Sustaining competitive pressure**
- **Attracting investment**
- **Building digital skills and demand**

Policy and regulatory measures to achieve these objectives can help create the necessary enabling environment to further develop the sector, laying the foundation for future investment and growth. As described earlier in the document, the next phase of broadband development involves extending services outside economically profitable urban centers to rural and remote areas. Ensuring that the urban-rural divide does not increase in the digital realm means that companies will need to invest to expand their networks, even as they face the possibility of low ARPU in those areas. An NBDS can help the public sector to identify and close such access and economic viability gaps in the market through essential actions and to address investment needs in critical infrastructure.

The NBDS is also a focused strategy, with a major push on the supply side of the broadband ecosystem, centering on access even as it recognizes the importance of demand-side development. This focus helps to ensure a manageable scope of work, with the measures identified below aiming to reduce the costs of network deployment while increasing competitive pressure in the market to deliver the widespread availability of broadband at affordable prices. Noting the importance of a holistic approach, the measures below make specific reference to the demand side also, as the adoption of broadband will help reduce costs and create incentives for universal access and even greater adoption of broadband services across Ukraine.

A list of all the recommendations provided in this document and its annexes can be found in **Annex 1.**

8 OUTPUT INDICATORS MONITORING AND EVALUATION

An NBDS for Ukraine should include a set of indicators, each mapped to one of the targets identified above, and a mechanism to track the progress toward reaching the targets. **Table 8.1** provides some suggested indicators, along with their initial estimated baseline—based on existing data sources—and possible progress toward the targets by 2025, with a midterm indicator in 2023.

TABLE 8.1
Targets and Suggested Indicators for Ukraine's NBDS

#	Target and Indicator	Baseline (2019–2020 Estimate)	2023	2025 Target	Baseline Estimate Source
1.	**4G covers 99% of Ukraine; pilots for 5G services in major urban centers of at least four oblasts**				
1a	4G coverage (% of territory)[175]	79	90	99	NCCIR, MDT
1b	Number of 5G services tested and piloted in four oblasts[176]	0	2	4	MDT
1c	Uninterrupted 5G wireless broadband coverage along major roads and railways (%)	0	50	90	NCCIR
2.	**All households have access to networks for high-speed (100 Mbps+) broadband**				
2a	Households with access to 100 Mbps+ broadband (% of total)	>60	80	100	MDT
3.	**All objects of social infrastructure involved in service provision (institutions) located in cities and ATCs have access to 1 Gbps connectivity**				
3a	Institutions with access to 1 Gbps+ broadband (% of all such institutions in cities)	>5	85	100	Ministry of Communities and Territories Development, MDT
3b	Institutions with access to 1 Gbps+ broadband (% of all such institutions in ATCs)	>1	66	100	Ministry of Communities and Territories Development, MDT

Notes: 1c: Estimate based on expert views. The main roads are listed here: https://www.kmu.gov.ua/npas/40436397 and the main railways here: https://www.swrailway.gov.ua/timetable/routes/. 2a: Estimate based on percentage of households with OFC subscriptions as of May 2020; the total number of households per current UkrStat estimates. 3a: Estimate based on a data review of the fixed broadband connections of the education and health care sectors (MDT data, 2020). 3b: Estimate based on a data review of the fixed broadband connections of the education and health care sectors in rural areas; the number of ATCs is changing, hence every year should take into account the latest data (MDT data, 2020).

Unit Responsible for Coordination and Monitoring and Evaluation (M&E): Department of Digital Infrastructure Development, the MDT, with inputs from the NCCIR, Ministry of Community and Territory Development, and electronic communications operators.

Period of Monitoring: 2020–25

Monitoring Mechanism: The unit responsible should utilize existing data collection and analytics mechanisms to gather data for performance M&E. These sources include UkrStat (relevant surveys), the NCCIR (sector reporting data), and other commissioned or high-quality surveys, as needed. M&E data will be collected, analyzed, and reported annually (as is the existing minimum data collection frequency for required data).

The NBDS implementation plan includes an annual consultation with private sector stakeholders by the MDT and NCCIR to receive feedback on actions and existing bottlenecks and monitor progress. These consultations will also serve as qualitative M&E information for performance evaluation and will inform the midterm review of the strategy and its action plan.

Midterm Review: It is recommended that a midterm review be conducted in 2023, three years after the onset of strategy implementation. The review should track performance according to the above indicators against the planned targets. In addition, as part of the NBDS implementation plan, the MDT and the sector regulator should conduct annual private sector consultations to receive feedback and plan investment. The results of the midterm M&E and private sector consultations should be discussed with the NBDS working group and other stakeholders as the responsible unit deems fit. Based on performance against targets, as well as projected growth trajectories, the NBDS action plan should be reviewed and revised accordingly. If needed, additional M&E indicators should be included following the midterm review.

9 BUILDING INSTITUTIONAL CAPACITY

Even as the GoU considers these recommendations and how to invest its resources—legal and financial—in the design and implementation of an NBDS, it is critical that an investment be made in administrative capacity and expertise to draft and implement the strategy.

From this perspective, the GoU may seek support from its development partners and the private sector—through transparent consultative processes—to build the appropriate administrative capacity in the relevant national agencies to perform important tasks, such as the adequate mapping of infrastructure, coverage, service, and future investments, or to gain the expertise needed to provide the regulatory, technical, or financial guidance to policy makers and project promoters.

This capacity development is critical, given the constant evolution of technology and hence public policy in the digital economy, and also given the wide range of agencies, organizations, and entities that should work together to make any such strategy a success. Building the institutional capacity for collaboration and implementation will help Ukraine to attain these targets, to position itself to pursue new opportunities, and to encourage all its citizens and businesses to login to the future.

NOTES

[1] Throughout this document, the targets exclude the occupied and annexed territories.

[2] This document defines broadband as a high-speed telecommunications system, capable of simultaneously supporting voice, data services, and video services on demand. Given that most technologies supporting broadband can be upgraded, and that the focus of efforts is on delivering specific connectivity speeds to customers, this document refers to fixed broadband (xDSL, cable, Wi-Fi, and fiber internet) and mobile broadband (3G, 4G, and 5G) technologies, which have been used since 2018 to deliver such services at speeds of 2 Mbps and higher (the presently accepted definition in Ukraine), with *entry-level broadband* being defined here at 30 Mbps and *high-speed broadband* at 100 Mbps or higher, all for download. This is in line with the European Commission's definitions. See: EC, "Broadband Glossary," https://ec.europa.eu/digital-single-market/en/broadband-glossary.

[3] The term general purpose technology, or GPT, is used to describe technologies with a wide range of potential applications in households and businesses. For example, the steam engine and electricity are classic examples of GPTs. See B. Jovanic and L. Rosseau, "General Purpose Technologies," NBER Working Paper 11093 (Cambridge, MA: National Bureau of Economic Research, 2005).

[4] W. Briglauer and others, "Does State Aid for Broadband Deployment in Rural Areas Close the Digital and Economic Divide?" *Information Economics and Policy* 46 (2019): 68–85.

[5] "Europe region countries overall would enjoy an increase of 2.1 per cent. When low-income Europe region countries were included, the increase would be 2.0 – most regional economic impact is concentrated in countries with GDP per capita lower than USD 20 000", ITU, "How broadband, digitization and ICT regulation impact the global economy Global econometric modelling" (Geneva, International Telecommunications Union, 2020) https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.BDR-2020-PDF-E.pdf

[6] Government of the United Kingdom, "Government Digital Strategy: December 2013," https://www.gov.uk/government/publications/government-digital-strategy/government-digital-strategy.

[7] For instance, it was recently estimated that managing 1 million transactions online that are currently carried out in person in Colombia would allow the country to avoid 816 tons of CO_2 emissions per year.

[8] By the length of the transport corridors, Ukraine is the largest European country with substantial transit potential.

[9] J. Woetzel and others, "Smart Cities: Digital Solutions for a More Livable Future" (New York: McKinsey Global Institute, 2018), https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/smart-cities-digital-solutions-for-a-more-livable-future.

[10] S. Muzira and T. Peralta-Quiros, "The Future of Transport is Here. Are You Ready?" *Transport for Development* (blog), June 24, 2018, http://blogs.worldbank.org/transport/future-transport-here-are-you-ready.

[11] Ibid.

[12] Ibid 8.

[13] For an expanded view of the opportunities and risks of the digital economy, see World Bank, *World Development Report* 2016: Digital Dividends (Washington, DC: World Bank, 2016).

[14] E. Brynjolfsson and L. Hitt, "Beyond Computation: Information Technology, Organizational Transformation and Business Performance," *Journal of Economics Perspectives* 14, no. 4 (2000): 23–48.

[15] "Ukraine," Human Capital Project, World Bank, Washington, DC, https://databank.worldbank.org/data/download/hci/HCI_2pager_UKR.pdf.

[16] Available at https://www.kmu.gov.ua/diyalnist/programa-diyalnosti-uryadu.

[17] Available at https://zakon.rada.gov.ua/laws/show/67-2018-p.

[18] Available at https://zakon.rada.gov.ua/laws/show/534-2020-%D0%BF#Text.

[19] World Bank, "Country Partnership Framework for the Period FY17–FY21," Report 114516-UA (Washington, DC: World Bank, 2017), http://documents.worldbank.org/curated/en/847421498183265026/pdf/Ukraine-Country-Partnership-Framework-FY2017-21-05262017.pdf.

[20] For more information, see EC, "Broadband Europe," https://ec.europa.eu/digital-single-market/en/broadband-europe.

[21] "Association Agreement," *Official Journal of the European Union*, May 29, 2014, https://trade.ec.europa.eu/doclib/docs/2016/november/tradoc_155103.pdf.

[22] IIC, "The State of Digitization in Latin America Facing the Pandemic" (London, International Institute of Communications, 2020), https://www.iicom.org/feature/report-the-state-of-digitization-in-latin-america-facing-the-pandemic/.

[23] C. Schwaerzler and others, "Beyond the Curve: How Governments Can Galvanize Their Nations for the Rebound" (Boston: Boston Consulting Group, 2020), https://www.bcg.com/publications/2020/three-government-priorities-for-rebuilding-post-covid.aspx.

[24] TeleGeography data, 2019 (refers to the share of total subscriptions, not unique subscribers).

[25] C. Zhen-Wei Qiang, "Broadband Infrastructure Investment in Stimulus Packages: Relevance for Developing Countries" (Washington, DC: World Bank, 2009), http://documents.worldbank.org/curated/en/154041468339016052/Broadband-infrastructure-investment-in-stimulus-packages-relevance-for-developing-countries.

[26] Z. Chong, "South Korea Gets Super-Duper Fast Internet," *CNET News*, May 10, 2018, https://www.cnet.com/news/south-korea-gets-super-duper-fast-Internet/.

[27] International best practices recommend minimal intervention in retail markets, reliance on regulatory tools to ensure non-discriminatory open access to all upstream markets, and cost-based pricing of wholesale resources.

[28] World Bank, *World Development Report 2016*.

[29] M. Forzati and others, "Guide to High-Speed Broadband Investment" (Brussels: European Commission, 2014). http://ec.europa.eu/regional_policy/en/information/publications/guides/2014/guide-to-high-speed-broadband-investment.

[30] Atene KOM, *Study on National Broadband Plans in the EU-28* (Brussels: European Commission, 2014), https://ec.europa.eu/digital-single-market/en/news/study-national-broadband-plans-eu-28-connectivity-targets-and-measures.

[31] Y. Kim, T. Kelly, and S. Raja, Building Broadband: *Strategies and Policies for the Developing World* (Washington, DC: World Bank, 2010), https://openknowledge.worldbank.org/handle/10986/2469.

[32] "Digital Agenda for Ukraine," a presentation at the MEDT, January 2018.

[33] This can be found at https://zakon.rada.gov.ua/laws/show/67-2018-p.

[34] As reflected in the program of activities of the Cabinet of Ministers of Ukraine from October 2019, https://www.kmu.gov.ua/diyalnist/programa-diyalnosti-uryadu. Despite changes in the government, the MDT's goals have remained the same.

[35] "Association Agreement, https://trade.ec.europa.eu/doclib/docs/2016/november/tradoc_155103.pdf.

[36] EC, "Communication – Connectivity for a Competitive Digital Single Market – Towards a European Gigabit Society" (Brussels: European Commission, 2016), https://ec.europa.eu/digital-single-market/en/news/communication-connectivity-competitive-digital-single-market-towards-european-gigabit-society.

[37] EC, "Communication – 5G for Europe: an Action Plan and Accompanying Staff Working Document" (Brussels: European Commission, 2016), https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document.

[38] EC, "20 Deliverables for 2020: Monitoring – State of Play March 2019," Eastern Partnership (Brussels: European Commission, 2019), https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20_deliverables_for_2020_monitoring_state_of_play_2019.pdf.

[39] The paper can be found at https://thedigital.gov.ua/storage/uploads/files/page/Policy_digital_infrastructure_v3%20(1).pdf (in Ukrainian).

[40] "Association Agreement," https://trade.ec.europa.eu/doclib/docs/2016/november/tradoc_155103.pdf.

[41] This report can be found at https://www.eurointegration.com.ua/experts/2017/02/6/7061244/.

[42] See https://nkrzi.gov.ua/index.php?r=site/index&pg=99&id=1883&language=uk.

[43] Except for those engaged in agriculture and selected industries, for which the official statistics are not available. UkrStat, "Use of ICT in Enterprises," 2018, http://www.ukrstat.gov.ua/operativ/operativ2018/zv/ikt/arh_ikt_u.html (in Ukrainian).

[44] "Population of Ukraine," http://database.ukrcensus.gov.ua/PXWEB2007/ukr/news/op_popul.asp.

[45] This can be found at https://inau.ua/sites/default/files/file/1910/dani_ustanovchyh_doslidzhen_iii_kvartal_2019_roku.pdf.

[46] This is despite the fall in the national active mobile subscriber base due to the annexation of Crimea and the armed conflict in the eastern part of the country.

[48] Ukraine Wireless. GlobalComms Database. TeleGeography; and World Bank Open Data, Population (total), https://data.worldbank.org/indicator/SP.POP.TOTL.

[49] Ibid.

[50] Here and elsewhere in this paragraph, Herfindahl-Hirschman Index (HHI) index calculations are based on TeleGeography GlobalComms data.

[51] NCCIR, "Annual Report for 2019," https://nkrzi.gov.ua/index.php?r=site/index&pg=34&id=8484&language=uk (in Ukrainian).

[52] Based on interviews with MNOs since the start of the project.

[53] WEF, "Global Information Technology Report 2016: Ukraine" (Geneva: World Economic Forum, 2016), https://reports.weforum.org/global-information-technology-report-2016/economies/#economy=UKR.

[54] Based on an analysis of the cheapest (50/100 Mbps download) fixed and mobile (prepaid, unlimited, 6/15G) internet offerings of the top three ISPs/MNOs by market share as of March 19, 2020. The underlying analysis on income consumption per decile comes from PovcalNet, the online tool for poverty measurement developed by the Development Research Group of the World Bank (http://iresearch.worldbank.org/PovcalNet/povOnDemand.aspx). Information on population and the purchasing power parity (PPP) conversion rate is from the World Bank Open Data indicators; on market shares from Ukraine, see GlobalComms Database. TeleGeography.

[55] Ukraine Wireless. GlobalComms Database.

[56] Multiple court cases in Ukraine and the United Kingdom were brought up in relation to the privatization process in 2013.

[57] Ukraine Wireless. GlobalComms Database. .

[58] *Ukraine News*, December 17, 2019. GlobalComms. TeleGeography.

[59] See https://www.gsmsota.com.ua/blog/novosti/mobilnym-operatoram-razreshili-poluchit-novye-litsenzii-na-4g/.

[60] European Council, "Freeing up 700 MHz Band for Mobile: Council Agrees to its Position" (Brussels, Council of the European Union, 2016), https://www.consilium.europa.eu/en/press/press-releases/2016/05/26/freeing-up-700-mhz-band-for-mobile/.

[61] NCCIR, "Annual Report for 2019."

[62] Ukraine Wireless. GlobalComms Database. TeleGeography.

[63] In its annual 2019 report, the NCCIR affirms that 50 percent of operators and ISPs working in the fixed broadband submarket do not comply with their regulatory reporting obligations. See NCCIR, "Annual Report for 2019," 20.

[64] This register is based on self-reporting, hence it is frequently updated. It can be found at https://nkrzi.gov.ua/index.php?r=site/index&pg=55&language=uk.

[65] Since the registry has been changed very recently (January 2020), many operators and providers have not yet had time to re-register. Those that have are referred in-text as "active."

[66] The single tax system is designed to reduce the tax and administrative burden for small businesses, both legal entities and individuals. It also uses a model allowing for the optimization of the tax burden on labor payments (22 percent from the minimal monthly wage).

[67] Interview with a major ISP, August 2019, Kyiv, Ukraine. It should also be noted that other than competitive strategies, the lowering purchasing power of the local population since 2014 has had an impact on the pricing policy of ISPs.

[68] See "Prospects for 2018: Why Tariffs for 'Wired' Internet Will Increase," *Mind*, January 17, 2018, https://mind.ua/publications/20180578-perspektivi-2018-chomu-zrostut-tarifi-na-drotovij-internet.

[69] Authors, based on TeleGeography GlobalComms data.

[70] World Bank, "Electronic Communications in Ukraine: The Bottleneck to Sustainable Development" (Washington, DC: World Bank, 2005).

[71] That could be partially explained by the fact that the study may have included both mobile and fixed broadband subscriptions among households with internet. The report can be found at https://inau.ua/sites/default/files/file/1903/dani_ustanovchyh_doslidzhen_za_1-y_kvartal_2019_0.pdf (in Russian).

[72] Data for EaP countries, Finland, and France from country profiles in GlobalComms, TeleGeography, March 2020; data for the rest of the EU countries taken from Eurostat, "Households with Broadband Access," 2020, https://ec.europa.eu/eurostat/databrowser/view/TIN00073/default/table.

[73] Ibid.

[74] The list of settlements was shared with the MDT during the preparation of this analysis.

[75] One of the worldwide leaders in internet testing and analysis.

[76] The number of targeted settlements was adjusted from 17,988 down by 30 percent and recorded at 12,429. This is because about 30 percent of settlements have fewer than 100 dwellers per settlement and are therefore likely below the minimum feasible size for ISPs to service.

[77] D. Elixmann and K-H Neumann, "The Broadband State Aid Rules Explained: an eGuide for Decision Makers" (Brussels: European Commission, 2013) https://ec.europa.eu/regional_policy/sources/conferences/state-aid/broadband_rulesexplained.pdf.

[78] See "EU Guidelines for the Application of State Aid Rules in Relation to the Rapid Deployment of Broadband Networks" *Official Journal of the European Union* (2013/C 25/01), https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:025:0001:0026:EN:PDF.

[79] The fundamental principle in state aid programs is "that public funds are carefully used in this sector and that the Commission ensures that State aid is complementary and does not substitute investments of market players. Any State intervention should limit as much as possible the risk of crowding out private investments, of altering commercial investment incentives and ultimately of distorting competition contrary to the common interest of the European Union." See "EU Guidelines for the Application of State Aid Rules." A long list of cases considered by the EC is available at http://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf.

[80] The Bank is supporting the MDT in this aim through the provision of technical assistance.

[81] WEF, "Global Information Technology Report 2016: Ukraine" (see note 52).

[82] See http://www.ukrstat.gov.ua/operativ/operativ2007/gdvdg_rik/dvdg_u/str_vut2010_u.htm.

[83] The affordability criteria was derived from the UN Broadband Commission for Sustainable Development.

[84] Based on interviews with ISPs and university students in Kyiv, April 2020.

[85] This information can be found at https://www.ftthcouncil.eu/documents/PressReleases/2019/PR%20Market%20Panorama%20-%2014-03-2019%20V3.pdf.

[86] I. McKetta, "In-Depth Analysis of Changes in World Internet Performance Using the Speedtest Global Index" (Seattle, WA: Ookla, 2019), https://www.speedtest.net/insights/blog/global-index-2019-internet-report/.

[87] UkrStat, "Number of Administrative-Territorial Units in Ukraine, 1990-2019."

[88] Data as of January 2019. UkrStat, "State and Development of Communications in 2018," http://www.ukrstat.gov.ua/operativ/operativ2018/zv/srz/arh_srz_u.htm (in Ukrainian).

[89] *Ukraine News*, March 24, 2020, GlobalComms. TeleGeography.

[90] GlobalComms Database. TeleGeography.

[91] Data as of October 2019. Ukraine Broadband. GlobalComms Database. TeleGeography.

[92] See https://nkrzi.gov.ua/images/upload/142/9088/Zvit_2020_NKRZI.pdf (in Ukrainian).

[93] The text of the bill can be found at https://zakon.rada.gov.ua/laws/show/1834-19.

[94] A copy of the directive can be found at https://ec.europa.eu/digital-single-market/en/news/directive-201461eu-european-parliament-and-council.

[95] Interview with the UIA, July 2019, Kyiv, Ukraine. Interviews with alternative ISPs in March–April 2020.

[96] Interviews with major wholesale providers, July 2019, Kyiv, Ukraine. Interviews with alternative ISPs in March–April 2020.

[97] The averages for the three DSOs in Bulgaria and in Romania were obtained through direct requests to TSOs. Poland's average price comes from: https://www.telko.in/uke-45-zl-za-dostep-do-slupa-energetycznego (in Polish). Ukraine's average of multiple DSOs comes from data at: https://inau.ua/news/inau-zibrala-informaciyu-pro-indykatyvni-ciny-na-sumisnyy-pidvis-v-regionah-ukrayiny-poslugy. The most recent PPP conversation factor was used to convert amounts in local currencies into international dollars. World Bank Open Data, PPP Conversion Factor, GDP (LCU per international $), https://data.worldbank.org/indicator/PA.NUS.PPP.

[98] OECD, "Snapshot of Ukraine's Energy Sector: Institutions, Governance and Policy Framework (Paris: Organisation for Economic Co-operation and Development, 2019), https://www.oecd.org/eurasia/competitiveness-programme/eastern-partners/Snapshot-of-Ukraines-Energy-Sector-EN.pdf.

[99] For more information, see https://www.scm.com.ua/en/about.

[100] Global Internet Geography. TeleGeography.

[101] Tier 1 is an Internet Protocol (IP) network that can reach every other network in the internet solely via settlement-free interconnection. Tier 1 networks can exchange traffic with other Tier 1 networks without having to pay any fees for the exchange of traffic in either direction, while some Tier 2 networks and all Tier 3 networks pay for transmit traffic on other networks.

[102] For more information, see https://www.teliacarrier.com/our-network.html.

[103] See https://www.orange-business.com/en/connectivity.

[104] See https://www.cogentco.com/files/images/network/network_map/2020web_networkmap_page.jpg; https://en.wikipedia.org/wiki/Tier_1_network#List_of_Tier_1_networks; and https://he.net/HurricaneElectricNetworkMap.pdf.

[105] For any network, the number of paths to Tier 1 ISPs determines its degree of connectivity. Hence, the more Tier 1 networks in its proximity, the more reliable the internet access for that network.

[106] Interview with major wholesale operators, July 2019, Kyiv, Ukraine.

[107] See https://www.ix.net.ua; https://giganet.ua; and https://dtel-ix.net/#.

[108] PeeringDB, https://www.peeringdb.com/advanced_search?country__in=UA&reftag=ix.

[109] Ukraine Wireless. GlobalComms Database, TeleGeography .

[110] This assumes a peak use by 50 percent of all households in Ukraine, with a 50:1 contention ratio, as measured by peak use in multi-storied buildings in Kyiv during the first week of confinement due to COVID-19. It is also assumed that half of the traffic remains domestic. For more information, see Annex 9.

[111] https://www.telegeography.com/products/global-internet-geography/analysis/capacity-and-traffic-trends/index.html.

[112] D. Levine, "Google Data Centers: Economic Impact and Community Benefit" (New York: Oxford Economics, 2018), https://www.oxfordeconomics.com/recent-releases/d8d830e4-6327-460e-95a5-c695a32916d9.

[113] IP transit prices. Global Internet Geography, TeleGeography.

[114] Based on interviews with major operators, July 2019, Kyiv, Ukraine.

[115] Ibid 69 .

[116] Interview with UIA, July 2019, Kyiv, Ukraine.

[117] Construction of a high-capacity open cable system from Poti, Georgia to Constanta, Romania, is planned in the near future. See "SubCom Announces Agreement to Build Diamond Link Global Cable System Linking Georgia and Romania," Press release, November 9, 2018, https://www.subcom.com/documents/Diamond-Link-Global-Build-SubCom-9NOV2018.pdf.

[118] Payments of incoming international traffic are made in dollars or euros when local currencies are unstable. Interview with major wholesale operators, July 2019, Kyiv, Ukraine.

[119] Ukraine scores the lowest on the Cyber Crisis Management pillar. See the National Cyber Security Index at https://ncsi.ega.ee/ncsi-index/.

[120] Interview with the UIA, July 2019, Kyiv, Ukraine.

[121] The EC and the World Bank could facilitate Ukraine's participation in both initiatives.

[122] NCCIR, "Annual Report 2019" (see note 50).

[123] Based on interviews with major operators, May 2020, Kyiv, Ukraine.

[124] NCCIR, "Annual Report for 2019."

[125] The data for Romania as of the first quarter of 2019 (the latest available) can be found at https://statistica.ancom.ro/sscpds/public/files/178_ro. Data on the EU wholesale market comes from the estimate in the World Bank's analysis of the Western Balkan telecom wholesale market.

[126] See the "Internet Exchange Map" at https://www.internetexchangemap.com.

[127] NCCIR, Per License Register from December 24, 2019, https://nkrzi.gov.ua/index.php?r=site/index&pg=58&language=uk.

[128] In the case of Datagroup, the data come from: http://sib.com.ua/sib-03-100-2018/dwdm.html; in the case of Ukrtelecom, from https://dragon-capital.com/what-we-do/research/companies/utlm/tab2/tab1/tab1/.

[129] Interviews with wholesale operators, March–April 2020, Kyiv, Ukraine.

[130] NCCIR, "Register of the Operators and Providers of Telecommunications" (as of March 19, 2020), https://nkrzi.gov.ua/index.php?r=site/index&pg=55&language=uk.

[131] Interview with a major wholesale operator, February 2020, Kyiv, Ukraine.

[132] More information can be found at https://ua.energy/wp-content/uploads/2019/09/PZ-Nove-budivnytstvo.pdf; and https://ua.energy/wp-content/uploads/2019/09/IP-2020-Nove-budivnytstvo.pdf (in Ukrainian).

[133] For more information on Ukrenergo's "Strategy," see https://www.slideshare.net/Ukrenergo/20192028-148139363.

[134] See https://www.ukrtransnafta.com/dodatkovi-poslugi/.

[135] The access gap refers to the portion of the market that even under ideal legal and regulatory environments would not be covered by operators owing to its high cost and/or low income. See A. Muente-Kunigami and J. Navas-Sabater, *Options to Increase Access to Telecommunications Services in Rural and Low-Income Areas* (Washington, DC: World Bank, 2010), http://documents1.worldbank.org/curated/en/277671468330886996/pdf/518390PUB0REPL101Official0Use0Only1.pdf.

[136] World Bank Open Data, "Individuals Using the Internet (% of population)," https://data.worldbank.org/indicator/IT.NET.USER.ZS

[137] Data can be found at http://www.ukrstat.gov.ua/operativ/operativ2007/gdvdg_rik/dvdg_u/Ndtt2010-_u.htm.

[138] Data can be found at http://www.ukrstat.gov.ua/operativ/operativ2018/gdvdg/Arh_sdg_dtp_u.htm.

[139] See https://inau.ua/sites/default/files/file/2001/presentation_osm_december_2019.pdf (in Ukrainian).

[140] For more information, see https://mon.gov.ua/ua (in Ukrainian).

[141] For more on decentralization, see https://decentralization.gov.ua/uploads/library/file/526/10.01.2020.pdf (in Ukrainian).

[142] See http://uran.ua/~eng/net-ukraine.htm; and http://www.uran.net.ua/~ukr/net-operator.htm.

[143] For more information, see https://clarity-project.info/edr/34662584.

[144] https://panorama.uran.ua/en/uran-rapidly-deploys-edumeet/.

[145] Data can be found at https://dostup.pravda.com.ua/request/46951/response/110010/attach/6/4.pdf (in Ukrainian).

[146] https://uar.net/about/

[147] See https://mon.gov.ua/storage/app/media/kolegiya-ministerstva/2018/05/1-dorozhnya-karta-integratsii-ukraini-do-evro.pdf (in Ukrainian).

[148] EC, "Horizon 2020 Country Profile for Ukraine," https://ec.europa.eu/research/horizon2020/index.cfm?pg=country-profiles-detail&ctry=Ukraine.

[149] See "Eastern Partnership Connect," http://uran.ua/projects/eapconnect/first.htm.

[150] More information can be found at https://zakon.rada.gov.ua/laws/show/1013-2016-p.

[151] See https://decentralization.gov.ua/uploads/library/file/526/10.01.2020.pdf (in Ukrainian).

[152] Data from https://dostup.pravda.com.ua/request/46951/response/110010/attach/4/.pdf (in Ukrainian).

[153] While specific analysis was not conduced, it is likely that at the time of finalizing this report (December 2020), situation with connectivity could have improved as a result of provider payment reforms in the health sector.

[154] The whole list of these institutions (geomapped) can be found in Annex 10.

[155] Ibid 145.

[156] See https://osvita.diia.gov.ua.

[157] As many as 120 more youth centers are scheduled to open. See https://youthcenters.net.ua/perelik-tsentriv-ukraini/?fbclid=IwAR1BGWw9-6dgoFd-qG9s1gOdwRuzbtm6QynD6rwyyGQxuszk3s2UipyARLEw. On educational hubs, see https://osvita.diia.gov.ua/hubs.

[158] See https://zakon.rada.gov.ua/laws/show/148-2016-n#n11.

[159] Text can be found at https://zakon.rada.gov.ua/laws/show/z1061-17.

[160] Information is available at https://zakon.rada.gov.ua/laws/show/695-2020-%D0%BF#Text (in Ukrainian).

[161] Per measure #29, https://zakon.rada.gov.ua/laws/show/67-2018-p.

[162] Information on this proposal can be found at https://www.ukrposhta.ua/ua/news/57036-do-verhovnoi-radi-povtorno-vneseno-zakono-prokt-2788-pro-rozshirennja-finansovih-poslug-ukrposhtoju.

[163] Data from UkrPoshta submitted to the MDT, 2019.

[164] See https://dostup.pravda.com.ua/request/46951/response/110010/attach/5/.pdf (in Ukrainian).

[165] The main exceptions are those engaged in agriculture and selected industries, for which official statistics are not available in the UkrStat databases.

[166] See http://www.ukrstat.gov.ua/operativ/operativ2018/zv/ikt/arh_ikt_u.html.

[167] Personal communication with a member of the IT staff of a local (oblast-level) tax authority, March 2020.

[168] Information on the digital literacy of the population of Ukraine can be found at https://osvita.diia.gov.ua/uploads/0/588-the_first_in_the_history_of_ukraine_research_compressed.pdf.

[169] Ministry of Social Policy, as stated in "In Ukraine, the Term 'Disabled' has been Officially Phased Out," *BBC Ukraine*, January 16, 2018, https://www.bbc.com/ukrainian/news-42700678.

[170] D.S. Raja, "Bridging the Disability Divide through Digital Technologies: Background Paper for the 2016 World Development Report: Digital Dividends" (Washington, DC: World Bank, 2016), http://pubdocs.worldbank.org/en/123481461249337484/WDR16-BP-Bridging-the-Disability-Divide-through-Digital-Technology-RAJA.pdf.

[171] The targets for 2025 are: (a) gigabit connectivity for all of the main socioeconomic drivers, (b) uninterrupted 5G coverage for all urban areas and major transport paths, and (c) access to connectivity offering at least 100 Mbps for all European households. See "Broadband Europe," https://ec.europa.eu/digital-single-market/en/broadband-europe.

[172] The Broadband Commission aims that "by 2025, entry-level broadband services should be made affordable in developing countries at less than 2% of monthly Gross National Income (GNI) per capita." See "2025 Targets: Connecting the Other Half," https://broadbandcommission.org/Documents/publications/wef2018.pdf.

[173] It is recommended that the GoU define which of the existing objects are considered priorities from the standpoint of service provision. These may include (but not be limited to): primary and secondary health care facilities, schools, centers for administrative service provision, post offices, youth centers, and so on.

[174] For more information, see https://nkrzi.gov.ua/index.php?r=site/index&pg=86&id=3948&language=uk; and https://nkrzi.gov.ua/index.php?r=site/index&pg=444&id=8996&language=uk.

[175] This indicator is based on the government's intention to have the entire territory of Ukraine covered with 4G by 2023 and is backed by market readiness, as reflected in the October 2019 MoU signed by four MNOs and the GoU on covering the country with high-quality, high-speed communications networks.

[176] This indicator is based on current machine to machine (M2M)/IoT and 5G developments and government plans. Thus, MNOs have started to launch NB IoT services, which is connected to their readiness for 5G. For example, Lifecell has completed a first-stage NB-IoT rollout in Kyiv. Vodafone has conducted NB-IoT tests in Kyiv, Kharkiv, and Odesa. Kyivstar has also tested NB-IoT in Kyiv, Odesa, and Ternopil and launched its networks in five oblasts (Kyiv, Odesa, Lviv, Kharkiv, and Dnipro). All MNOs plan for a 5G network rollout in 2021, following the tendering of 5G licenses by the government, which was announced in 2019. They have successfully tested their 5G-ready equipment. Based on information found on MNOs' websites and Ukraine, GlobalComms. TeleGeography.

ANNEX 1. CONSOLIDATED LIST OF RECOMMENDATIONS

This annex consolidates all the recommendations formulated throughout the report and its annexes.

Section 4.1. Strategic Context

Recommendation 1:
Given the vital importance of broadband connectivity to the country's economic and social functioning and the many specifics of its advancement, prepare a separate strategic document dedicated to broadband connectivity and its development, that is, a National Broadband Development Strategy (NBDS).

Recommedation 2:
Define and include a monitoring and evaluation plan as part of the NBDS to ensure the timeliness and diligency of its implementation and accountability.

Recommendation 3:
Align the high-level stategic broadband goals of the NBDS and other relevant strategic documents with those of the European Union (EU) to comply with the Association Agreement with the EU (EUAA).

Recommendation 4:
Strengthen the institutionality, mandate, and responsibilities of the national sector regulator (the National Commission for the State Regulation of Communications and Informatization [NCCIR]) through the alignment of the relevant legal framework with the European Electronic Communications Code (EECC).

Annex 2. Current Broadband-Related Goals in Ukraine and the EU

Recommendation 1:
Consult with the private sector on the goals as currently proposed compared to those used in the EU. Incorporate the assumptions of the private sector into the connectivity growth forecast, based on the collected data. Set goals that are realistic yet sufficiently ambitious and future-oriented.

Recommendation 2:
Work closely with the State Statistical Agency of Ukraine (UkrStat) to align the statistical effort in the area of broadband connectivity with that of the EU's Digital Economy and Society Index (DESI). This could be achieved by, among other actions, incorporating the DESI indicators into any respective changes to the annual plans of UkrStat's state statistical observations. Collect broadband statistics by speed ranges.

Recommendation 3:
Cooperate with the Body of European Regulators for Electronic Communications (BEREC) to learn from operators about the best practices of data collection, aligned with the DESI indicators.

Section 4.2.1. Mobile Broadband

Recommendation 1:
Improve data collection and reporting by the NCCIR to obtain a more objective picture of the state of mobile broadband connectivity with a higher granularity in time.

Recommendation 2:
Accelerate the deployment of 4G for consumers and businesses by removing barriers to operators, such as spectrum allocations.

Recommendation 3:
Ensure full connectivity to remote areas by performing spectrum refarming in the 800–900 MHz band, based on the principles of technology neutrality and efficient resource uitilization.

Recommendation 4:
Promote the introduction of IoT services through a

shift in coverage requirements from the share of the covered population to the percentage of geographical territory.

Recommendation 5:
In line with the EU Gigabit Society, as soon as 5G becomes available, ensure that the service is accessible along major highways to facilitate 5G pilots and applications for transport, including digital transport corridors (DTCs).

Annex 3. 4G/5G Spectrum – Situation Analysis

Recommendation 1:
Improve efficiency in spectrum use by prioritizing spectrum refarming in the 700–900 MHz band.

Recommendation 2:
Reallocate spectrum that is reserved for special communication services to LTE and auction it to mobile operators.

Recommendation 3:
Implement license sharing access, allowing mobile operators to access the reserved spectrum on the condition that they guarantee the primary users owning that band undisturbed operations.

Recommendation 4:
In cases where the above is not possible (e.g., old jet navigation), consider putting the burden of aircraft renewal on the operator that wants to acquire the corresponding range in the T-GSM band.

Recommendation 5:
Free up the important 5G spectrum by increasing the rent for the owned frequencies in the 2600 and 3500 MHz bands.

Recommendation 6:
Consider matching spectrum supervision rates in the 5G bands 2300–2400 MHz and 3400–3800 MHz with those in 900 and 1800 MHz, regardless of the current technology implemented there.

Recommendation 7:
Arrange for the Government of Ukraine (GoU), together with mobile network operators (MNOs), to hold a targeted information campaign on 5G network operations to increase the public's knowledge of the radiation aspects.

Recommendation 8:
Develop online service with a visual representation of frequency allocations for better spectrum management and transparency and for the oversight of radio frequency spectrum usage.

Annex 3. Introduction to 5G

Recommendation 1:
Ensure the availability of spectrum for 5G by implementing a refarming in lower frequencies and removing the players that are not utilizing the spectrum in the mid-band ranges.

Recommendation 2:
Develop and implement additional regulations in the field of artificial intelligence (AI).

Recommendation 3:
Establish regulations to control the use of private and sensitive information gathered by sensors.

Recommendation 4:
Arrange for the establishment of a data management framework for the GoU and develop a set of regulations regarding cybersecurity, AI, and big data analytics, including on the sectoral level

Recommendation 5:
Encourage operators to include VoLTE/VoNR in the default service package and offer devices that support these technologies.

Recommendation 6:
Complete the transposition of Directive 2014/61EC with regard to the implementation of a single information point and a dispute-settlement body through relevant amendments to the Law on Access to the Objects of Construction, Transport, Energy for the Purpose of Development of Telecommunication Networks (No. 1834-VIII).

Recommendation 7:
Organize capacity-building activities on all levels of government to promote infrastructure sharing.

Section 4.2.2. Fixed Broadband

Recommendation 1:
Improve the NCCIR's data collection process to obtain a more objective picture of the state of fixed broadband connectivity in the (occupied) residential buildings and on the level of public institutions.

Recommendation 2:
Undertake a more granular analysis of the retail market on the oblast level to understand the concentration at varying levels of geographic aggregation.

Recommendation 3:
Develop a publicly funded financial incentive (state aid) scheme to support broadband infrastrutcure investments in unconnected areas of the country.

Recommendation 4:
Develop an action plan for the implementation of Directive 2014/61/EU as a whole and especially its provision related to effective dispute settlement, access to residential buildings and electricity poles, and the efficiency of the permit-granting process.

Recommendation 5:
Review existing dispute-resolution procedures in collaboration with the involved parties, including the NCCIR, Antimonopoly Committee of Ukraine, and Ministry of Justice, and establish consistency in these procedures to avoid the development of conflicting practices within the Ukrainian judicial system. This could be implemented through a review of the access laws and an elaboration of the particularities of dispute settlement (for example, the dispute-settlement body, dispute-settlement timeline, price setting, and coordination procedures between the various regulators, as the case may require).

Annex 8. Broadband Mapping

Recommendation 1:
Approach the development of the Broadband Atlas as a long-term geographic information system (GIS) solution, the implementation of which should be divided into several stages.

Recommendation 2:
Ensure that all stakeholders are involved in developing the Atlas and its tools and in filling the Atlas with the requisite data and information. Compile a list of all the relevant stakeholders and make the GoU (represented by the NCCIR or the Ministry of Digital Transformation [MDT]) a moderator of their involvement.

Recommendation 3:
Based on the goals of the GoU, display data in the Atlas about the existing and planned infrastructure and services. Create an exhaustive list of information layers, as well as a list of data sets and their holders.

Recommendation 4:
Improve the regulatory framework in order to strengthen the authority and responsibilities of the NCCIR to require data from all stakeholders. The specifications and requirements for the requested data should be clearly defined. For example, it is necessary to separately determine the geospatial data requirements.

Recommendation 5:
Provide specific mechanisms for stakeholders to enter data into the Atlas. Develop a user-friendly web interface for entering information.

Recommendation 6:
Establish a special GIS department within the NCCIR or the MDT to develop and subsequently support the work of the Broadband Atlas, or ensure that the functioning of the Atlas is supported by third parties (outsourced to companies).

Section 5.1. International Connectivity (Wholesale)

Recommendation 1:
Consider diversifying sources of international connectivity by attracting Tier 1 and Tier 2 networks and by joining, initially as an observer, the Three Seas Digital Highway and the Balkans Digital Highway initiatives.[1]

Recommendation 2:
Take action to attract the GAFA tech giants (Google, Apple, Facebook, and Amazon) and provide them with incentives to build data centers in Ukraine by creating a proper tax and regulatory climate for their operations.

[1] The EC and the World Bank could facilitate Ukraine's participation in both initiatives.

Recommendation 3:
Strengthen national cybersecurity capacity by transposing and implementing the relevant EU aquis.

Recommendation 4:
Consider increasing the supply of submarine connectivity in the Black Sea to ensure resilient alternative connectivity between Ukraine and, for example, Bulgaria, Romania, and Turkey and with other Eastern Partnership (EaP) countries. This in itself will help develop Ukraine's largest seaport and internet exchange point (IXP) cluster host-city Odesa as a new international point of digital traffic exchange.

Section 5.2. Domestic Wholesale Market

Recommendation 1:
Commercialize the spare fiber-optic assets of Ukraine's state-owned enterprises (SoEs) in transport and energy as a short-term objective (Ukrenergo, Ukrtransgaz, Ukrzaliznytsia). Over the medium term, work with other SoEs, private and public electricity distribution companies, and municipal water and sewage providers on the same objective

Recommendation 2:
Use the fiber-optic infrastructure of SoEs to boost the capacity of the networks servicing the GoU to organize communications during crisis events.

Recommendation 3:
Reach a principal agreement with the GoU and with donors that every new linear infrastructure upgrade or construction project should take into account internal SoE telecom capacity needs, as well as those of the telecom sector. No new pipeline or road segment should be built without laying fiber-optic cables, and/or cable ducts planned for the future, alongside it.

Recommendation 4:
Design a procedure (mechanism) for optimally fast and effective information sharing on the connection networks and investment plans from SoEs to the MDT and NCCIR for evidence-based decision making.

Section 5.3. Demand Side

Recommendation 1:
Finalize the upgrade of the telecom infrastructure supporting the education and health care sectors, including connecting the currently unconnected facilities.

Recommendation 2:
Create a national digital skills strategy and throughout its implementation, introduce digital awareness (including on cybersecurity) and digital skills programs to specific population groups to increase the productive usage of broadband. Leverage educational institutions, libraries, post offices, and youth clubs for this purpose.

Recommendation 3:
Encourage the GoU to facilitate the participation of URAN and possibly UARnet in the EaPConnect Project, with Ukrainian NREN's integration into the European data network GÉANT.

ANNEX 2. CURRENT BROADBAND-RELATED GOALS IN UKRAINE AND THE EU

This annex includes a table that compares Ukraine's strategic objectives set up through its current policy framework and those of the EU. It also provides insights into the definition of broadband and how it is defined in both the EU and Ukraine, as well as some suggestions on setting up high-speed connectivity goals.

TABLE A.2.1.
Broadband-Related Goals of Ukraine and the EU

EU
Gigabit society
• Access to 1 Gbps for all schools, transport hubs, and main providers of public services and digitally intensive enterprises • Access to download speeds of at least 100 Mbps to be upgraded to 1 Gbps for all European households • Uninterrupted 5G wireless broadband coverage for all urban areas and major roads and railways by 2025 Note that previously, the EU set as a strategic goal by 2020 the use of Next Generation Networks (NGN): 100 Mbps or more by 50% of households.[1]
Ukraine
Cabinet of Ministers of Ukraine - Concept of the Development of a Digital Economy and Society in Ukraine in 2018–2020 and Digital Action Plan (January 2018)
#22 "Ensuring access to broadband internet for students in classrooms and auditoria in the educational facilities of all levels" #26 "Development of a national program of development and hard and soft digital infrastructure, determination of stages of their rollout and the scaling of relevant PPP [public-private partnership] models and attraction of required investments" #27 "Development of a draft law of the Cabinet of the Minister of Ukraine on the development use of broadband internet access while taking into account the digital divide, creation of special funds to eliminate the digital divide with the use of PPPs in this field"

[1] European Commission, "Broadband Strategy and Policy," https://ec.europa.eu/digital-single-market/en/broadband-strategy-policy.

#28 "Submission of proposals for the use of railway and automotive physical infrastructure as base infrastructure for laying optical communication lines, taking into account their repair, restoration, and construction works"
#29 "Proposals for the use of the postal infrastructure as a digital platform to provide services to residents of villages and remote territories, including to objects of social infrastructure, for e-commerce development in rural areas"
#30 "Submission for approval of a plan for the development of wireless communications, including internet, on transport infrastructure, including train and bus stations, aviation, sea and river ports, transport hubs, and on the rolling stock in accordance with the needs of society, business and the state"
#31 "Submission of proposals for the use of digital technologies, including the Internet of Things, on the transport infrastructure, taking into account the possibilities of the monitoring and managing of traffic and traffic flows, use of sensors and sensors for safety issues, monitoring of road conditions, and provision of appropriate services for road users and traffic optimization"
#32 "Submission of proposals for establishing a physical security and cybersecurity management center on transport infrastructure"
#33 "Development of a plan of measures to stimulate and support the implementation of blockchain technology in public administration and other areas"
#34 "Elaboration of the draft act of the Cabinet of Ministers of Ukraine on the stimulation and introduction of high-potential and innovative technologies, concepts, and methodologies in the economy, priority industries, the sphere of public administration"

Ministry of Digital Transformation's Strategic Broadband Goal – Program of Activities of the Cabinet of Ministers (October 2019)

Ukrainians can use ultrafast internet along all major highways and in all settlements (KPIs: % of international highways and settlements with coverage of ultrafast internet with a speed of **no less than 30 Mbps**).

Ministry of Digital Transformation's Strategic Broadband Goal – Concept of the State Policy on Digital Infrastructure (December 2019)

Priority #1: "Fixed and mobile broadband should be accessible to every citizen"
Indicators:

- 90% of settlements should have access to mobile broadband at a speed of no less than 2 Mbps
- 100% of international and national highways should be covered with broadband at a speed of no less than 2 Mbps
- 80% of households should have access to fixed broadband at a speed of no less than 30 Mbps
- 50% of households should have access to fixed broadband at a speed of no less than 100 Mbps
- 100% of objects of social infrastructure (e.g., education, health care institutions, etc.) should be connected to the internet
- 70% of people with disabilities should use broadband

Priority #2: "Ensuring the affordability of broadband services for every citizen"
Indicators:

- share of household income used for broadband
- 80% of mobile subscribers use mobile broadband
- 70% of households covered with fixed broadband at a speed of no less than 30 Mbps
- 15% of households covered with fixed broadband at a speed of no less than 100 Mbps
- 70% of people with disabilities should use broadband

Priority #3: "Ensuring the stable accessibility and service quality of broadband"
Indicators:

- -number of fixed broadband disconnections within a month
  -time of fixed broadband disconnections within a month
  -time to restore access after a break
  -jitter at less than 15 ms
  -loss of data packets at less than 0.1% from the amount of data transmitted
  -round-trip delay time (RTT) at less than 50 ms

State program of economic stimulation to overcome the negative consequences caused by restrictive measures to prevent the occurrence and spread of the acute respiratory disease COVID-19 caused by coronavirus SARS-CoV-2, for 2020-2022

Priority #1 Stimulating modernization and improving access to infrastructure
#162 Simplifying the construction of the telecommunications network by facilitating the registration of declarations of readiness for operation by the third quarter of 2020
#163 Simplifying the certification of telecommunications equipment already certified in EU countries by the third quarter of 2020
#164 Accelerating the introduction of new radio technologies and services: increasing the volume of allowable frequencies and introducing the principle of technological neutrality by the third quarter of 2020
#165 Improving the efficiency of the use of existing radio technologies and creating competitive conditions for access to radio technologies by the third quarter of 2020
#166 Increasing the emission limit values for mobile base stations by July 2021
#167 Connecting social infrastructure facilities to fiber-optic networks by December 2024
#168 Launching high-speed internet coverage of railways by 2021
#169 Arranging entry/exit checkpoints, improvement of the necessary infrastructure for citizens crossing the demarcation line in Donetsk and Luhansk oblasts and the administrative border of the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol by 2020–21
#170 Encouraging the registration of companies in Ukraine: improving the protection of intellectual property rights and the introduction of preferential tax treatment, as well as ensuring the protection of personal data in accordance with the General Data Protection Regulation (GDPR) by the third quarter of 2020
#171 Creating an automated information-analytical system of the regulatory body used to perform its powers, transition to digital interaction between the regulatory body and providers of electronic communications services;
settling the issue of access to electronic communication networks of operators and their infrastructure, which should reduce the costs of operators for the deployment of networks; and determining service quality parameters by the second quarter of 2021

Priority #2 Providing access to markets
#172 Developing and implementing the concept of an extraterritorial technological zone for the information technology sector, aimed at creating favorable conditions for the development of information technology in Ukraine by the third quarter of 2020
#173 Stimulating existing and new related industries: improving the legal framework in the field of virtual assets and cybersecurity by 2020–21

Priority #3 Ensuring the development and realization of talents
#174 Simplifying the hiring of foreign highly qualified workers by the third quarter of 2020
#175 Developing entrepreneurial education and entrepreneurial culture (higher education reform, creation of national development programs) in the field of information technologies by the third quarter of 2020

Source: Authors, based on publicly available information.

Definition of Broadband

The term "broadband," in the context of internet access, does not have a specific technical meaning but is used to refer to any infrastructure for high-speed internet access that is always on and faster than traditional dial-up access.

Broadband connectivity is typically referred to as access to a communication network of certain quality, for example, determined by the amount of information one is able to obtain/provide at a certain time instance. To operationalize this definition, one has to enrich it with some quantitative indicators, taking into account both the end-user's demand and the provider's supply.

The European Commission (EC) has defined different categories of broadband in terms of speed:

- Broadband – at least 144 Kbps – EuroStat[2]
- Basic broadband – at a speed of at least 2 Mbps – Gigabit Society
- Basic broadband for speeds of 30 Mbps – Gigabit Society
- Fast broadband for speeds above 30 and below 100 Mbps
- Ultrafast broadband for speeds higher than 100 Mbps

In its 2018 report, the National Commission for the State Regulation of Communications and Informatization of Ukraine (NCCIR) classified broadband as access to the internet at a speed above 256 Kbps, with reference to the threshold established by the International Telecommunication Union (ITU) in 2001.[3] Although gathering data on 256 Kbps may have operational benefits, it is not particularly useful from the standpoint of long-term planning for sector development. Today, 256 Kbps (dial-up internet) is equivalent to a poorly functioning black-and-white television, which very few in Ukraine are still using.

The Ministry of Digital Transformation (MDT), the line ministry responsible for the development of information and communications technology (ICT) in Ukraine, believes that the value of 256 Kbps should be increased. In the newly adopted Law No. 3014 on Electronic Communications, the broadband threshold is to be set by legislation, and broadband access as such is defined as access to the internet "with a transmission rate that is not lower than the one determined pursuant to the legislation and without the use of channel switching systems."[4] Although the exact speed range remains unclear, it effectively excludes dial-up internet.

[2] For more on the definition, see https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Broadband.

[3] Although there were attempts to review this threshold, no consensus emerged on a new acceptable baseline. See ITU and others, "The State of Broadband: Broadband Catalyzing Sustainable Development" (Geneva: International Telecommunication Union, 2018), https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.19-2018-PDF-E.pdf.

[4] The law can be found at http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=68059.

High-Speed Connectivity Goals

The MDT's current vision[5] is that Ukraine should strive to ensure 30 Mbps (fast internet) connectivity throughout the country, with 100 Mbps across all urban areas and at least this speed in the five biggest cities (Kyiv, Dnipro, Lviv, Odesa, and Kharkiv). The MDT also believes that modern learning and medicine requirements call for public institutions, especially education and health care facilities, to provide 100 Mbps+, with the capacity to upgrade to 1 Gbps. **This vision seems to be realistic, given the improving coverage—both fixed and mobile—from the standpoint of technologies (the rapid growth of 4G, the planned introduction of 5G, and the fact that over half of the country's households are connected to fiber optics).**

The European Gigabit Society recommends that EU member states should improve their telecommunication infrastructure to provide internet connections with download/upload speeds of 1 Gbps for schools, transport hubs, and public services providers, and 100 Mbps for households in rural and urban areas.[6] It is thus clear that **the current vision of the MDT largely aligns with that of the EU, except for rural broadband connectivity.**

Regardless of the ultimate goals that Ukraine pursues, they would need to be validated by the market players. Prior to the establishment of the MDT, the Ministry of Economic Development and Trade (MEDT) initiated a working group consisting of government stakeholders and industry associations, which, among other issues, deliberated on the definition of broadband. A similar approach of soliciting stakeholder feedback may be instituted by the MDT, including through virtual consultations when public consultations are not possible due to the epidemic situation or otherwise, to allow the participation of stakeholders who are outside the capital.

It is also important to highlight that regardless of the broadband definition that Ukrainian policy makers choose, **good practice says that the definition should be periodically reviewed to satisfy the access requirement at a given degree of technology maturity on the market.** For instance, contemporary households may require a minimum threshold of 30 Mbps, given their daily bandwidth needs (e.g., internet provider (IP) communications, video streaming, gaming); however, their requirements just five years ago were different. Education and health care institutions may not seem to require 100 Mbps with a capacity to upgrade to 1 Gbps today, but higher-intensity bandwidth requirements for conducting applied research, telemedicine, or surgical procedures will emerge in the future, as Ukraine finishes its health care reform program and joins more and more programs under Horizon 2020. And the same is likely true for businesses and public administrations, whose needs for daily video conferencing and fast data exchange will gradually increase over time.

The above is especially relevant during *force majeure* events, like the COVID-19 outbreak, affecting people's internet usage patterns. The increased demand for home entertainment has caused the loads on broadband networks worldwide to skyrocket during the pandemic.[7] The same pattern can also be observed in Ukraine as seen in the figure below, which presents the relative change in broadband speeds with respect to the average over the 12 previous weeks. It can be clearly seen that when COVID-related restrictions were imposed in the country, the massive downloads dropped the available speeds by 15–20 percent in both fixed and mobile broadband segments.[8]

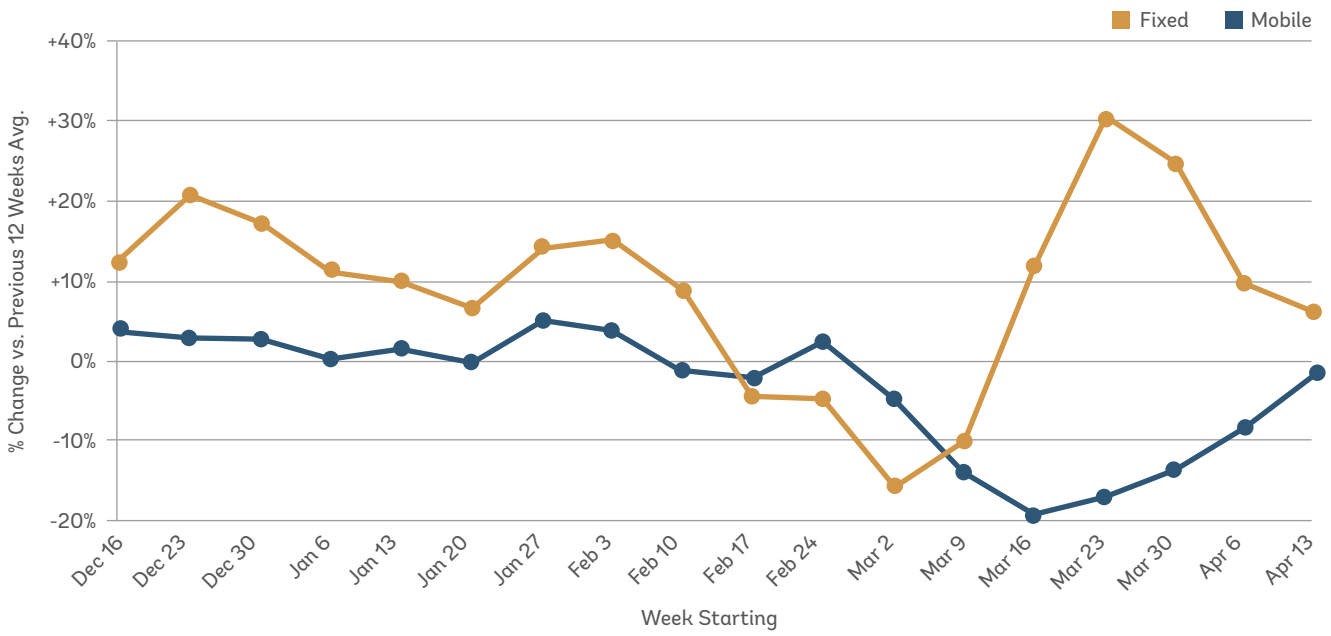
[5] Available at https://thedigital.gov.ua/storage/uploads/files/page/Policy_digital_infrastructure_v3%20(1).pdf (in Ukrainian).

[6] European Commission, "Connectivity for a European Gigabit Society," https://ec.europa.eu/digital-single-market/en/policies/improving-connectivity-and-access.

[7] D. George, N. Afonso, and F. Elizalde, "Covid-19 Impact: Fixed Broadband Rises to the Challenge amid Unprecedented Demand," GSMA Intelligence, April 2020, https://data.gsmaintelligence.com/research/research/research-2020/covid-19-impact-fixed-broadband-rises-to-the-challenge-amid-unprecedented-demand.

[8] The Ookla® Speedtest® can be found at https://www.speedtest.net/insights/blog/tracking-covid-19-impact-global-internet-performance/#/Ukraine.

FIGURE A2.1.
Ukraine's Change in Broadband Download Speeds Compared to the Average



Source: Ookla®.

Based on the mutually agreed operational definition of broadband and broadband goals, the MDT and NCCIR should assess connectivity throughout the country, identify settlements where the connection quality does not satisfy the basic technical requirements, and determine an appropriate course of action—on the regulatory side and/or through public investments. To benchmark against comparator countries, Ukraine's policy makers may want to consider aligning their definitions and broadband statistical reporting to the Digital Economy and Society Index (DESI), "a composite index that summarizes relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness." DESI requires reporting on fast (at least 30 Mbps download) and ultrafast (at least 100 Mbps download) broadband.[9]

Official statistics on broadband should also take into account the following parameters:

Connectivity (availability/coverage)

The user experience is best when internet is easily available in different places, such as cities and rural areas as well as major roads and railways; all of these places should have uninterrupted wireless broadband coverage.

Speed

Broadband definitions typically outline download speed requirements. However, upload speed should not be neglected. Ideally, official statistics should collect data on the speed ranges (0–30 Mbps; 30–50 Mbps; 50–100 Mbps; and 100 Mbps+) available and used.

Capacity

This parameter is important for mobile and wireless networks and shows how many customers might have good connectivity in the same place. It is especially important for crowded places, such as stadiums, university campuses, and railway and bus stations.

[9] See https://ec.europa.eu/digital-single-market/en/desi.

Latency

Latency is a parameter that shows the time delay between a user's request and the service response. This is critical now for any kind of electronic transaction, including e-commerce, involving payments and Internet of Things (IoT) applications. In the future, however, high latency may undermine e-health services and any virtual reality applications.

Price

The service price is a key factor influencing the degree of broadband adoption. On the one hand, it determines how affordable this service is for the population and hence drives demand. On the other hand, it incorporates the deployment costs for the service providers, thus dictating the possible supply.

Recommendation 1:

Consult with the private sector on the goals as currently proposed relative to those used in the EU. Incorporate the assumptions of the private sector into the connectivity growth forecast, based on the collected data. Set goals that are realistic yet sufficiently ambitious and future-oriented.

Recommendation 2:

Work closely with the State Statistical Agency of Ukraine (UkrStat) to align the statistical effort in the area of broadband connectivity with that of EU's Digital Economy and Society Index (DESI). This could be achieved by, among other measures, inscribing the DESI indicators into any respective changes to the annual plans of UkrStat's state statistical observations. Collect broadband statistics by speed ranges.

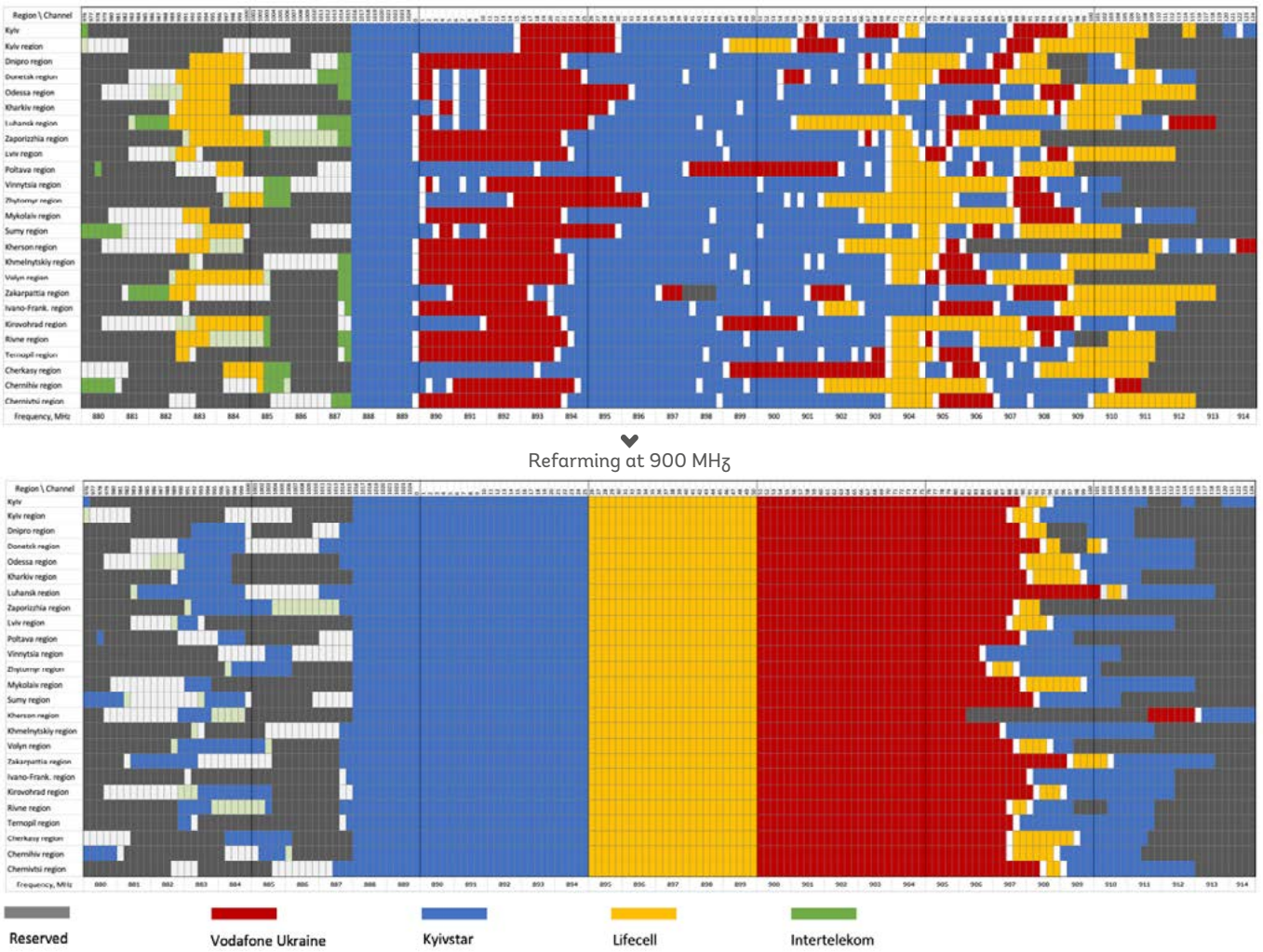
Recommendation 3:

Cooperate with the Body of European Regulators for Electronic Communications (BEREC) to learn from operators about the best practices of data collection, aligned with the DESI indicators.

ANNEX 3. 4G/5G SPECTRUM – SITUATION ANALYSIS

4G LTE in Ukraine operates in the bands 1800 and 2600 MHz. The corresponding spectrum has already been auctioned, and mobile network operators (MNOs) have already been deploying LTE throughout the country. 4G LTE also requires spectrum at 800–900 MHz for mobile coverage in rural areas. It is noteworthy that **to enable further implementation of 4G LTE, it is necessary to ensure that at least 5 MHz continuous spectrum is available to MNOs**, which is currently not the case.

FIGURE A3.1.
Ukraine's Change in Broadband Download Speeds Compared to the Average



Source: NCCIR.[1]

[1] Based on NCCIR decision N° 510, October 29, 2020.

As can be seen from the figure above, **current spectrum allocation in the E-GSM uplink band (880–915 MHz in uplink and 925–960 MHz in downlink) is quite fragmented,** which makes the usage of the available spectrum inefficient. For instance, to ensure the suppression of unwanted emissions, operators need to cut off guard bands of 0.1 MHz from each side of their owned bands. **Thus, the more separated chunks of spectrum an operator owns, the more spectrum is wasted on guard bands. Moreover, such fragmentation prevents the ownership of a continuous chunk of spectrum and makes it impossible for operators to roll out 3G/4G in those bands.**

In addition, as the spectrum allocation varies across regions (the vertical dimension of the figure), **additional spatial isolation at oblast borders is required.** That is, as with the guard bands, the operators have to provide guard spaces or invest in specialized equipment with better filters to suppress interference to and from neighboring regions where they are allowed to transmit at the same frequency.

To fix the current situation of inefficient spectrum use in Ukraine, spectrum refarming should be performed in the 700–900 MHz band. In other words, the available spectrum should be reshuffled to gather adjacent frequencies into several larger chunks to be owned by a single operator each to allow the operators to deploy the technology they prefer to roll out. This would remove the necessity of guard bands and spatial regions, yielding improved spectrum utilization and allowing the entrance of new technologies.

After refarming (according to the allocation presented in the figure above), the number of guard channels wasted on guard bands will significantly decrease. Moreover, with the proposed continuous allocation, all the operators are ready to invest in better filters, hence eliminating the need for guard bands between the bands owned by different operators. **The resulting gain from spectrum refarming would be 1.48 MHz on average (across the regions), which was previously wasted on guard bands alone.**

It is also noteworthy that there is an allocation of 8 MHz in the E-GSM band given to the technology CDMA-800. To comply with the recommendations of the European Commission (EC) for spectrum harmonization, this spectrum should be instead released for LTE. Currently, this spectrum is utilized by Intertelekom to serve a niche market with country-wide connectivity. However, as Intertelekom has obtained permission to deploy LTE in the 800 MHz band, its network will gradually be transformed to provide additional LTE coverage, provided it settles its financial issues and current dispute with the regulator.[2]

Some of the bands in the 900 MHz region are reserved for special communication players, such as the military and close-range navigation services for jets. **This spectrum needs to be eventually reallocated to LTE and auctioned to mobile operators. Though complex, it is an essential step of tremendous importance for mobile broadband infrastructure development.** To move forward, all possible solutions should be identified and explored. The release of spectrum is apparently closely linked to the need to modernize old planes and the navigation equipment that utilizes those frequencies. To expedite the process, the Governement of Ukraine (GoU) may seek to release this spectrum through a special partnership whereby MNOs would commit to fully or partially financing the modernization costs of the old planes and their navigation equipment (utilizing those frequencies), financing that would count toward the relevant spectrum price.

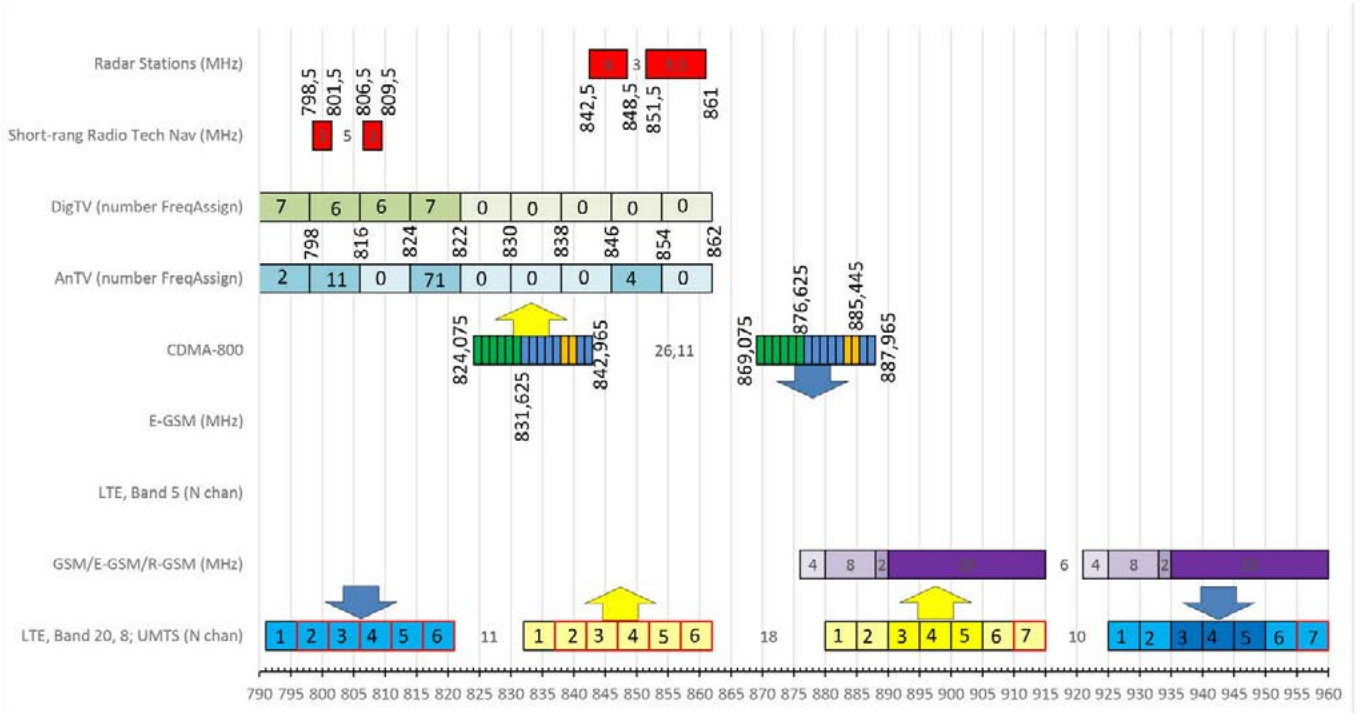
Figure A3.2 illustrates the spectrum allocations in the 800–900 MHz band.[3] **The regulator has now agreed to redistribute GSM 700–900 MHz licenses for LTE and agreed on specifications for converting spectrum from military to civilian use.**[4]

[2] See "Court Suspends Regulator's Decision to Cancel Intertelecom's 4G Licence," CommsUpdate, April 8, 2020, https://www.commsupdate.com/articles/2020/04/08/court-suspends-regulators-decision-to-cancel-intertelecoms-4g-licence/.

[3] Original can be found at https://eimg.pravda.com/images/doc/e/b/eb09423-2-3g-ukraine-original.jpg.

[4] NCCIR decision N°23, January 21, 2020; see also https://www.gsmsota.com.ua/blog/novosti/mobilnym-operatoram-razreshili-poluchit-novye-litsenzii-na-4g/.

FIGURE A3.2.
Spectrum Allocations in the 700–900 MHz Band



Source: NCCIR.

It is important to note that MNOs should be left with a choice of technology to deploy in their own spectrum (technology neutrality principle). Moreover, to facilitate technology migration, the GoU should conduct a public information campaign to raise awareness of the ongoing changes and increase the public's acceptance of the new technology.

The upcoming introduction of 5G could be approached by operators according to one of two strategies:

- Prioritize 5G investments, expecting accelerated commercial interest
- Upgrade existing networks for as long as possible, trying to transition smoothly

Ukrainian operators are likely to take the second path. However, even in that case, they will need to increase infrastructure (e.g., new macro sites or small cells) spending to cope with the growing traffic. **The point in time when most operators in the world will start running out of capacity is likely to be around 2025.**[5]

Even though low-frequency spectrum will eventually be auctioned, operators are likely to use those for a short-term increase in 4G traffic. **Global mobile players are testing a range of spectrum for 5G, from 3.5 to 80 GHz.** The trajectory is likely to look as follows. First, acquire 3.5 GHz bands over the short to medium term. Then, move to 26 and 28 GHz bands for the indoor coverage.

These above-mentioned bands will be the first up for auction in most of the world. **The benefit of the new spectrum is greater bandwidth and a subsequent increase in air capacity.** For example, the European

[5] F. Grijpink, A. Menard, and H. Sigurdsson, "The Road to 5G: the Inevitable Growth of Infrastructure Cost," McKinsey and Company, February 23, 2018, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-road-to-5g-the-inevitable-growth-of-infrastructure-cost.

Union is releasing up to 400 MHz bandwidth in the 3.5 GHz band. As mentioned before, operators that do not resort to these acquisitions and continue to rely on legacy bands will eventually run into capacity issues.

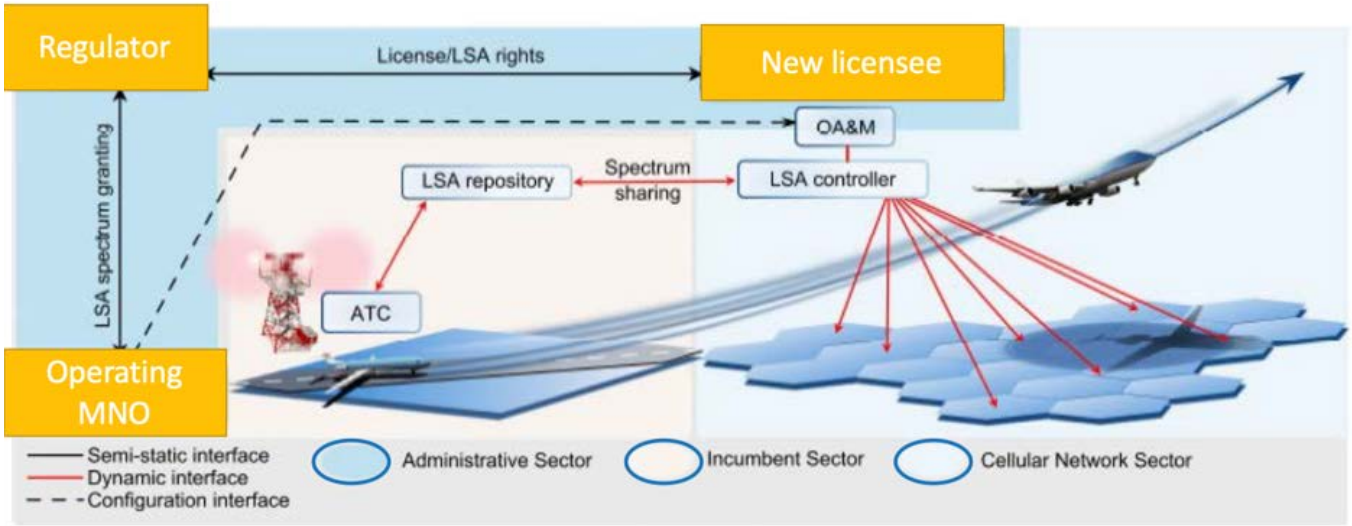
It is worth mentioning that certain spectrum bands in the attractive 2600 and 3500 MHz range are held by specific non-telecom players that are not utilizing the spectrum for any important services. Those players are using the fact that the current rent in those bands is quite low and are simply waiting for the next auction to obtain considerable funds from the operators interested in spectrum resource.[6] As a possible solution, the GoU could harmonize the prices for spectrum across all the bands. That is, the rent prices in the bands 2300–2400 MHz and 3400–3800 MHz should be matched to those in 900 and 1800 MHz, regardless of the current technology implemented there. This way, the state could free up important bands that will soon be required for the deployment of 5G.

In addition to the continuous rise in data traffic over mobile broadband networks, **there has been growing interest worldwide in using 4G/5G cellular networks for providing local connectivity in a range of sectors, such as manufacturing, enterprise, logistics, mining,** and agriculture. Given the the local nature of such spectrum demand and the fact that it becomes increasingly difficult to free up new spectrum, license-shared access (LSA) might provide decent connectivity for such scenarios. For example, a regulator could allow mobile access to be provided in certain bands for geographical areas and time instances where other services are not using them. The advantages of this approach would be the following:

- Financial benefit for the primary operator from the underutilized parts of the spectrum
- Spectrum harmonization and efficient utilization for the regulator
- Opportunity to use the spectrum at a discounted price for the licensee/secondary operator

LSA would support innovation and enable private networks for new use cases, such as low-latency automation, industrial Internet of Things (IoT), enterprise-deployed secure private networks within its premise, and fixed wireless access in rural areas. Such an approach also could help in accessing some of the rarely used frequencies occupied by special users (see **figure A3.3**).

FIGURE A3.3.
Example of an Implementation of LSA for Jet Navigation Systems



Source: Kyivstar.[7]

[6] See https://www.epravda.com.ua/publications/2017/07/12/626921/ (in Ukrainian).

[7] See https://www.itu.int/en/ITU-D/Regional-Presence/CIS/Documents/Events/2016/11_Kiev/Igor%20Yereshchenko.pdf (in Russian).

Nevertheless, the implementation of LSA would require careful regulatory and legislative efforts. First of all, LSA should be allowed after changes to the current law.[8] The changes introduced should be a complementary framework to the current one in which exclusive licensing remains at the core. LSA policy should also be comprehensive and investment friendly and ensure a high quality of service for consumers. MNOs should be allowed and incentivized to share the spectrum they own to support faster services, improve coverage, and drive innovation. Furthermore, it should be noted that LSA will be useful only in bands of sufficient amounts that are harmonized for mobile use.

Another important aspect that should not be ignored is the issue of radiophobia among the general public, as it creates serious problems for Ukraine's MNOs.[9] The network rollout cannot be conducted in certain areas due to prohibitions on access to infrastructure and collective petitions from poorly informed local populations. There are numerous conspiracies circulating about wireless networks and the supposedly accompanying radiation. A recent example is the believed connection between 5G and the spread of COVID-19, which has led to numerous base stations being damaged in the United Kingdom and Canada.[10] In Ukraine, there is already an online petition to the president on the subject.[11] **An appropriate response, preventing a potential backlash against 5G, would require a targeted information campaign, explaining to the public the principles of network operation and sharing the conclusions of reputable insitutions in the field, such as the World Health Organization, on the issue.**[12] **Both the government and MNOs should join forces to tackle this contentious issue.**

On the administrative side, and to support transparency in spectrum management, it is recommended that the presentation on spectrum usage be improved by developing an online visual tool. As an official record, Ukraine maintains a publicly available table of frequency allocations containing a list of allocated frequency bands between 9 kHz and 275 GHz.[13] The regulator also maintains an Excel file with a list of all active, extended, and expired licenses. Both instruments provide a record but are not visualizing the actual situation with regard to spectrum usage and are difficult to use for this purpose. For more convenient spectrum management and for the oversight of radio frequency spectrum use, it is recommended that an online service with visual representation of frequency allocations be used. Nearly all developed countries are using this approach.[14]

Recommendation 1:

Improve efficiency in spectrum use by prioritizing spectrum refarming in the 700–900 MHz band.

Recommendation 2:

Reallocate spectrum that is reserved for special communication services to LTE and auction it to mobile operators.

Recommendation 3:

Implement license sharing access, allowing mobile operators to access the reserved spectrum on the condition that they guarantee the primary users owning that band undisturbed operations.

8 The relevant laws are available at https://zakon.rada.gov.ua/laws/show/1770-14 (section 6, paragraph 7).

9 Interviews with MNOs, March–May 2020.

10 See "Mast Fire Probe Amid 5G Coronavirus Claims," *BBC News*, April 4, 2020, https://www.bbc.com/news/uk-england-52164358; and "Two Arrested after Two More Quebec Cell Towers Go up in Flames," CTV News, May 7, 2020, https://montreal.ctvnews.ca/two-arrested-after-two-more-quebec-cell-towers-go-up-in-flames-1.4928666.

11 See https://petition.president.gov.ua/petition/92038.

12 See WHO, "5G Mobile Networks and Health," February 27, 2020, https://www.who.int/news-room/q-a-detail/5g-mobile-networks-and-health.

13 Text available at https://zakon.rada.gov.ua/laws/show/1208-2005-%D0%BF.

14 NASA, "Electromagnetic Spectrum Regulation," October 29, 2012, https://www.nasa.gov/directorates/heo/scan/spectrum/txt_accordion3.html.

Recommendation 4:

In cases where the above is not possible (e.g., old jet navigation), consider putting the burden of aircraft renewal on the operator that wants to acquire the corresponding range in the T-GSM band.

Recommendation 5:

Free up the important 5G spectrum by increasing the rent for the owned frequencies in the 2600 and 3500 MHz bands.

Recommendation 6:

Consider matching spectrum supervision rates in the 5G bands 2300–2400 MHz and 3400–3800 MHz with those in 900 and 1800 MHz, regardless of the current technology implemented there.

Recommendation 7:

Arrange for the GoU, together with MNOs, to hold a targeted information campaign on 5G network operations to increase the public's knowledge of the radiation aspects.

Recommendation 8:

Develop online service with a visual representation of frequency allocations for better spectrum management and transparency and for the oversight of radio frequency spectrum usage.

ANNEX 4. INTRODUCTION TO 5G

This annex provides an introduction into fifth generation, or 5G, and the opportunities it offers. It also offers some recommendations to support and facilitate the implementaiton of this technology. There is a specific focus on infrastructure sharing because this policy is both an important enabler of a 5G network rollout and is not yet a common practice in Ukriane.

5G is expected to be one of the most important stepping stones to Ukraine's digital economy and society in the next decade. It has the potential to provide ubiquitous coverage, as well as ultrahigh-speed and low-latency connectivity to everyone and everything. 5G is also a superior technology to all the previous generations of wireless networks.

The drivers for the various generations of mobile communications can be summarized as follows:

1G: Mobile voice calls
2G: Mobile voice calls and SMS
3G: Mobile web browsing
4G: Mobile video consumption and higher data speed
5G: Technology to serve consumers and industries

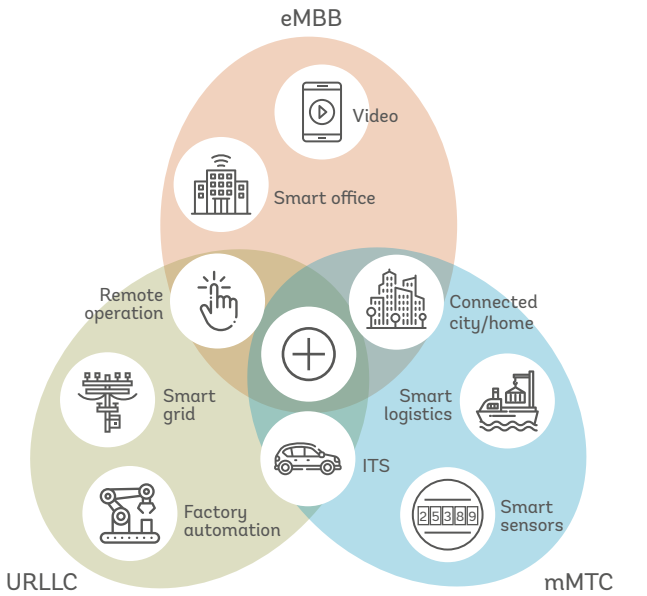
It is worth noting that the development of previous generations of mobile communications were mostly consumer-led. In contrast, 5G mobile networks target industry (enterprises). 5G will allow sectors of the economy to reinvent themselves, enabling novel and revolutionary ways of manufacturing (known as Industry 4.0).

5G has the capability to transform entire industry sectors, including agriculture, manufacturing, defense, transport, public infrastructure, and health care. It is already possible to start deploying 5G in factories, sports arenas, and universities, and along roads and railways, even prior to a national rollout. Ukraine, an agriculture powerhouse of Europe, has a real chance to revive its manufacturing through an industrial Internet of Things (IoT), for which it was known in the past. Manufacturing would help its evolving defense industry and aviation and support efforts to make advancements in transport and new materials production.

Technically speaking, 5G is a technology designed to satisfy the IMT-2020 requirements set by the ITU-R specification M.2083.[1] **5G New Radio (NR) is superior to the currently deployed 4G LTE (IMT-Advanced) technology in that it aims to provide 20 times the peak data rate, 10 times lower latency, and three times more spectral efficiency compared to 4G LTE.**

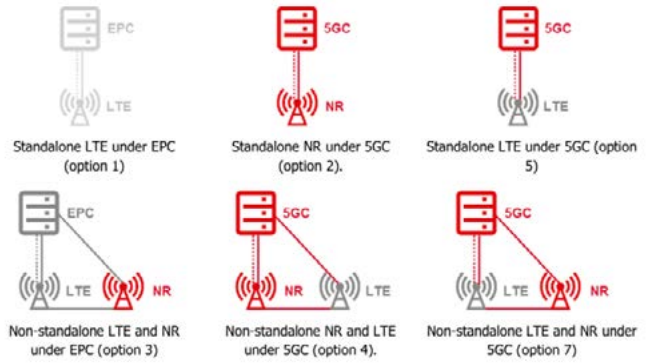
As elsewhere, 5G will help Ukraine significantly increase the variety of new applications and business services, and hence will stimulate demand for connectivity and the emergence of startups offering novel business models and products/services. For example, the capability of high-speed data transfer will enable high-definition streaming. Also, 5G is designed to address emerging critical applications, such as the industrial internet, smart grids, infrastructure protection, remote surgery, and intelligent transportation systems, by means of ultra-reliable low-latency communication. Last but not least, 5G will provide the possibility of fully leveraging the IoT applications, for example, the deployment of thousands of low-cost monitoring sensors that would be served by the network, thus enabling efficient monitoring and actuation. It is expected that machine-type communication, augmented decision support, and demand-driven supply chains will be powered by 5G. See **figure A4.1** for an illustration of the main 5G use cases, alongside some examples of potential associated applications.

FIGURE A4.1.
Main Use Cases and Applications for 5G



Source: Ericsson.[2]

FIGURE A4.2.
5G Rollout Options: Standalone and Non-Standalone



Source: GSMA.[3]

In addition to NR access technology, 5G also contains an own-enhanced 5G core (5GC) network. However, unlike 4G technology, in addition to a standalone solution, 5G allows for several hybrid non-standalone configurations (see **figure A4.2**). Namely, **to speed up the rollout and simplify a handover between generations, it is possible to deploy a radio access network and a core network of different generations.** For example, 5G NR access could be served by a 4G packet core.

A hybrid non-standalone introduction will eventually be followed by a full-blown standalone 5G architecture. One benefit of the latter is the new virtualized software-based core infrastructure. This allows for network function virtualization, moving hardware-based network functions to virtual servers and providing further flexibility in configuration, scaling, and load balancing. Another benefit is the so-called network slicing feature that divides the network into a set of logical software-based networks, each tailored to a particular service of interest. Network slicing ensures the most economical service differentiation while meeting end-user quality requirements.

In the case of Ukraine, the most critical bottleneck to a 5G rollout is related to spectrum. **The state needs to free up frequency spectrum from other services that are currently occupying it (e.g., military, radar, satellites) to enable 5G.** In certain cases, this would require that spectrum sharing with other sectors be implemented (e.g., a coexistence of military services with mobile communication networks). The first 5G deployments are likely to start at higher frequencies (e.g., mm-wave bands) and then successively migrate to the mid-bands.

Recent developments due to the COVID-19 outbreak have demonstrated the importance of planning for certain aspects of the network. First of all, as was described in **Annex 2**, the outbreak led to lockdowns in many places that were followed by immediate spikes in traffic, especially in residential urban and rural areas. This required certain operators to call for disciplined use of the network, while content providers had to lower the bitrates and disable HD streaming.[4]

[2] O. Teyeb and others, "Employing LTE to Fit the 5G Future," *Ericsson Technology Review*, January 31, 2017, https://www.ericsson.com/4ae09e/assets/local/reports-papers/ericsson-technology-review/docs/2017/etr_evolving_lte_to_fit_the_5g_future.pdf.

[3] GSMA, "Road to 5G: Introduction and Migration," https://www.gsma.com/futurenetworks/wp-content/uploads/2018/04/Road-to-5G-Introduction-and-Migration_FINAL.pdf.

[4] A. Hartmans, "Netflix is Reducing the Quality of its Streams in Europe to Avoid Straining the Internet During the Coronavirus Outbreak," *Business Insider*, March 19, 2020, https://www.businessinsider.com/eu-netflix-hd-video-internet-strain-coronavirus-outbreak-2020-3?r=US&IR=T.

In addition, due to the deadly nature of COVID-19, there was a huge increase in the number of voice calls.[5] **This has raised the importance of packet-switching features, such as VoIP/VoWiFi and VoLTE/VoNR**, that route voice calls over the internet and avoid overloading the load-susceptible voice-calling services. Since this requires the support of the feature by both the device and the network,[6] the Government of Ukraine **(GoU) should encourage mobile network operators (MNOs) to include this feature in the default service package and offer devices that support voice calls over the internet.**

Recommendation 1:

Ensure the availability of spectrum for 5G by implementing a refarming in lower frequencies and removing the players that are not utilizing the spectrum in the mid-band ranges.

Recommendation 2:

Develop and implement additional regulations in the field of artificial intelligence (AI).

Recommendation 3:

Establish regulations to control the use of private and sensitive information gathered by sensors.

Recommendation 4:

Arrange for the establishment of a data management framework for the GoU and develop a set of regulations regarding cybersecurity, AI, and big data analytics, including on the sectoral level

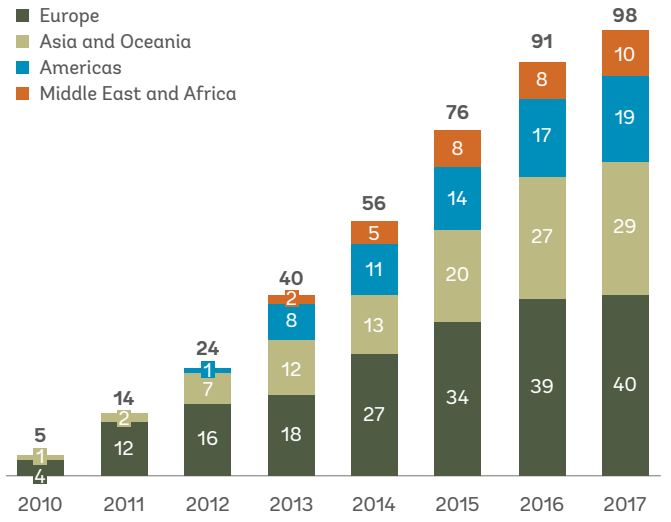
Recommendation 5:

Encourage operators to include VoLTE/VoNR in the default service package and offer devices that support these technologies.

Infrastructure Sharing to Support a 5G Network Rollout

Network (infrastructure) sharing can help reduce the network investments of MNOs and internet service providers (ISPs) and accelerate the rollout of otherwise infeasible communciation networks. Operators have been able to achieve up to a 30 percent reduction in the total cost of ownership, at the same time improving network quality by sharing their network equipment.[7] For ISPs, infrastructure sharing saves up to 80 percent of network deployment costs for certain technologies.[8] In fact, network sharing has gone mainstream[9]—see **figure A4.3** below illustrating the growth in the number of network-sharing agreements only since 2010.

FIGURE A4.3.
Number of Network-Sharing Agreements World-Wide



Source: McKinsey (see note 9).

5 M. Holroyd, "Europe's Coronavirus Lockdowns are Making Phone Calls Popular Again," *Euronews*, March 25, 2020, https://www.euronews.com/2020/03/25/europe-s-coronavirus-confinements-spark-voice-call-resurgence.

6 Huawei Technologies, "Vo5G Technical White Paper" (Shenzhen, China: Huawei Technologies, 2018), https://www-file.huawei.com/-/media/corporate/pdf/white%20paper/2018/vo5g-technical-white-paper-en-v2.pdf?la=en.

7 F. Grijpink and others, "Network Sharing and 5G: a Turning Point for Lone Riders," McKinsey and Company, February 23, 2018, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/network-sharing-and-5g-a-turning-point-for-lone-riders.

8 EC, "Impact Assessment Accompanying the Document Proposal for a Regulation on Measures to Reduce the Cost of Deploying High-Speed Electronic Communications Networks" (Brussels: European Commission, 2013), https://ec.europa.eu/digital-single-market/en/news/impact-assessment-accompanying-document-proposal-regulation-european-parliament-and-council.

9 World Bank, "World Global Toolkit on Cross-Sector Infrastructure Sharing: Module 8 of the Broadband Strategies Toolkit" (Washington, DC: World Bank, 2017), https://ppiaf.org/documents/4709/download.

Potential cost savings are even larger for the upcoming 5G neworks that will feature cell densification. For example, the cost of small-cell deployment can be halved if three or more players share the same network. Also, **the benefits go beyond just cost cutting: joint network rollout makes it possible to minimize the urban disruptions and visual effects of equipment installation in urban landmarks.** In the context of 5G, early planning may even allow for an extreme rollout: a single 5G network shared by all MNOs, whereby entry into the market would be implemented through spectrum ownership.

Cross-sector infrastructure allows for deployment costs to be lowered and market entry to be simplified. The sharing market segment would also leverage the existing assets and generate additional revenue.

Utilities—such as electricity and water providers—operate over infrastructures similar to that of traditional telecommunications networks. Therefore, **such infrastructure could, in principle, be shared for telecommunications purposes. Figure A4.4** below illustrates other types of utility providers that can be leveraged.

FIGURE A4.4.
Potential Utility Providers to Share Infrastructure

Network/ opportunity	Capilarity			
	City backbone	Street backbone	Building	
Water	→	→	→	
Gas	→	→	→	
Electricity	→	→	→	
Teleheating	→	→	→	
Sewage	→	→	→	
Public lighting	→	→		
Traffic lights	→			
Third parties ducts	→	→	→	
Transportation (rail, subway, tram)	→			
Third party fiber networks	→	→	→	
Maintenance and new additions	→	→	→	Spot
New construction areas	→	→	→	Spot

Source: World Bank.[10]

Moreover, utilities usually have better rights, land arrangements, and access to infrustracture objects (e.g., ducts, poles, and service plants). But most importantly, **they can help to extend MNOs' reach to previously underserved areas.**

Traditionally, utilities have been used to provide backbone and backhaul fiber connection. However, **this infrastructure is often serving wholesale and even retail access**. Cooperation with telecommunications providers varies from state-owned wholesale operators to independent retail operators. There has also been growing interest in having these players become telecommunications operators. For example, Ukrgazteklhzvyazok has registered in the National Commission for the State Regulation of Communications and Informatization's (NCCIR) registry of operators and ISPs, listing the provision of telephony and internet access as its main activity (the company uses its own fiber assets).[11]

To operationalize infrastructure sharing, the GoU should ensure that European Union (EU) rules[12] on this subject are fully implemented. It should also establish a single information point and a dispute-settlement body, as well as other competent bodies to effectively undertake these tasks. This may be implemented through the introduction of amendments to the existing Law on Access to the Objects of Construction, Transport, Energy for the Purpose of Development of Telecommunication Networks (No. 1834-VIII). Reforms related to the implementation of the European Electronic Communication Code (EECC) will further encourage an efficient use of infrastructure by promoting site sharing.

[10] World Bank, "Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps" (Washington, DC: World Bank, 2019), http://documents.worldbank.org/curated/en/674601544534500678/pdf/Main-Report.pdf.

[11] See http://utg.ua/img/menu/company/dodatok_UGTZ.pdf.

[12] These are found in Directive 2014/61EC.

Recommendation 6:

Complete the transposition of Directive 2014/61EC with regard to the implementation of a single information point and a dispute-settlement body through relevant amendments to the Law on Access to the Objects of Construction, Transport, Energy for the Purpose of Development of Telecommunication Networks (No. 1834-VIII).

Recommendation 7:

Organize capacity-building activities on all levels of government to promote infrastructure sharing.

ANNEX 5. 5G AND CYBERSECURITY[1]

This annex provides a general overview and set of recommendations that are country-agnostic with regard to a secure rollout and operation of 5G infrastructure and that may be considered for Ukraine's National Broadband Development Strategy (NDBS). The below box outlines the main messages about cybersecurity for 5G infrastructure.

BOX A5.1.
Main Messages about Cybersecurity and 5G

The past and current generations of mobile phone technology (2G, 3G, and 4G) have serious security weaknesses that have allowed for eavesdropping, the tracking of subscriber locations, data theft, and other criminal acts.

Most of these weaknesses are corrected in the 5G standards. There is a much greater use of encryption and authentication, providing more protection for subscriber identities.

5G is not bulletproof, however. Attacks on 5G networks and their subscribers can still be launched from older networks—5G must connect to them to enable roaming—and many of 5G's security features are options rather than requirements. National governments therefore have crucial roles to play in setting minimum security requirements for the new networks in their countries. Much can be learned from countries that are already adopting these benchmarks.

5G also has new vulnerabilities stemming from more data flowing through the network, greater reliance on configuration by software, and dependence on outside entities such as cloud service providers. Careful vetting of the supply chain and software updates will thus be essential throughout the networks' life cycle.

Source: 5G report, World Bank, forthcoming.

5G's exposure to both accidental and malicious attacks (its "threat surface"3) will increase compared to its predecessors, mainly due to the expected major increase in data traffic and novel types of Internet of Things (IoT)4 users. Gartner (2019) estimates that the number of operator-less terminals ("things") connected to the internet will nearly double in 2020. By then, the installed base of 5G endpoints could include 11.3 million IoT units and up to 49 million by 2023. By 2024, 5G networks are expected to carry 35 percent of global internet traffic, which will almost triple between now and then (Peisa et al. 2020).

The severity of the risks and potential damages of 5G cyberattacks varies with the type of user. The 5G risk landscape includes individual users, connected devices (IoT), mobile network operators, corporate users (businesses), and governments (especially from a public safety standpoint).

The recommendations provided here aim to advise on security-related measures relevant to the preparation, implementation, and operation of 5G networks. The tables below assemble the recommendations for all users and the major actors responsible for 5G network security. Given that Ukraine is actively planning 5G deployment, this annex provides recommendations relevant to countries with no actual implementation plans and to countries that are in the active planning phase.

It should be noted that 5G network operators will be key players in achieving and maintaining the security of 5G networks. Depending on the security measures taken, 5G networks will not all be equally secure. It is recommended that network operators, among other actions, implement the following security measures:

[1] The information is this annex is based on the World Bank's forthcoming flagship report on 5G and more specifically its chapter on cybersecurity. See World Bank, "5G as an Opportunity to Leapfrog Development" (Washington, DC: World Bank, forthcoming).

- internal network security certification
- supply chain verification, including vendor diversification and vendor verification for new network elements, software updates, and maintenance procedures
- definition and implementation of cloud hosting services

The zero-trust principle should be adopted when protecting one 5G subsystem from another, continuously applying a security assurance procedure.

Mobile IoT service operators will need to execute measures similar to 5G network operators. These include internal certification procedures, supply chain verification, cloud hosting service verification, personnel verification, and the provision of increased security services for sensitive users.

More than for legacy networks, the role of governments in defining requirements and supporting 5G security on a national level will be paramount. It is recommended that governments undertake thorough and regular national 5G cybersecurity risk assessments to identify vulnerabilities, threats, and risks and design or adjust the relevant mitigation measures. On the legislative front, it is advisable to define and establish a 5G certification framework that outlines the minimum security requirements to be implemented in 5G networks, as well as arrangements for implementing certification procedures for various defined network elements. It is recommended that a National Cybersecurity Center (as the cybersecurity policy execution body) be closely involved throughout the process. Implementation and usage of certified equipment and procedures in 5G are important from the cybersecurity standpoint and therefore should be consistently encouraged. To facilitate the validation and verification of software updates before implementation, it is recommended that governments (in collaboration with the private sector) establish a national 5G cybersecurity testbed. Another important recommendation is to anticipate the demand for cybersecurity-related skills to ensure an adequately trained labor force.

Table A5.1 targets countries with no current 5G implementation process. **Table A5.2** targets countries in the 5G implementation planning phase. Measures in both are equally relevant for Ukraine, as some active preparatory work on this front has already been conducted.

TABLE A5.1.
Recommendations for Countries with no Current 5G Implementation Process

#	User Group	Recommendations
1.	Individual users	› Encourage users to check personal/business use needs.
2	Mobile network operators	› Actively participate in the national 5G security group (see below). › Define internal network security certification process. › Define supply chain verification processes that include vendor diversification and verification of new network elements, software updates, and maintenance processes. › Define verification process for cloud hosting services. › Define personnel verification program that includes periodic random verifications, distribution of responsibility (avoid single responsibility), and implementation of security training programs.
3.	Mobile IoT service providers	› Identify IoT services requiring 5G capabilities in terms of performance but mainly in terms of enhanced security.
4.	Businesses	› Building the business case for 5G networks: would it be better to implement eMBB, mMTC, and/or URLCC?
5.	Governments, national level	› Conduct a national 5G cybersecurity risk assessment. › Define and adopt a 5G certification framework that should include: • Scope of application in terms of hardware and software, specifying hardware and software components, software updates, applications, services, and cloud hosting services. • Minimum security requirements to be implemented in 5G networks, including the type of encryption used and standardized but not formally mandated solutions defined by 3GPP, such as SUCI. • The certification process. › Create a national 5G cybersecurity group comprised of 5G network operators, operators of critical infrastructures, and the National Cybersecurity Center to maintain 5G cybersecurity. › Estimate the future demand for cybersecurity skills and develop educational tracks to ensure an adequately skilled labor force for 5G cybersecurity job profiles.

TABLE A5.2.
Recommendations for Countries Planning 5G Implementation

#	User Group	Recommendations
1.	Individual users	› Identify 5G utilization needs, considering also security aspects.
2	Mobile network operators	› Implement the internal network security certification process. › Implement the defined supply chain verification process. › Implement the verification process for cloud hosting services. › Due to the need to interconnect with legacy networks, verify the implementation of SEPP according to 3GPP requirements and maintain a whitelist of external connectivity partners. › Since initial 5G implementation in non-standalone (NSA) mode will be based on 4G (LTE) cores, roaming agreements should include definitions of the required proper interconnectivity security. procedures. In this context, use of the Diameter End-to-End Signaling Security (DESS) solutions as specified in recent updates of GSMA standards FS.19, FS.21, and IR.88 is suggested. › Implement a personnel verification program.
3.	Mobile IoT service providers	› Define an internal network security certification process. › Define a supply chain verification process that should include vendor diversification and verification of the following: vendor, new network elements, software updates, and maintenance procedures. › Define a verification process for cloud hosting services. › Define a personnel verification program that includes periodic random verifications, distribution of responsibility (avoid single responsibility) and implementation of security training programs.
4.	Businesses	› Start the commercial phase of security for the network.
5.	Governments, national level	› Set up the implementation of certification procedures through public, private, or international certification bodies. The National Cybersecurity Center should be closely involved in the definition and provide approval of the certification process. › Encourage implementation of certified equipment and procedures in 5G. In justified cases, consider economic incentives, such as fully or partially compensating for equipment custom fees, reviewing frequency licensing fees, and loosening coverage targets for heightened security services. › In collaboration with the private sector, establish a national 5G cybersecurity testbed to validate and verify hardware and software before any 5G deployment takes place. › Create a national forum to promote and debate relevant open 5G issues, including cybersecurity.

ANNEX 6. SUMMARY OF THE COST-BENEFIT ANALYSIS

This annex summarizes the key takeaways from the cost-benefit analysis model for a potential public investment aimed at bridging Ukraine's infrastructure financing gap: the Ukraine Broadband Development Project. It also outlines the model's key assumptions. The model considers the net benefits of investing in broadband infrastructure in areas currently without the technical feasibility for 30+ Mbps connections, that is, effectively without fiber-optic connections that can guarantee an internet speed of 30+ Mbps. The annex also briefly discusses the different financing options available to the Government of Ukraine (GoU).

Summary of the Cost-Benefit Analysis Model

The analysis feeding into this report has made a preliminary estimate of the costs of connecting all households in Ukraine to future-proof technologies. This means providing high-speed broadband connectivity with speeds of at least 100 Mbps for unconnected (no broadband connectivity) and underserved (with below 30 Mbps) households and selected public institutions, including schools and primary health care facilities, all of which are predominantly located in rural areas. The analysis was based on a set of assumptions, such as decreasing deployment costs (due to low labor costs), a further slowdown in fixed broadband penetration growth, and a high level of informality in the sector. **The yielding result (conservative scenario) suggests that covering roughly 4 million of the estimated unconnected households and all of the currently underserved schools (an estimated 3,468) and primary health care facilities (an estimated 3,107) would require investments of over €2.2 billion.**

The estimated amount of project investment (US$199.6 million) is based on the need for broadband connectivity in settlements that currently do not have fiber-optic infrastructure. In order to conduct a cost-benefit analysis within the context of drafting this report, an economic model was developed.[1] The calculations implemented through the model rely on the following data:

(a) According to the Ministry of Digital Transformation (MDT) and Ookla Speedtest Intelligence® data,[2] there are currently 17,988 settlements without fiber-optic connectivity (termed "white areas") in Ukraine, accounting for 12 percent of the population. We adjusted the number of targeted settlements down by 30 percent and recorded the target at 12,429 unconnected settlements (about 30 percent of settlements have fewer than 100 people and might be below the minimum feasible size).

(b) According to the MDT, an estimated 6,544 schools, 7,565 primary health care institutions, and 1.5 million rural households lack access to a fiber-optic network. Similar to settlements, we adjusted the unconnected household numbers down by 30 percent and recorded an estimate of 1.13 million households to be without fiber-optic coverage.

[1] The model was shared with the MDT.

[2] Based on an analysis by the World Bank of Speedtest Intelligence® data for May 2020. The Ookla trademark was used under license and reprinted with permission.

(c) The estimated investment amount needed to roll out the broadband infrastructure to unconnected settlements is in the range of US$344.9–$444.4 million, and additional investments of US$54.3 million are needed for the access network for the aforementioned schools, health care institutions, and rural households. The overall investment amount is in the range of US$399.2–$498.7 million.

(d) Recognizing that part of the required investment amount can be covered via private means, the model considers several scenarios with different private-to-public investment splits. The baseline case used in the model involves a split at 50:50 public-to-private investment, which would result in a required public investment of US$199.6 million (out of a total investment of US$399.2 million).

(e) The model also provides alternative scenarios to the public-to-private investment split. The scenario analysis can be used to adjust the model estimates in line with realized private investments solicited via the auctions process. The current version of the model assumes that private providers' capital expenditures (CAPEX) allow them only to break even. In principle, the auction process should allow the project to maximize the private contributions (of CAPEX) from internet service providers (ISPs), but the exact amounts are typically subject to prevailing market conditions at the time of implementation.

The model applies the discounted cash flow (DCF) approach to calculate the net present value (NPV) and internal rate of return (IRR) associated with the project, taking into account broadband development under a counterfactual scenario without the project. **We estimate the NPV of the project at US$7.6 million and the IRR at 37 percent,** using conservative assumptions (i.e., zero project benefits beyond a five-year horizon and a cost of capital at 26.38 percent). The DCF approach allows for a granular analysis of cash flows associated with the project, including dynamic estimates of benefits that apply to households, schools, and health care institutions, as well as costs that are incurred by the government and the private ISPs.

An alternative approach involves estimating the long-term effects of broadband on various socioeconomic indicators. To arrive at the estimates, the model relies on research papers studying the effects of broadband. For example, in 2009, Qiang, Rossotto, and Kimura studied 120 countries from 1980 to 2006 and found that on average, a 10-percentage point increase in broadband penetration was associated with 1.38 percent increase in GDP growth in developing countries.[3] Applying that estimate to Ukraine (assuming an investment in the order of magnitude suggested by the project), **we estimate the long-term economic benefit of broadband investment to be US$ 455.5 million.** Additionally, if the project allows a doubling of broadband speed in Ukraine, the associated economic benefit could reach US$459.6 million.

Studies of broadband effects on jobs, business creation, and health care suggest that increased broadband penetration **could create an additional 94,600 jobs and over 5,000 new businesses yearly (see table A6.1).** In addition, a broadband-enabled health care system (including telemedicine) makes it possible to enhance treatment outcomes, save on transportation costs, and improve medical care for remote communities. **The estimated savings due to broadband-enabled health care could reach roughly US$1.8 billion per annum.**

Even though it was a preference of the MDT to arrive at these estimates using a multiples approach, the World Bank's position is that **the results should be taken with a grain of salt, as there are concerns about the comparability between Ukraine and the countries studied in the papers that produced these estimates** (e.g., the United States, Western Europe). **Additionally, the broader macroeconomic reality during the project implementation horizon** (e.g., the economic downturn due to the COVID-19 pandemic) **also differs from that studied** in the related research.

[3] C. Qiang, C. Rossotto, and K. Kimura, "Economic Impacts of Broadband," in *Extending Reach and Increasing Impact*, Information and Communications for Development (Washington, DC: World Bank, 2009). Please, note that this estimate relates to broadband penetration rather than broadband coverage, and is derived from the regression analysis of highly heterogenous cross-section of counties." It is an estimate only, and should be treated with caution, given the analysis was performed over a decade ago, and marginal effects of broadband penetration tend to decrease as penetration increases.

TABLE A6.1.
Summary of the Long-Term Benefits of Broadband Investment

Summary measure of project (based on multiples approach)	Long term benefit (in USD)
Additional GDP due to increased BB penetration	$ 455,487,753
Additional GDP due to increased BB speed	$ 459,600,000
Additional GDP due to increased use of BB infrastructure	$ 448,886,481
Additional jobs created (per year) due to increased BB penetrarion	94,605
Additional businesses created due to increased BB penetration	5,785
Savings due to broadband-enabled healthcare	$ 1,827,902,807

Our estimates suggest that the majority of broadband investments (86 percent) would go toward extending the backhaul network to cover the settlements that currently do not have fiber-optic connectivity ("white areas"). The remaining investments (14 percent) would cover an access network for unconnected public institutions. **As stated above, the project seeks to provide broadband connectivity of at least 100 Mbps**[4] for unconnected (i.e., with no broadband connectivity) and underserved (i.e., with below 30 Mbps) households and institutions. The current estimates rely on three categories of beneficiaries: (i) households, (ii) schools, and (iii) primary health care institutions. Connectivity for additional categories (e.g., other educational institutions, providers of administrative services, social infrastructure facilities, and so on) can be connected at a marginal cost, given that they are located in a settlement with fiber-optic backhaul point availability.

As noted, the cost-benefit analysis suggests that the project is feasible and delivers an NPV of benefits to society worth US$7.6 million, with an IRR of 37 percent. The positive NPV in the cost-benefit analysis suggests that the project's economic benefits exceed the economic costs from the view of society overall. Note that these estimates rely on conservative assumptions of the high cost of capital (26.38 percent, which takes into account the project's commercial risk and the country risk in Ukraine), and project benefits spanning only five years of the project. **Table A6.2** provides the DCF model details.

The cost-benefit analysis model quantifies the project impact by comparing the project-related net benefits to a counterfactual "no project" scenario. This approach involves calculating benefits that accrue to households, schools, and rural health care institutions. The model compares the stream of net benefits under the project scenario to those under private provision of a similar project during the 2021–25 time period. The hypothetical "no project" scenario reflects the fact that some households (an estimated 50 percent) might connect to high-speed broadband without the project but would do so at a higher cost (an estimated 5 percent difference), and only in areas that ISPs would consider financially viable. However, it is assumed that no public institutions would become connected without the project. **Overall, the "no project" scenario (i.e., connecting some of the "white areas" to broadband without any public funding) delivers a negative NPV to ISPs and therefore would not be undertaken on a commercial basis.**

The potential project benefits may continue for longer than five years, but the uncertainty over such cash flows is too high to make any reliable estimates. The fast pace of innovations in broadband technologies further exacerbates this uncertainty. Hence, we rely on the conservative scenario of zero net benefits beyond the five-year horizon.

[4] Upgradable to 1 Gbps.

The rationale for undertaking the project stems from two key arguments. The first relies on the positive value of the net economic benefits to society, as quantified in the model. The second highlights the market failure in delivering a comparable broadband rollout to underserved households and public institutions in Ukraine. The model suggests that undertaking the project with private means alone would be unprofitable and therefore would not proceed.

At the same time, amid the major economic downturn triggered by COVID-19, broadband connectivity becomes critical to sustaining the earning capacity for many businesses and households. It can further generate economic benefits by allowing for home-based education and telemedicine. Therefore, the project's direct economic benefits and the positive externalities are likely to outweigh the costs.

TABLE A6.2. The DCF Model

Scenario 1 - with the project					
	2021	2022	2023	2024	2025
Year into the project	1	2	3	4	5
1. Social benefits, USD					
1.1. Value to households (consumer surplus)	$ 158.625	$ 753.468	$ 2.149.365	$ 4.091.329	$ 6.495.842
Reserve price	$ 88	$ 88	$ 88	$ 88	$ 88
Market price	$ 80	$ 72	$ 64	$ 58	$ 52
Number of project-targeted households that choose to connect (cumulative)	35.906	89.765	179.529	269.294	359.058
1.2. Value to educational institutions (cost savings)	$ 33.123	$ 78.667	$ 149.468	$ 212.992	$ 269.790
Actual price paid	$ 456	$ 433	$ 411	$ 391	$ 371
Market price	$ 506	$ 481	$ 457	$ 434	$ 412
Number of project-targeted schools (cumulative)	654	1636	3272	4908	6544
1.3. Value to healthcare institutions (cost savings)	$ 38.291	$ 90.941	$ 172.788	$ 246.223	$ 311.883
Actual price paid	$ 456	$ 433	$ 411	$ 391	$ 371
Market price	$ 506	$ 481	$ 457	$ 434	$ 412
Number of project-targeted healthcare institutions (cumulative)	757	1891	3783	5674	7565
2. Commercial revenues and costs, USD					
2.1. Total revenues to ISPs	$ 3.497.972	$ 7.950.779	$ 14.464.049	$ 19.743.989	$ 23.968.316
Revenues from households	$ 2.855.245	$ 6.424.302	$ 11.563.744	$ 15.611.054	$ 18.733.265
Revenues from educational institutions	$ 298.108	$ 708.006	$ 1.345.212	$ 1.916.927,56	$ 2.428.108
Revenues from healthcare institutions	$ 344.619	$ 818.470	$ 1.555.093	$ 2.216.008	$ 2.806.944
2.2. Project costs	$ 43.365.771	$ 57.729.706	$ 64.141.369	$ 69.338.943	$ 33.575.002
OPEX (ISPs)	$ 2.219.114	$ 5.043.974	$ 9.175.993	$ 12.525.587	$ 15.205.500
CAPEX - private	$ 1.224.290	$ 2.782.773	$ 5.062.417	$ 6.910.396	$ 8.388.911
CAPEX - public	$ 39.922.367	$ 49.902.959	$ 49.902.959	$ 49.902.959	$ 9.980.592
2.3. EBITDA to ISPs	$ 54.568	$ 124.032	$ 225.639	$ 308.006	$ 373.906
3. Project net benefits	$ (39.637.760	$ (1.735.664)	$ (2.365.157)	$ (2.051.846)	$ (937.491)
4. Net benefits relative to no-project scenario	$ (33.526.750)	$ 4.369.270	$ 12.882.750	$ 28.416.549	$ 44.726.031

Cost / benefit analysis	5 Years
IRR Cashflow	37,37%
NPV Cashflow -using social discount rate	$ 38.014.785
NPV Cashflow -using financial discount rate	$ 7.601.828
NPV Cashflow -using the average of social and financial discount rates	$ 19.015.959
NPV under private provision	$ (42.874.799)
Social discount rate	6,40%
β (pure time preference rate)	1,00
ε (elasticity of marginal utility of consumption)	1,50
σ (expected growth rate per capita of consumption)	3,60
Financial discount rat	26,38%
Rf (Risk-free rate)	8,82%
(Rm-Rf) (equity risk premium)	19,73%
β (equity beta for the telecommunications equipment industry)	0,89
Average of social and financial dicount rates	16,39%

Source: : Authors, based on economic modeling. See Excel file for "no-project" scenario and further assumptions.

Summary of the Financing Options

Over the years, a few initiatives leveraging public funding have increased access to broadband internet. The most recent was the state program by the Ministry of Education and Science, with technical support from the State Agency for e-Governance (now transformed into the MDT). In 2019, UAH 1 billion was allocated out of the state budget to connect primary and secondary schools (roughly 20 percent of the total number) to the internet and to purchase computers and hardware, of which 70 percent was spent on internet connectivity alone. The funding, allocated under the *Concept of Development for Digital Economy and Society in Ukraine in 2018–2020 and Digital Action Plan* (measure #22), was cascaded from the central executive level to local budgets proportionately to each oblast, leveraging oblast state administrations (OSAs) as budget administrators. The OSAs were mandated to coordinate closely with schools directly and with amalgamated territorial communities (ATCs) on the needs of their schools. An online public procurement platform ProZorro was used for tendering purposes to identify ISPs to connect a share of hub schools[5] to 100 Mbps and the rest to 30 Mbps. As of September 2018, 658 schools reported not having internet access and 8,566 reported speeds of less than 30 Mbps. The schools without internet access were prioritized under the state program. Although the impact evaluation of the program is not yet available, it is known that some priority schools had not been connected due to high connection costs of over UAH 100,000. Furthermore, some OSAs found it impossible to find ISPs to service rayons with speeds of over 30 Mbps due to the technology used. Schools in mountainous areas faced a particular difficulty in getting connected under the subsidy amount provided.[6]

The role of public financing should remain important in the context of strategy implementation. Several financing options that could be utilized for this purpose are outlined below.

Public-Private Partnerships

Public-private partnerships (PPPs) are becoming increasingly common around the world and along the whole broadband value chain. Of course, the existence of a market failure, as in the case of the application of state aid, should be clearly proven through feasibility studies.

Although there have been few successfully functioning PPPs in Ukraine, in 2018, the Cabinet of Ministers tasked the Ministry of Economic Development and Trade (MEDT), National Commission for the State Regulation of Communications and Informatization (NCCIR), State Service of Special Communication and Information Protection of Ukraine, and State Agency for e-Governance to work out a draft law on tackling the internet digital divide through the creation of special funds using PPPs.[7] **This speaks to an understanding of the importance of crowding in private investments at the central executive branch, given the estimated digital inclusion needs.**

Telecom market players appear to be willing to participate in a telecom PPP with the aim of bridging rural broadband gaps. For example, in 2018, incumbent Ukrtelecom proposed a project to narrow the digital divide by connecting 8,000 villages with an estimated population of 6 million through 58,000 kilometers of new fiber-optic deployment; of these villages, 6,900 would also have their schools connected. The company estimated that 21,700 villages, with a population of 8.3 million, remain unserved. The company sought to anchor, through its allocated US$106 million, a further UAH 3.2 billion in investment from the state or international donors.[8] **This report does not weigh in on the merits of this particular proposal; it merely highlights the fact that bigger players are open to telecom PPPs. The analysis underpinning this report also shows that alternative market players are equally enthusiastic about PPPs, provided that they can compete on an equal footing with major players and that the financed networks will be open-access and based on the principles of non-discrimination and technological neutrality.**

[5] Hub schools are those with at least 200 pupils and with grades I-III (i.e., offering primary and secondary education). Some hub schools have branches/affiliate schools.

[6] Data from the MDT.

[7] See https://dostup.pravda.com.ua/request/46951/response/110010/attach/5/.pdf (in Ukrainian).

[8] "Ukrtlelcom Announces Digital Divide Project to Connect 8,000 Villages to Broadband," *CommsUpdate*, May 16, 2018, https://www.commsupdate.com/articles/2018/05/16/ukrtelecom-announces-digital-divide-project-to-connect-8000-villages-to-broadband/.

It is laudable that the GoU is looking into the option of leveraging PPPs for the rollout of broadband access networks. Draft Law No. 3014, which aims to transpose the European Electronic Communications Code (EECC), refers to the Law on PPPs and to the Law on Concessions, proposing them as possible mechanisms for the rollout of universal electronic communications services. As for current PPP law, it determines the PPP's scope of application and enlists the sectors for PPP use, which do not include electronic communications. However its articles 4.1 and 4.2 stipulate that "The public-private partnership can be used in other areas, save for the economic activities allowed only to state enterprises, institutions and organizations according to law. The public-private partnership is applied with consideration of peculiarities of the legal regime for particular facilities and particular activities prescribed by law."[9] Thus, these articles could be interpreted as not precluding telecom PPPs. The Law on Concessions, Article 2.5, unambiguously states that concessions may be implemented in any sector, unless there is a restriction or prohibition on transferring objects into concession.[10]

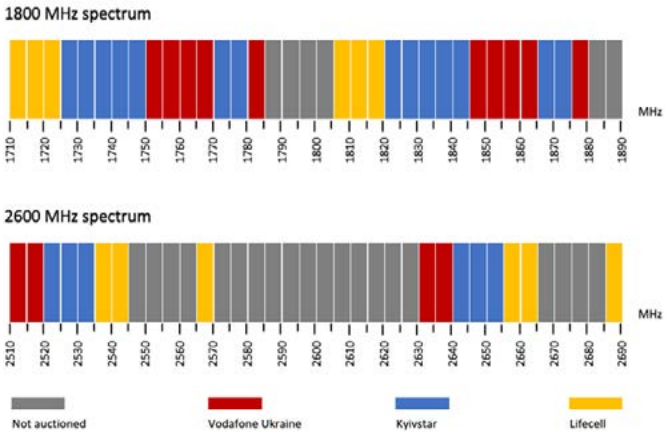
The GoU may also leverage PPPs for broadband demand-side initiatives, such as those focusing on digital skills. In the past, the Ministry of Education and Science (MES), MEDT, State Agency for e-Governance, and National Academy of Sciences have looked into this idea.[11]

Spectrum Auctions

In 2018, 4G LTE license auctions in the 2600 and 1800 MHz bands generated approximately UAH 7.73 billion (roughly US$300 million). In 2020, LTE-900 licenses raised a further UAH 611 million (US$21 million).[12] A portion of the funds raised through future spectrum concessions could be used to provide public support to the white area settlements.

Two auctions were held in 2018 to distribute spectrum in bands 1800 and 2600 MHz for 4G LTE communications. As a result of the auctions, the regulator raised UAH 2.288 billion in the 2600 MHz auction and UAH 5.7 billion from the 1800 MHz assignments.[13] The resulting spectrum allocation is summarized in the figure below. It is noteworthy that 1800 MHz is the most popular band for LTE.[14] The global adoption of this band has greatly assisted international roaming for mobile broadband services (roughly 46 percent of LTE operators worldwide operate at 1800 MHz). Meanwhile, spectrum at 2600 MHz is useful mainly in densely populated areas with large demands and financial capabilities to pay for capacity provision. The order of the two auctions (2600 MHz first and then 1800 MHz) therefore influenced the operators' decision making.

FIGURE A6.1.
Spectrum Allocations after the Auctions for Bands 1800 MHz and 2600 MHz



Source: World Bank analysis.

[9] Text can be found at https://zakon.rada.gov.ua/laws/show/2404-17.

[10] See https://zakon.rada.gov.ua/laws/show/155-20.

[11] See https://zakon.rada.gov.ua/laws/show/67-2018-p.

[12] Ukraine. GlobalComms Database, Telegeography, 2020.

[13] See https://nkrzi.gov.ua/index.php?r=site/index&pg=392&id=7492&language=uk; and https://nkrzi.gov.ua/index.php?r=site/index&pg=392&id=7556&language=uk.

[14] GSA, "Band 3 (1800 MHz): the Most Popular Global Band for LTE," 2019, https://gsacom.com/paper/band-3-1800-mhz-jan2019/.

As can be seen from the above figure, a lot of spectrum in the 2600 MHz band has not been auctioned. A number of entities rent it without active use, apparently waiting to cash in when the right time comes. It is thus important that the GoU complete a cost-benefit analysis of whether to auction this spectrum now or in the future. It should also reflect the earlier recommendation (see **Annex 3**) to increase the rent for the owned frequencies, thus pushing some of these rent seekers to release the resource.

State Aid and Reverse Auctions for Broadband

Since the EU-Ukraine Trade Association Agreement obliges Ukraine to approximate its competition as well as electronic communications laws and enforcement practices to some of the *EU acquis*, it would be relevant for Ukraine to learn from the experience of the EU state aid framework. This regulates the financing of many broadband deployment projects in the EU, including those involving new generation access (NGA), when providing public support to broadband projects using, for example, direct subsidies, matching grants, or other form of state aid allocation.

State aid is an integral part of EU competition policy. Although it is generally prohibited when it distorts or threatens to distort competition or affect trade between member states, there are a number of exceptions allowing for state aid application. Under such exceptions, the use of state aid needs to be justified by economic reasons, and projects should demonstrate a beneficial development impact. Thus, state aid represents a common approach to correct market failures (market power, information asymmetries, inefficient allocation of resources, public services) and contribute to the achievement of specific state objectives, for example, on broadband development.

Annex 6 of this report contains several case studies of the application of EU state aid rules on broadband projects that would be relevant to Ukraine's policy makers. The case study from Lithuania was chosen, as this country has opted for a Design-Build-Operate (DBO) model, implemented by a public non-profit entity and created specifically for the purpose of broadband rollout. The case of Sweden is relevant in the context of Ukraine's administrative-territorial decentralization reform that is allocating new powers, especially budgetary, to the ATCs. The case study from Romania is also interesting, as an incumbent operator was entrusted with bridging the rural broadband connectivity gaps; the country was also selected because of its regional proximity and its role as part of the benchmark used for this report.

Reverse auctions in the United States under the Connect America Fund II Auction (US$1.48 billion) and Rural Digital Opportunity Fund (approximately US$20.4 billion) represent one of the many vehicles for channeling state aid. What is peculiar about the U.S. approach is that it allows any entity (including utilities and non-telecom firms) to bid for state aid at an online auction on the condition that every winner on a specific eligible census block group (target area) register at the regulator as a provider of electronic services. Ukraine, with its liberalized electricity market, multiple state-owned enterprises that have spare fiber optics, and myriad of ISPs, may want to look into this particular experience when devising its ultimate state aid scheme. Positive perceptions of the private sector utilizing the state-of-the-art online procurement platform ProZorro are a case in point.

USO/USF

In 2009–10, ahead of the privatization of the incumbent operator, the GoU planned to establish a Universal Service Fund (USF) for broadband development in rural areas and finance it by levying 3 percent charges on all operator revenues.[15] However, this attempt failed under pressure and resistance from the market players.

The EU-Ukraine Trade Association agreement stipulates that Ukraine has the right to define the kind of universal service obligations it wishes to maintain. The same Article (#120) outlines principles for the administration of universal service obligations (USOs) so that they are considered competitive. Draft Law No. 3014, which aims to transpose the EECC, defines broadband access services and voice electronic services—both at a fixed location as universal electronic communication services. It also stipulates that vulnerable social groups should have access to affordable universal services through special purpose and targeted social assistance, delivered by a service provider selected through a competitive tender.

[15] Ladcomm Corporation, "Universal Service Fund Study, Conducted on Behalf of the GSM Association" (GSM Association, 2013), https://www.gsma.com/publicpolicy/wp-content/uploads/2016/09/GSMA2013_Report_SurveyOfUniversalServiceFunds.pdf.

The history of the USF worldwide has been rather mixed, with some living up to their purpose and others representing a clearly missed opportunity to expand access to electronic communications to underserved populations. **Ukraine, through its regulator, should thus look into imposing USOs where they are due. Any planning for a USF should be highly rigorous and based on conservative assumptions to minimize the risk of failure and have buy-in from the sector. A well-functioning USF could become a vehicle for steady reinvestments in the sector.**

Partnerships

Collaboration is essential to achieving sustainably positive results, especially with the private telecom and IT sector. Partnerships can not only help raise capital, but also smooth administrative burdens and fix information asymmetries and coordination failures, which are just as important to heed in the context of broadband network development.

Given the patterns of broadband coverage (low rural connectivity), ATCs are poised to play an outsized role in any large-scale broadband project, as was evidenced by the education broadband project of the MES. As of January 2020, there were 1,029 ATCs formally established throughout the country, out of 1,441 planned. The operating ATCs account for one-third of the country's population and cover 44.2 percent of its territory. On average, one ATC has a population of over 11,000. Once the decentralization reform is completed (planned by 2021), it is expected that 90.3 percent of the country's territory, or 86.9 percent of the population, will be administratively governed by ATCs.[16] Aside from a significantly strengthened tax-raising mandate and a direct budgeting relationship with the central governments, the ATCs have been granted authority over local infrastructure development, administrative service provision, secondary education, and primary-level health care.[17] **Given the ATCs' pattern of geographic and population coverage, as well as the coverage of public institutions (including centers of administrative service provision, schools, libraries, youth centers, and health care facilities), direct subsidies to them could be used to cover the currently unconnected localities—those that are part of ATCs or remote areas for which ATCs are responsible by their mandate.** Such schemes are widely used in the EU and elsewhere.

Horizontal coordination mechanisms on the level of state bodies involved in public investment decisions are essential to the success of state-aid broadband projects, especially if they are to connect smaller, presently underserved localities. Until end-2020, such mechanisms are inscribed in the toolbox of the Ministry of the Development of Communities and Territories through the State Regional Development Fund (SRDF).[18] The SRDF strives to improve multi-level institutional coordination around infrastructure development by executing vertical coordination between the central and subnational institutions involved in developing and supporting regional development projects, each of which should be formulated according to the State Strategy for Regional Development 2020 (SSRD-2020).[19] The SSRD-2020 outlines several measures related to internet development that the SRDF can implement through subsidies, including to ATCs (which already make up the majority of its recipients), while covering up to 90 percent of a new project involving construction.

Thus far, it seems that the SRDF has been underutilized as a source of funding for bridging broadband coverage inequalities.[20] This situation should be changed through the active involvement of the MDT, including on the level of amendments to annual investment programs and projects financed by the SRDF on orders of the Cabinet of Ministers. ATCs should be incentivized through the SRDF to propose investment projects to connect their villages and objects of social infrastructure within their territory to high-speed broadband internet. Similarly, the MDT should contribute to the new SSRD post-2020 on matters related to cohesive regional digital development, thus ensuring the SRDF sustainable allocations for broadband projects.

[16] See https://decentralization.gov.ua/uploads/library/file/526/10.01.2020.pdf (in Ukrainian).

[17] V. Romanova and A. Umland, Ukraine's Decentralization Reforms Since 2014: Initial Achievements and Future Challenges (London: Chatham House, 2019), https://www.chathamhouse.org/sites/default/files/2019-09-24-UkraineDecentralization.pdf.

[18] Text at https://zakon.rada.gov.ua/laws/show/385-2014-n#n11.

[19] See https://zakon.rada.gov.ua/laws/show/385-2014-n#n11.

[20] Based on the key word project search using this database: http://dfrr.minregion.gov.ua/Projects-list.

It is thus proposed that all levels of government should be mobilized as partners in the implementation of the new Strategy's vision to the extent and capacity of their respective mandates. Local self-government bodies, including ATCs and municipal governments, should support this effort through efficient administrative procedures and the deployment work of the operators. They may also co-finance investments where a market failure prevents the private sector from providing services to the population (e.g., in white or grey areas). The central and oblast governments should monitor the achievement of the goals, provide technical support and expertise to ATCs and municipal governments engaged in broadband projects, and (co)finance investment projects in the event of a market failure. The central government should also enforce infrastructure sharing on the level of its state-owned enterprises, and the energy regulator (National Energy and Utilities Regulatory Commission of Ukraine) may need to be involved in matters concerning electricity pole rental from electricity distribution companies. The NCCIR should provide an enabling environment and a level-playing field for investments through fair and transparent regulations.

Donor support should not be overlooked in the process. Donors, as impartial market observers, arouse respect and trust from the private sector. Their convening power, coordination support, technical expertise, and financial support are indispensable to Ukraine in its current situation, and the government should thus absorb as much of this assistance as possible. The European Commission and its funded entities (including development banks) are natural allies; their regulatory toolbox is considered state-of-the-art. EU member states have a rich experience in implementing broadband projects, as do bilateral donors and private foundations, such as the governments of the United States, Canada, or Australia, which have recently successfully implemented large-scale projects to bridge the rural digital divide. The World Bank Group is the largest multilateral development bank operating in Ukraine and has vast experience implementing broadband projects in Europe and other regions. Schematic donor mapping is reflected in the table below based on the publicly available information on ongoing projects in Ukraine.

TABLE A6.3.
Ongoing Donor Technical Assistance Engagements in Digital Development in Ukraine, June 2020

Donor	Project Name	Issue Area(s)	Amount of Total Financing	Time Frame	Recipient
EU	EU4Skills: Better Skills for Modern Ukraine	Support for digital skills development, incl. modernization of training infrastructure	€38 million	2019–2023	MES
	EU4Digital (implemented by the World Bank)	Support for telecommunications sector development	€1,071,695 (for all EaP countries)	2018–2021	MDT
	EU4Digital Programme	Support for various e-Government initiatives, NREN connectivity (EaPConnect)	€25 million	2020-onward	MDT, MES
	Multiple initiatives	Support to e-Government, incl. capacity building	€3 million	2019*	MEDT
German Agency fo International Cooperation (GIZ), Swedish International Development Cooperation Agency (SIDA)	Support to e-Government, incl. capacity building (U-LEAD Project 1st and 2nd Phases), EU-funded program	Support for establishment of up to 600 Administrative Service Centers, incl. development of IT solutions.	€102 million**	2016–2020	Ministry for Communities and Territories Development
GIZ	Multiple initiatives	Support to e-Government, incl. capacity building	€0.5M	2019*	MEDT
GIZ	Reform of Municipal Services in Eastern Ukraine	IT support for services for citizens	€3 million	2017–2020	Local governments (ATCs), MEDT
GIZ	Good Financial Governance in Public Finance III	Support for online procurement systems	n/a	2019–2022	Ministry of Finance
Government of the United States (incl. the U.S. Embassy U.S. Department of State, etc.)	Multiple initiatives	Support to e-Government, incl. capacity building	US$2 million	2019*	MEDT
	Cybersecurity and Grid Synchronization	Support for cybersecurity critical infrastructure and grid synchronization	US$2 million	2019–2022	GoU
Swedish International Development Cooperation Agency (SIDA)	Multiple initiatives	Support to e-Government, incl. capacity building	90 million SEK	2019*	MEDT
	EGOV4Ukraine	Support for e-governance, decentralization, and other reforms	US$10,785,636	2016–2020	MDT
U.S. Agency for International Development (USAID)	Transparency and Accountability in Public Administration and Services (TAPAS) Program (co-funded with UKAID).	e-Government tools and e-Services platform, open data	US$19 million	2016–2021	MDT, MEDT, Ministry of Health
	Policy for Ukraine Local Self-Governance (PULSE)	Financing of IT technology solutions	US$8.2 million**	2015–2020	Local governments (ATCs)
	Decentralization Offering Better Results and Efficiency (DOBRE)	Financing of IT technology solutions	US$50 million**	2016–2021	Local governments (ATCs)
	Supporting e-Health Infrastructure Development in Ukraine	Sectorial ICT application (national e-Health system)	US$2 million	2018–2020	MoH, its SoE

Note: *The support was provided in 2019 and may be still ongoing. **The amounts were found at: https://donors.decentralization.gov.ua/en/project.
Source: Information on EU programming was found at: https://eeas.europa.eu/; information on GIZ programming: https://www.giz.de/en/worldwide/302.html; information on SIDA programming: http://proaid.gov.ua/uk/projects/10433; information on U.S. government programming: https://www.foreignassistance.gov; and information on USAID programming: https://www.usaid.gov/ukraine/democracy-human-rights-and-governance. Projects captured as "Support to e-Government, incl. capacity building," including information on donors, contributions, and beneficiary institutions, were found at: https://www.kmu.gov.ua/storage/app/sites/1/17-prezentation-2019/8.2019/transition-book-final-stisnuto.pdf.

ANNEX 7. COLLECTION OF STATE AID PROJECT CASE STUDIES FROM THE EUROPEAN UNION

Case Study: Romania

Romania at a glance	
Area (sq km):	237,000
Population 2018 (million):	19.5
Households 2018 (million):	8.6
GDP per capita 2018 (current US$ thousand):	12.3
Broadband indicators, 2019	
Fixed BB coverage (% of HH)	62.5
Share of fiber-optic subscriptions (% of fixed BB subsc.)	68.9

Source: World Bank[1] and TeleGeography.[2]

Romania's low GDP per capita compared to the rest of the European Union (EU), relatively high proportion of rural population (46 percent[3]), and particular landscape (mountains, plains, hills) are making broadband infrastructure rollout complex and costly. Nevertheless, Romania belongs to the **catching-up** group of countries in terms of broadband penetration because, although it still performs worse than the EU as a whole, it has rapidly developed and come closer to the EU average.[4] The case of Romania is even more pertinent to this report, as it has a dynamic competitive environment.

The country was chosen to show how state aid is helping move the country closer to the EU average. In 2014, the European Commission (EC) approved a state aid measure called the "Ro-Net project," aimed at deploying broadband backhaul networks in 721 localities of Romania with no existing or potential broadband infrastructure.

In other words, the primary goal of the state aid measure was to support the construction of backhaul networks for operators in areas where broadband services were not available and where there were no future investment plans.

Romania conducted a detailed mapping and coverage analysis to identify the target areas where state intervention was necessary. It pinpointed areas where no operators offered broadband connectivity at a speed over 4 Mbit/s for business users and 1 Mbit/s for residential users. Out of the initially identified

[1] World Bank Open Data, https://data.worldbank.org.

[2] Romania. GlobalComms Database, https://www.telegeography.com/products/globalcomms/data/country-profiles/ee/romania.

[3] World Bank, "Indicators: Rural Population," https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS.

[4] EC, "Shaping Europe's Digital Future: Romania," https://ec.europa.eu/digital-single-market/en/scoreboard/romania.

2,287 rural localities without any broadband infrastructure at all, 721 were selected where the provision of backhaul might result in the development of last-mile broadband investments. Localities were grouped into seven regions, and a tender was organized for seven lots (each per region).

Compliance with Broadband Guidelines. The notification of Romania's state aid Ro-NET measure took place in 2013, meaning that it had to follow the requirements of the renewed version of the Broadband Guidelines (see **table A7.1**). As Romania intended to support backhaul network construction for the delivery of primarily basic broadband services, the designed aid measure had to comply with the requirements of Part I and Part II of the Guidelines (see **table A7.2**).

TABLE A7.1.
Features of Approved State Aid Measure, Romania

1	Target area	Countrywide white (basic broadband) areas
2	Technology	Technology neutral
3	Part of network	Only backhaul networks covered
4	Market failure	In Romania, 46% of the population lives in rural areas, where the population density is low. Together with economic factors (such as low GDP per capita, low average revenue per user [ARPU]), it makes these regions very unattractive for private investors. Furthermore, the variety of landscape and complex topology is not favorable to civil works (digging trenches, erecting towers) and makes networks' deployment costs even higher. The low PC penetration and digital literacy rates lowered the investment appeal even more, creating a significant infrastructure gap between urban and rural areas in Romania.
5	State involvement	**Public outsourcing:** An open tender, divided into 7 lots corresponding to the grouped regions, was organized to select operators to design, build, and operate infrastructure. The infrastructure, however, should remain in public ownership. The infrastructure operators (concessionaires) should pay a concession fee for the subsidized infrastructure and have the right to retain revenues from managing and operating the networks.
6	State aid measure's scope	A financing scheme, though only the Ro-NET project is financed
7	Financing option	Direct grant
8	Budget	The overall cost of the measure was approximately €84 million. A significant part (approximately 82%) of the budget came from European Regional Development Fund (ERDF) (€45 million) and the remainder from the state budget (€9 million). Aid intensity – 100%, meaning that all costs of network deployment are covered.

Source: World Bank, based on the EC decision.

TABLE A7.2.
Compliance with Broadband Guidelines of the Approved State Aid Measure, Romania

Requirement		Compliance
Contribution to the common interest	✓	By extending broadband coverage to unserved areas of Romania, the measure contributed to the achievement of greater cohesion and economic development objectives, in line with the Digital Agenda.
Absence of market delivery due to market failures	✓	Lack of commercial investments in broadband networks in rural areas: 721 localities were selected with no broadband coverage and no investment plans in the near future (3-year time horizon).
Appropriateness of state aid as a policy instrument	✓	Romania demonstrated that without further public intervention, it would be impossible to achieve its national objectives: › Demand-side measures are insufficient to solve the systemic problems illustrated on the supply side in Romania's rural areas. › Regulatory measures did not solve the problems related to the lack of broadband infrastructure and services in the targeted areas.
Incentive effect	✓	During public consultations, operators indicated having no investment plan in the targeted areas without public support, hence the aid produced a change in the investment decisions of the operators. Moreover, open access to subsidized infrastructure to third-party operators was expected to encourage investments in last-mile networks.
Aid limited to minimum necessity	✓	Romania has designed the measure in such a way as to minimize the state aid involved and potential distortions of competition. The Romanian authorities carried out **a mapping exercise** as part of a broader feasibility study. Following several rounds, the country identified 721 localities with no existing or potential backhaul network. At least three **public consultation** rounds were undertaken, along with a mapping exercise. **Open and technology-neutral tender,** in line with national and EU procurement rules, was foreseen for 7 lots (regions). The contracts intended to be awarded to the applicants presenting the **most economically advantageous offer** (for each lot), where the most important award criterion was the lowest amount of public aid requested. Although the measure supports only white areas where no broadband infrastructure is available, it encourages the **use of existing infrastructure** wherever possible. For this purpose, existing infrastructure and its availability was identified (e.g., towers, overhead optic fiber, roads, ducts, roofs of existing buildings, other infrastructure, etc.). The inventory should be made public on the national regulator (ANCOM) website. A third of the network planned for the initiative was to be built on existing support infrastructure. Wholesale services were an essential requirement of the project. The selected operators had to offer wholesale services, i.e., access to the subsidized networks for other operators in an open, transparent, and non-discriminatory manner for the entire concession period (18 years). The price for wholesale access had to be based on the prices already set by ANCOM for similarly regulated services (i.e., **benchmarked prices**). The **monitoring and claw-back mechanisms** were foreseen. All relevant documentation concerning the state aid measure was to be published to ensure **transparency**. Periodical **reporting** to EC services was foreseen.
Limited negative effects	✓	Given the design of the project, a crowding-out effect on potential future investments of private operators was deemed unlikely.
Transparency	✓	It had to be ensured that the public authorities, economic operators, the interested public, and the EC would have easy access to all relevant acts and pertinent information about the aid.

Source: World Bank, based on the EC decision.

Results. Fixed line incumbent RomTelecom (an incumbent that in 2014 was renamed Telekom Romania Communications) and sister mobile operator Cosmote Romania (renamed Telekom Romania Mobile Communications)[5] **were selected as the winners of the tender organized by the Ministry for an Information Society.** RomTelecom was designated the winner of four of the lots, and Cosmote Romania of three.

The ministry gave a concession of 18 years to the winning companies. For this period, two companies will have to ensure the operation and maintenance of the subsidized infrastructure. It is estimated that the 721 localities covered by the project would ultimately result in broadband coverage for some 400,000 residents, 8,500 businesses, and 2,800 public institutions. All in all, it was estimated that 480 jobs would be created upon completion of the project.[6]

By September 2018, investments were completed in 607 localities, while in 484 localities, the work was finalized and accepted, with a new grant scheme for next generation network (NGN) deployment underway (€64 million) in additional white areas.[7]

[5] Both companies belong to the Deutsche Telekom Group.

[6] EC, "RO-NET: Building Broadband Internet Access to Boost the Economy," http://ec.europa.eu/regional_policy/en/projects/romania/ro-net-building-broadband-internet-access-to-boost-the-economy.

[7] EC, "Shaping Europe's Digital Future: Romania."

[8] World Bank Open Data, https://data.worldbank.org.

[9] Sweden. GlobalComms Database, https://www.telegeography.com/products/globalcomms/data/country-profiles/we/sweden.

Case Study: Sweden

Sweden at a glance	
Area (sq km):	449,964
Population 2018 (million):	10.2
Households 2018 (million):	4.7
GDP per capita 2018 (current US$ thousand):	54.6
Broadband indicators, 2019	
Fixed BB penetration (% of HH)	85.5
Share of fiber-optic subscriptions (% of fixed BB subsc.)	70.9

Source: World Bank[8] and TeleGeography.[9]

Sweden was chosen as a case study for two main reasons. First, Sweden is one of the leading "fiber to the x" (FTTx) countries in Europe. According to the latest data of the Fibre to the Home (FTTH) Council, in terms of penetration, although Lithuania (see page 108) ranks second with a penetration rate of 46.8 percent, Sweden is quickly caching up at 43.6 percent and stands in fourth place.[10] Second, Sweden has a unique approach in which local municipalities have long been important (if not the main) drivers of broadband deployment. A study by the Organisation for Economic Co-operation and Development (OECD) recognizes that the extensive municipal broadband development across Sweden has contributed to a remarkably high level of nationwide fiber penetration.[11] There are some 200 metropolitan networks in more than 100 towns owned and run by local authorities. According to the OECD report, municipal networks accounted for 23 percent of the fixed broadband investments in Sweden in 2014.[12]

8 World Bank Open Data, https://data.worldbank.org.

9 Sweden. GlobalComms Database, https://www.telegeography.com/products/globalcomms/data/country-profiles/we/sweden.

10 Fibre to the Home Council Europe, "New Market Panorama and Forecast Data," press release, https://www.ftthcouncil.eu/documents/PressReleases/2019/PR%20Market%20Panorama%20-%2014-03-2019%20V3.pdf.

11 T. Ernste, "OECD Study on Munis Digs Deep, Discovers Dividends," Community Networks, Institute for Local Self-Reliance, March 25, 2016, https://muninetworks.org/content/oecd-study-munis-digs-deep-discovers-dividends.

12 S. Paltridge, "Development of High Speed Networks and the Role of Municipal Networks," Working Party on Communication Infrastructures and Services Policy (Paris: OECD, 2015), http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/CISP(2015)1/FINAL&docLanguage=En.

However, the contribution of the national government is also important in terms of funds allocation and the promotion of infrastructure sharing. The Swedish government assigned Svenska Kraftnät, a national electricity utility company, to build a backbone network that links all of Sweden's municipalities on commercial grounds.[13] In sum, the Swedish broadband expansion model is based on a state-owned fiber backbone, combined with municipal networks.

It should be noted that the Swedish government recognized the importance of broadband back in 2000 when it decided to provide a financial stimulus to broadband deployment by creating a Rural Development Program. That was the start of the strong development of fiber networks. Before the Rural Development Program, there was no real broadband investment in Sweden's rural areas due to the lack of commercial interest. And although most areas did have DSL, quality was clearly an issue.[14] The program was extended for the periods 2007–13 and 2014–20. As the program anticipated the use of state resources to stimulate broadband development, it had to receive clearance from the EC, which was notified in January 2010.[15] In 2011, Sweden received clearance for a budget increase,[16] which occurred one more time in 2013.[17]

The main aim of the state aid measure was to help to achieve the objectives of the Swedish Broadband Strategy by increasing broadband availability in rural areas. The measure aimed to cover both: i) areas where basic broadband was still not available and would not be in the near future—the white areas; and ii) areas where new generation access (NGA) networks did not exist and would not in the near future— the white NGA areas.

[13] See http://www.lvm.fi/lvm-site62-mahti-portlet/download?did=189278.

[14] "Annex C. Aims and Results of Example Projects," https://www.innova.puglia.it/documents/10180/14203/Guidetobroadbandinvestment-Part-Annexes.pdf.

[15] EC, "State Aid to Broadband within the Framework of the Rural Development Program" (Brussels: European Commission, 2010), http://ec.europa.eu/competition/state_aid/cases/234820/234820_1087454_35_2.pdf.

[16] EC, "Amendment of the State Aid Broadband Scheme within the Framework of the Rural Development Program" (Brussels: European Commission, 2011), https://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf.

[17] EC, "Amendment of the State Aid Broadband Scheme within the Framework of the Rural Development Program" (Brussels: European Commission, 2013), https://ec.europa.eu/digital-single-market/en/news/sweden-amendment-state-aid-broadband-scheme-within-framework-rural-development-program.

TABLE A7.3.
Features of the Approved State Aid Measure, Sweden

1	Target area	Countrywide white areas and white NGA areas
2	Technology	Both basic broadband and NGN Technology neutral
3	Part of network	Access, backhaul, and core networks are covered. The measure also covered the upgrade of existing broadband infrastructure and the laying of passive broadband infrastructure.[18]
4	Market failure	Unserved demand for broadband services 13% of the Swedish population lives in rural areas where investments in infrastructure are expensive. As a result, broadband availability is poorer in more sparsely populated areas. The need for broadband is, however, just as great as in other parts of the country. Public services are being digitalized, which implies increased dependency on broadband infrastructure.
5	State involvement	Case-by-case decision on which type of intervention is the most suitable for the area concerned Private DBO (design, build, operate) as the main alternative. Two alternatives: i) a bottom-up approach: the need for broadband could in many cases be identified and the initiative taken by citizens and small enterprises in rural areas that could organize themselves in, for example, a non-profit organization. ii) In rare occasions when the operator, selected through an open tender procedure, did not want to own the network but was only interested in operating it (for instance, due to the high maintenance costs in comparison to the potential revenues that could be generated), the Swedish authorities foresaw the possibility of the project owners owning the network.
6	State aid measure's scope	A financing scheme The measure was designed as a national scheme, serving as an umbrella state aid scheme.
7	Financing option	Direct grant
8	Budget (initial)	The total amount of public funding available for the measure is €28.152 million, of which 75% will stem from European Agricultural Fund for Rural Development (EAFRD) funds and 25% from Swedish government funds.

Source: World Bank, based on the EC decision.

Compliance with Broadband Guidelines. The measure was reported to the EC in 2010, which means that it had to comply with the older version of the Broadband Guidelines. Though the renewed version added some additional features, the main guiding principles and requirements for state aid to broadband remained the same.

[18] EC, "State Aid to Broadband within the Framework of the Rural Development Program" (2010).

TABLE A7.4.
Compliance with Broadband Guidelines of the Approved State Aid Measure, Sweden

Requirement		Compliance
Measure aimed at well-defined objectives of common interest	✓	By extending basic and NGA network coverage to areas where private operators had no commercial interest to invest, Sweden contributed to the EC objective of "broadband for all."
Measure designed to deliver the objectives if it is of common interest and: • is an appropriate instrument • has an incentive effect • is proportional	✓	Swedish authorities stated that efforts from alternative instruments (including ex ante regulation) had not solved the problems related to the lack of supply of basic or high-speed broadband in rural areas. It was expected that financial support given to market players selected in a tender manner would provide appropriate investment incentives.
Has limited negative effects and distortions of competition	✓	Sweden designed the measure in such a way as to minimize the state aid involved and potential distortions of competition, as a number of necessary conditions were met in order to minimize potential distortions: Before approving state aid for each project, authorities had to conduct a market analysis to identify the existing broadband networks and services on the target areas, i.e., **a mapping exercise** had to be done, followed by **public consultations and open tender selection procedures.** Tender award criteria were foreseen as follows: the amount of aid requested, the quality and quantity of the broadband, how long the applicant committed to offering services in the subsidized network, and prices of services. The selection procedures had to be technology neutral. To avoid unnecessary and wasteful duplication of resources, the Swedish authorities encouraged the use of existing infrastructure. The wholesale access to the subsidized network was foreseen for 7 years at benchmarked prices. The **monitoring and claw-back mechanisms** were foreseen for each project.

Source: World Bank, based on the EC decision.

Results. Under the Rural Development Program in Sweden, a typical local investment project was initiated by residents and enterprises showing interest and forming co-operatives or economic associations.[19] They applied to the local authority for support, making significant contributions themselves (in the form of investments or work done, e.g., digging to install new ducts). Municipalities were actively involved as they:

- are responsible for providing a majority of public services (potential for exploiting synergies)
- have a considerable degree of autonomy and may engage into business activities
- provide e-services
- are regarded by end-users as reliable service providers[20]

These municipal networks are predominately providing basic (passive) infrastructure, operator-neutral networks that are based on fiber technologies, usually with more than one internet service provider (ISP) using the network to provide broadband services to the end users.

There are more than 1,000 community broadband networks in Sweden, either under construction, completed, or planning to expand, according to the Swedish Broadband Forum.[21] This, together with the fact that the budget of the state aid measure was increased twice due to a higher number of applications for grant money than was anticipated, shows that Sweden's Rural Development Program was successful, which may be measured not only by kilometer of network deployed. The OECD study revealed that, at

19 "Annex C. "Aims and Results of Example Projects."

20 S. Paltridge, "Development of High Speed Networks."

21 "Survey: Over 1000 Rural Broadband Networks in Sweden," Fibre Systems, February 5, 2015, http://www.fibre-systems.com/news/story/survey-over-1000-rural-broadband-networks-sweden.

least in the case of Sweden, a 10 percent higher fiber penetration was correlated with:

- reduced car use of 135 kilometers per year per inhabitant (250 kilometers for highly urbanized municipalities)
- 1.1 percent higher employment (1.7 percent for highly urbanized municipalities)
- increased business creation by one additional company per 12,000 inhabitants per year[22]

Sweden serves as a good example of state support with positive spillovers that lead to broader economic development outcomes. At the same time, it should be noted that many rural broadband networks in Sweden have been built without governmental support.[23]

[22] S. Paltridge, "Development of High Speed Networks."

[23] http://www.lvm.fi/lvm-site62-mahti-portlet/download?did=189278s.

Case Study: Lithuania

Lithuania at a glance	
Area (sq km):	65,200
Population 2018 (million):	2.8
Households 2018 (million):	1.4
GDP per capita 2018 (current US$ thousand):	19.2
Broadband indicators, 2019	
Fixed BB coverage (% of HH)	59.1
Share of fiber-optic subscriptions (% of fixed BB subsc.)	73.2

Source: World Bank[24] and TeleGeography.[25]

Lithuania was chosen as a case study for the following reasons. For over 10 years in a row, Lithuania has held one of the leading positions in the EU in terms of fiber-optic penetration (as ranked by the FTTH Council). Obviously, there are many factors influencing this result (such as competition in the market, prices, demand for and supply of ICT services), though state resources were also used to contribute to this success.

The history of broadband deployment with support from public resources in Lithuania goes back to 2005. A public non-profit entity "Placiajuostis Internetas" was established with the mission of bringing broadband access to unserved areas of the country. In the same year, it started to implement the first project, the Development of Rural Area Information Technology Network (abbreviated as RAIN),[26] which initially focused on providing broadband access to public administrations in rural areas. Later in 2008, the Lithuanian government started discussions on the need to support the further development of broadband networks in rural areas. At that time, only 39 percent of the Lithuanian population in rural areas was covered by broadband networks (compared to almost 100 percent in urban areas).

Around one-third (1.1 million inhabitants) of the population lived in rural areas; moreover, numerous government, education, and health care institutions, libraries, public internet access points, local activity groups, and businesses, about 11,000 institutions or entities in total, were lacking reliable access to broadband internet. This unmet demand was the main stimulus to initiating a support program for the RAIN project. Lithuania notified the EC of the initial measure in 2009 (which was later amended several times: in 2012 to expand its geographic scope and in 2013 to prolong the duration and increase the budget[27]), when the economic downturn in the country was at its peak. This indicated that the government understood the potential benefits of broadband deployment for society and the economy and was ready to allocate resources to it.

22 S. Paltridge, "Development of High Speed Networks."

23 http://www.lvm.fi/lvm-site62-mahti-portlet/download?did=189278s.

24 World Bank Open Data. Area, Population, GDP per capita indicators, https://data.worldbank.org.

25 Lithuania. GlobalComms Database, https://www.telegeography.com/products/globalcomms/data/country-profiles/ee/lithuania.

26 For more information, see https://www.placiajuostis.lt/lt/rain.

27 The EC documents can be found at http://ec.europa.eu/competition/state_aid/cases/243182/243182_1335424_70_2.pdf and http://ec.europa.eu/competition/state_aid/cases/247516/247516_1435107_91_2.pdf.

The main aim of the state aid measure in Lithuania was to develop an ICT infrastructure that offered wholesale broadband services in rural areas of the country that were not being served and where there were no plans for coverage in the near future. The ultimate goal of the project was to provide opportunities for residents, public institutions, and businesses to use broadband in the country's unserved areas. In addition, three socioeconomic goals were identified:

- reducing Lithuania's digital divide by creating favorable broadband infrastructure conditions throughout the country
- promoting competition in the broadband sector through an open-access policy of the subsidized network
- accelerating the development of an information society in Lithuania and contributing to the state's economic growth

Lithuania has chosen to tackle the lack of necessary backhaul broadband infrastructure and not to invest in last-mile infrastructure, hoping to create the right stimulus for the private sector to engage in the latter.

TABLE A7.5.
Features of Approved State Aid Measure, Lithuania

1	Target area	Countrywide white areas and white NGA areas
2	Technology	Backhaul fiber lines only to be placed as a result of the notified measure where no such infrastructure is available from other private operators.
3	Part of network	Only backhaul and core networks are covered.
4	Market failure	As in many countries in the EU, broadband services are available in more densely populated locations (in particular in Vilnius), whereas the rollout of basic broadband connections is lagging behind in rural and remote areas. In 2008, rural areas in Lithuania (32% penetration) were far behind urban areas (99% penetration) in network connectivity. The rural areas had received little private investment in previous years due to their commercial unattractiveness (low subscriber density), creating a digital divide. It is important to have wide-spread broadband networks across the whole country, including rural areas, in order to gain potential benefits that broadband could bring. The Lithuanian authorities have identified that the necessary core/backhaul network infrastructure and capacity were missing across Lithuania.
5	State involvement	Public DBO Placiajuostis Internetas – a non-profit entity owned by the Ministry of Transport and Communications was responsible for the implementation of the project. The entity is deploying and operating a public backhaul network that connects various public and private institutions, including municipalities, schools, libraries, hospitals, and masts of mobile operators. It provides open access services to interested third party internet providers and cable companies.
6	State aid measure's scope	A financing scheme However, it is mainly RAIN-2 (and its extension PRIP[28]) that was financed through the scheme.[29]
7	Financing option	Direct grant
8	Budget (initial)	The notified initial amount of the RAIN Project was approximately €60.5 million, €51.4 million coming from the resources of the European Regional Development Fund (ERDF) and €9.1 million from resources of Lithuania.

Source: World Bank, based on the EC decision.

Compliance with Broadband Guidelines. The measure was reported to the EC in 2009 and had to comply with the older version of the EC's Broadband Guidelines.

[28] A supplemental project, with the same objectives as RAIN-2.

[29] Additionally, a project of broadband infrastructure deployment in Lazdijai and Alytus was covered by the scheme; however, this was a relatively small project (in terms of geography and funds) compared to RAIN and its extensions.

TABLE A7.6.
Compliance with Broadband Guidelines of the Approved State Aid Measure, Lithuania

Requirement		Compliance
Measure aimed at well-defined objectives of common interest	✓	By extending broadband coverage to unserved areas of Lithuania, the measure helped achieve greater social and regional cohesion and was therefore considered in line with the commo interest of the EU.
Measure designed to deliver the objectives if it is of common interest and: • is an appropriate instrument • has an incentive effect • is proportional	✓	Lithuanian authorities realized that efforts from alternative instruments (including ex ante regulation) were not sufficient to encourage broadband expansion throughout the country. The demand-side measures—tax incentives, computer literacy courses, development of e-services—had been in place in Lithuania for several years, but this did not solve the problem on the supply side. Existing ex ante regulation had facilitated broadband deployment in urban and more densely populated areas, but it was unlikely that it would have led to sufficient private investments in rural areas. The EC recognized that the measures did not narrow the digital gap between urban and rural areas, and therefore the suggested state aid measure was considered to be appropriate and proportional. It was expected that the creation of a backhaul network in the unserved areas would reduce the entry barriers for commercial operators, thereby encouraging them to extend their broadband network coverage to rural areas.
Has limited negative effects and distortions of competition	✓	The Lithuanian authorities aimed to improve broadband availability in rural areas by tackling the lack of necessary backhaul broadband infrastructure. The network was expected to offer open wholesale access to third-party operators to deliver broadband services to end-users. The Lithuanian authorities conducted a detailed mapping and coverage analysis to identify the target areas. Operators provided information about the infrastructure they managed to help the planning of the fiber routes. In return, Placiajuostis Internetas revealed the planned fiber routes to any interested parties (to avoid duplications and to employ existing infrastructure). The built infrastructure may be employed by all operators as network topology ensures technological neutrality. The state aid measure is considered to have promoted the development of a competitive environment, as the end user is allowed to freely choose the service provider and services. Tariffs of the wholesale service, determined by the Ministry of Transport and Communications, are set at a level that ensures that retail broadband services in the targeted areas are provided at a price similar to urban areas.

Source: World Bank, based on the EC decision.

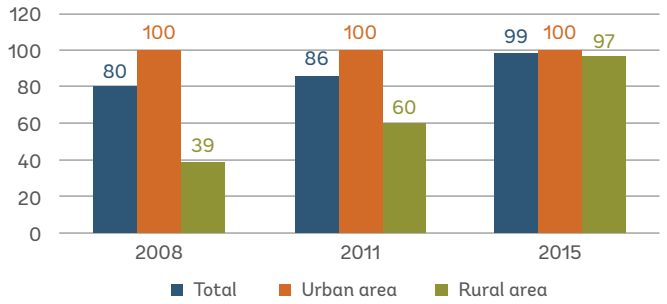
Results. Under the analyzed state aid measure, the RAIN-2 project was the main receiver of allocated funds. However, as it is a continuation of the initial RAIN-1 project, the results are best evaluated jointly. See **box A7.1** for the details of the results of each project.

Altogether, the infrastructure created during the two projects enables operators to provide broadband services to at least 97 percent of the country's rural areas. It is used by 51 operators[30] and reaches roughly 1 million inhabitants—one-third of Lithuania's population—which was the initial intention of the project, meaning that the objectives were achieved. Changes in broadband coverage during the implementation of the projects are provided in **figure A7.1**. The increased coverage resulted in increased penetration (see **figure A7.2**). As fixed broadband take-up in Lithuania is still lagging behind the majority of EU countries, this indicates that even almost absolute coverage of broadband networks will not necessarily mean that the objectives of penetration (subscriptions) will be reached easily.[31] This implies that demand stimulation measures should be strongly considered.

[30] Placiajuostis Internetas, "Rural Area Information Technology Broadband Network," https://ec.europa.eu/digital-single-market/sites/digital-agenda/files/lithuania_rain_facts_briuselis2.pdf.

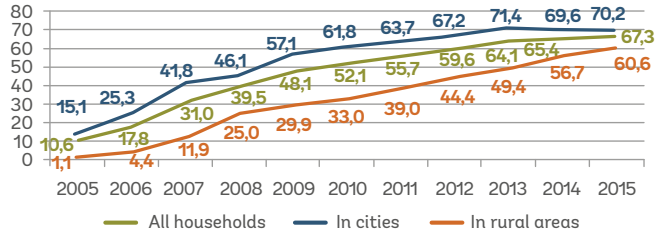
[31] See EC, "The Digital Economy and Society Index (DESI)," Indicator 1a "Fixed Broadband," https://ec.europa.eu/digital-single-market/en/desi.

FIGURE A7.1.
Changes in Fixed Broadband Coverage in Lithuania during the Implementation of the State Aid Measure (2008 v. 2011 v. 2015)



Source: RRT (the Regulatory Authority of the Republic of Lithuania).[32]

FIGURE A7.2.
Dynamics of Fixed Broadband Penetration in Lithuania, 2005–15



Source: RRT.[33]

Additional lessons from the Lithuania case concern the project's infrastructure cost controls. First, the cables were laid only in areas where no other cables existed. Second, to avoid any duplications, information on the planned routes was shared with the market players. Third, the fiber connection points were installed in all the settlements that a route passes through, ensuring future connections. Fourth, existing public infrastructure was used, for example, protective zones under roads, to minimize the total distance of the cables.

As a result, in 2015, the EC designated the RAIN-2 project as the **winner of the European Broadband Award 2015** in the category of socioeconomic impact and affordability.[34]

BOX A7.1.
Deployment of Broadband Networks in Rural Areas of Lithuania

There are several main phases that may be distinguished in the development of broadband networks in rural Lithuania:

- 1st phase (2005–08): The RAIN -1 project was initiated, and the public DBO model was chosen to implement it. A non-profit public entity "Placiajuostis Internetas" was established. During this phase, it designed and constructed approximately 3,400 kilometers of fiber lines, and 467 rural settlements were connected to broadband infrastructure. Total value of the project: roughly €21 million.
- 2nd phase (2009–15): The RAIN-2 project covered the design and construction of approximately 5,800 kilometers of fiber optic lines, and 982 rural settlements were connected to broadband infrastructure. Total value of the project: roughly €60 million.
- 3nd phase (2014–15): "Development of Broadband Network Infrastructure in Rural Areas" (PRIP) project. It aimed at designing and constructing an additional 485 kilometers of fiber lines, connecting 440 rural entities, such as the largest farms, agricultural institutions, and organizations, to the lines already constructed by the RAIN project. Total value of the project: roughly €6 million.
- 4th phase (foreseen for 2016–20): The continuation of the PRIP project with the aim of constructing an additional 340 kilometers of fiber optical lines and connecting an additional 400 or more rural entities.

Source: Placiajuostis Internetas.

[32] http://www.rrt.lt/lt/pranesimai_296/2016.html.

[33] Ibid.

[34] "European Broadband Awards Showcase Best Practice," Fibre Systems, November 18, 2015, http://www.fibre-systems.com/news/story/european-broadband-awards-showcase-best-practice.

ANNEX 8. BROADBAND MAPPING

Informed and consistent broadband policy making and implementation will require a well-considered and sustainable broadband mapping tool: the Broadband Atlas.[1] This Atlas has yet to be developed. It is therefore essential that the development of the Broadband Atlas directly correspond to the principles and directions of the *Concept for the Development of the Digital Economy and Society of Ukraine for 2018–2020*, the National Broadband Development Strategy (NBDS), and other sector-specific policy documents.

In accordance with the draft Law of Ukraine "On Electronic Communications" No. 3014, the National Commission for the State Regulation of Communications and Informatization (NCCIR) as a national regulator should undertake to develop an electronic regulatory platform to exercise its powers.[2] However, today the NCCIR does not have sufficient financial, technical, and other resources to develop such a tool. The Law of Ukraine "On a Communications Regulator" and other changes in the legislative framework may improve this situation, but before such changes are adopted, the Ministry of Digital Transformation (MDT) plans to take responsibility for the platform's development. At the time of this writing, the MDT was already actively elaborating the concept of the platform: the broadband.gov.ua portal (the portal).

The portal should become a tool to ensure the participation of all stakeholders in the implementation of the State Policy on Digital Infrastructure. This multifunctional all-in-one platform will provide a wide range of tools and services to enable geographic surveys of broadband coverage (fixed and mobile), analysis of the availability and quality of universal electronic communications and services, and greater transparency of the regulator's activities (Articles 10–11).

According to the plans of the MDT, the portal will consist of seven modules: (i) infrastructure mapping, (ii) a coverage and penetration map of fixed and mobile broadband, (iii) submission of data and reporting to state authorities, (iv) feedback from citizens about the quality of service monitoring, (v) simplification of public procurement in broadband, (vi) a comparison of tariffs and services of operators and internet service providers (ISPs), and (vii) interoperability and open data. **The successful achievement of the MDT's ambitious stipulations in draft Law No. 3014 is only possible on the condition that the Broadband Atlas is developed, which should be seen as a long-term geographic information system (GIS) solution.**

The development of broadband mapping tools is a regular practice for many countries in the European Union (EU) and elsewhere to speed up and reduce the cost of deploying broadband networks, to provide citizens with access to e-services, and to facilitate the efficient spatial distribution of investments. However, the specific set of data and functions in each individual case depends on the primary issues and targets set by the country. **In this regard, the vision of the MDT outlines the three top goals as:**

- providing general access to the service with the development of broadband networks and the connection of social facilities
- setting the minimum price of the service
- obtaining high-quality service

[1] This is the term agreed with the MDT.

[2] For text of the law see https://zakon.rada.gov.ua/laws/show/67-2018-%D1%80 (in Ukrainian).

At the same time, the MDT is paying special attention to increasing the coverage and penetration of broadband services. Broadband coverage refers to its physical availability, especially in settlements and along major roads and railways. Penetration is characterized by an actual usage of broadband services and is determined by demand and user activity. The approaches to the development of the Atlas and its architecture, content, and tools should be determined primarily by these goals.

Thus, the Broadband Atlas, as a GIS component of an all-in-one electronic regulatory platform, should contribute to solving the strategic goals of the Government of Ukraine (GoU) and to ensuring its authority by means of the regulator. The Atlas should also become a helpful tool for users, including businesses and citizens.

The Atlas' implementation and data collecting will not be possible without the intensive involvement of a wide range of stakeholders that will be also its users. The MDT has identified three large user groups:

- consumers
- governments
- businesses

Stakeholder involvement should be coordinated by the GoU, as in other countries. This stage is extremely important and should include bilateral and group meetings to discuss the benefits and challenges of the development of the Atlas. The GoU would need to involve state and municipal authorities, the regulator, military authorities, scientific institutions and academic circles, public companies, businesses, telecom operators and ISPs, utilities, and all other companies interested in broadband deployment, as well as representatives of the end users of services. These meetings should be held even in the early stages of Atlas development to facilitate the creation of a useful and convenient tool for all user groups. Informing all stakeholders of the importance and goals of developing the Atlas, its work principles, and approaches to protecting confidential data would help stimulate data holders into providing the necessary data.

In the European Commission's (EC) Study on Broadband and Infrastructure Mapping (SMART 2012/0022), four kinds of broadband mapping were defined:

- infrastructure mapping
- service mapping
- demand mapping
- investment and funding mapping

Based on the goals of the MDT, the powers vested in the regulator in draft Law No. 3014, available resources, and possible challenges to Broadband Atlas development, it would be appropriate for Ukraine, as a first step, to develop a mapping tool with two types of information: infrastructure and service.

Infrastructure information should include the mapping of active and passive physical infrastructure objects with an exact indication of their geographic location (e.g., ducts, poles, or masts), as well as the mapping of planned infrastructure, for which administrative and construction permits have already been issued.

Service mapping should describe systems that gather, analyze, and present information on the supply of broadband services available in a specific area (e.g., supplier name, type of technology, download speeds, quality of services). It should also provide insights into the current state of broadband availability and quality. Thus, the country's territory can be divided into white, grey, and black areas, per EU methodology,[3] which would serve as a good source of data for decision making on the development of broadband access.

In subsequent stages, if it is necessary and there are sufficient resources and data sources, it also makes sense to consider the possibility of investment and demand mapping. This mainly relates to demand mapping, which should focus on gathering information on the existing demand for broadband services to identify (i) territories whose residents have high unmet demand, (ii) the level of digital literacy of the citizens, and (iii) the primary ways that broadband will be used. These data would be important to both the authorities and businesses in planning the deployment of new networks and in providing public support for the process.

[3] "EU Guidelines for the Application of State Aid Rules in Relation to the Rapid Deployment of Broadband Networks," January 26, 2013, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2013.025.01.0001.01.ENG.

The basis of the Broadband Atlas should be reliable, accurate, and constantly updated with high-quality data. However, collecting this data is a serious challenge for the GoU in the current regulatory and legal environment. Thus, the improvement of the regulatory framework is necessary to ensure the involvement and interest of all stakeholders that own relevant information.

The current situation in Ukraine with regard to data collection on broadband is far from satisfactory. The main problems are the fragmentation of data sources and lack of accuracy and reliability of the information provided. Among the institutions that systematically collect data are the regulator (the NCCIR), the State Statistics Service of Ukraine, the Ukrainian State Center of Radio Frequencies, and various other organizations. However, the majority of the information they collect does not have a geographic location of sufficient accuracy, while indicators, data types, and formats are unsuitable for inclusion in the GIS. For example, according to the NCCIR's Resolution No. 180 of 04/05/2016[4] (with amendments), the bulk of the information that the regulator collects from operators and ISPs relates to their economic performance and is not designed to be used for GIS development with the necessary accuracy. Also, the collected data sets are insufficient for the creation of full-fledged maps of infrastructure, services, or demand. Market players also have a large amount of relevant information, but due to a weak regulatory framework that does not clearly specify the requirements for geospatial data, they collect information in a disparate form and do not provide it to the regulator.

Of the positive aspects, it is worth noting that in 2020, the MTD introduced a new reporting form for the use of the NCCIR to analyze the current state of broadband coverage. This decision turned out to be effective and allowed market players and stakeholders to mobilize, which contributed to the collection of the information needed for a quick assessment of the availability of broadband services. Another positive aspect is the initiative of the Ministry for Communities and Territories Development to collect 25 data layers of public service network objects in a GIS format (based on institutions' self-mapping). This database will become a good basis for assessing the level of broadband connection among social institutions.

To address the current deficiencies, the regulator's capacity to collect the necessary data and information should be strengthened. This can be achieved through the adoption of a special regulatory framework that will ensure the successful development and implementation of the Broadband Atlas. Another way is to conclude memoranda of understanding (MoUs) or agreements with selected major market players. One of the conditions for gaining access to the eventually developed Broadband Atlas may be for stakeholders to provide the information that it will contain (a temporary exception could be made for new market players only).[5]

In the regulatory framework, it is necessary to separately determine the type of geospatial data that contain information about the geographic location of objects. Appropriate accuracy requirements and other specifications must be established. Obviously, the NCCIR would also have to update the reporting requirements of operators and ISPs so that they begin to prepare the types of data needed to fill the Atlas that had not been previously collected.

Another important aspect is the mechanisms and tools to collect the data. Several methods for inputting information into the GIS should be provided. This may be the data input interface on the platform itself, XML, or JSON files, with a clear structure and determined sets of information to provide other formats of geospatial or tabular data. Particular attention should be paid to technical support for the quality and accuracy of the data before they are posted on the Atlas.

It should be expected that the data collection process will be a key and long-lasting stage in the development of the Atlas. This is due to the fact that in order to obtain a complete and representative picture of the development of broadband access in Ukraine, data sets are needed from the overwhelming majority of market players, of which there are hundreds, if not thousands (if only active market players are considered).

[4] Text can be found at https://zakon.rada.gov.ua/laws/show/z0739-16.

[5] Based on the World Bank's recommendations on developing a Broadband Atlas for a Western Balkan client.

To start collecting the data, it is necessary to identify thematic layers of information that will be available on the Atlas. This will make it possible to create a list of the required data sets and determine their holders. Further, through intensive interaction with the holders of relevant information, the regulator would be able to begin the process of immediate data collection.

The basis for filling the Broadband Atlas in the early stages can be the data from government institutions and public companies: infrastructure and contact details of energy, transport, and telecommunications companies; statistical information; cadastral data; and the location of social facilities, as well as the data from regional and local governments (municipalities and amalgamated territorial communities [ATCs]). An additional source of information about the quality of services can be the results of speed tests (including data from international crowdsourcing initiatives, such as RIPE Atlas, Measurement Lab, or Ookla®). All relevant information from the reporting that the regulator collects could also be used, such as the data from the quarterly reporting forms No. 1-K "Mobile and data services, including internet access," 3-K "Fixed access to internet," 4-K "Provision of telecommunication channels, telecommunication networks and other telecommunication services," and 7-K "Distribution of active identification telecommunication cards of the mobile communication network by administrative and territorial units," as well as the annual reporting form No. 6-P "Allocation of lines of fixed access to internet by administrative and territorial units."[6] Representative nationwide opinion polls and statistical surveys can serve to fill the demand mapping component of the Atlas (e.g., Canada's Connectivity Strategy includes two statistical surveys to measure broadband usage[7]).

Ultimately, the electronic regulatory platform would become a storage of diverse information that will be structured and presented, including through one of its functionalities—the Broadband Atlas. The holder of these data will be the regulator. It is important that these thematic datasets be harmonized and become part of the National Geospatial Data Infrastructure,[8] which is aligned with the INSPIRE EU Directive.[9] In addition, it is recommended that new datasets be developed and that their metadata comply with the International Organization for Standardization (ISO) 19100 "Geographic Information Standards"[10] and the national standard of Ukraine ISO 19131:2019 "Specification of geo-informational product."[11]

A prerequisite for accessing data from the Atlas must be the confidentiality of certain layers of information and other security requirements that are related to matters of national security. This can be achieved by controlling the access levels of different user groups to data, by data aggregation and generalization, and by usage of special technical security solutions. For data and system security, it is recommended that the global approaches as outlined in the OECD Guidelines for Security Information Systems and Networks be followed. In the Ukrainian context, it is also worth taking into account the Law of Ukraine "On the Protection of Personal Data" No. 2297-VI of 01/06/2010 and the regulatory framework that considers concerns about trade secrets.

At the same time, the bulk of the information on the electronic regulatory platform and in the Broadband Atlas should be available in an open data format. This means that public information should be available in data sets that can be automatically processed (have a defined structure and appropriate file formats, e.g., CSV, XML, JSON, etc.), freely accessed for use and reuse, and freely distributed. This data presentation is regulated and required by several legislative acts: the Law of Ukraine "On Access to Public Information" No. 2939-VI of 13/01/2011, Cabinet of Ministers of Ukraine Resolution No. 835, the draft Law of Ukraine "On National Geospatial Data Infrastructure" No. 2370 of 01/11/2019, and the draft Law of Ukraine "On Electronic Communications" No. 3014 of 02/05/2020. In accordance with Law No. 2939-VI, all public information is open, except as stipulated by law. Also, if all three conditions from the second

6 See the NCCIR, https://nkrzi.gov.ua/index.php?r=site/index&_pg=48-&language=uk.

7 Government of Canada, "High-Speed Access for All: Canada's Connectivity Strategy" (Ottawa: Innovation, Science and Economic Development Canada, 2019), https://www.ic.gc.ca/eic/site/139.nsf/eng/h_00002.html.

8 The Law of Ukraine "On National Geospatial Data Infrastructure" No. 2370 of 01/11/2019 was adopted on 13/04/2020 and defines the basis for the development and functioning of this infrastructure. See http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=67268.

9 For more information, see https://inspire.ec.europa.eu/inspire-directive/2.

10 See "Geographic Information/Geomatics," https://www.iso.org/committee/54904.html.

11 See http://online.budstandart.com/ua/catalog/doc-page?id_doc=86567.

paragraph of Article 6 of this law are met, access restrictions may be imposed on confidential, secret, and service information. Thus, issues of access to information contained in the Atlas should be carefully considered, and the balance between open access to data and respect for confidentiality and security should be maintained.

In the EU, the development of such mapping tools most often takes from three to five years and is divided into several stages. Ukraine should be ready to follow the same scenario. The initial stages may include the active mobilization of all stakeholders and data collection, resulting in a proprietary GIS. To develop this kind of system, the regulator or the MDT will need to establish and build the capacity of its own GIS department. Otherwise, in European practice there are cases where the development and support of such systems is outsourced to third parties, that is, private companies. Proprietary GIS will become a planning and decision-making tool for the GoU before the full launch of the Broadband Atlas. At the same time, the data can be provided to interested parties on the basis of official requests for specific purposes (e.g., the deployment of new networks). The development of the web version of the Atlas should be the next stage, and data access issues should be considered. For example, information about the exact geographic location of infrastructure objects may need to be subject to increased privacy requirements and severe access restrictions. At the same time, information about the supply of broadband services should be available to a wide range of users, including businesses and citizens. Moreover, special attention should be paid to data and reporting visualizations, the creation of useful tools and user-friendly interfaces, and the provision of feedback functionalities.

According to an analysis of EU practices and their adaptation to the Ukrainian context, the following development plan for the Broadband Atlas as a long-term solution is proposed:[12]

Stage 1	Time frame: 9 months	Cost: US$100,000
Actions: 1. Developing the concept, requirements, and terms of reference for the Atlas (taking into account the involvement of consultants and donors) 2. Mobilizing stakeholders in the process of data and information collection by the NCCIR 3. Improving the regulatory framework for data collection, harmonizing it with that of the EU		
Stage 2	Time frame: 18 months	Cost: US$1.5 million
Actions: 1. Organization of the GIS department (including equipment, salaries of employees until the final launch of the Atlas, and the involvement of consultants and donors) 2. Data collection and processing 3. Development of a proprietary GIS		
Stage 3	Time frame: 12 months	Cost: US$400,000
Actions: 1. Development of a web application for the Broadband Atlas (including data input tools)		

[12] The cost estimate is based on the median value of the costs of implementing such projects during the first three years in the EU (e.g. the experience of Portugal).

However, the final time frames and costs will greatly depend on the ability of the GoU to mobilize all stakeholders in the process and the efficiency of improving the regulatory framework. Also important will be the specific data layers, tools, and functionalities that would be chosen for the Broadband Atlas.

The electronic regulatory platform (broadband.gov.ua) should become a powerful all-in-one tool for the regulator and the MDT that will enable them to make optimally good decisions on broadband network deployment, analyze the relevant markets and network coverage, and facilitate communication with market players and citizens. The Broadband Atlas, as an important part of this platform, will combine various data sets and determine the standards for their systematization. For the successful implementation of this scenario and the speedy achievement of the set goals, the GoU should become the main participant in the process and ensure the active involvement of all stakeholders in the development of the electronic regulatory platform and the Broadband Atlas.

Recommendation 1:

Approach the development of the Broadband Atlas as a long-term GIS solution, the implementation of which should be divided into several stages.

Recommendation 2:

Ensure that all stakeholders are involved in developing the Atlas and its tools and in filling the Atlas with the requisite data and information. Compile a list of all the relevant stakeholders and make the GoU (represented by the NCCIR or MDT) a moderator of their involvement.

Recommendation 3:

Based on the goals of the GoU, display data in the Atlas about the existing and planned infrastructure and services. Create an exhaustive list of information layers, as well as a list of data sets and their holders.

Recommendation 4:

Improve the regulatory framework in order to strengthen the authority and responsibilities of the NCCIR to require data from all stakeholders. The specifications and requirements for the requested data should be clearly defined. For example, it is necessary to separately determine the geospatial data requirements.

Recommendation 5:

Provide specific mechanisms for stakeholders to enter data into the Atlas. Develop a user-friendly web interface for entering information.

Recommendation 6:

Establish a special GIS department within the NCCIR or the MDT to develop and subsequently support the work of the Broadband Atlas, or ensure that the functioning of the Atlas is supported by third parties (outsourced to companies).

ANNEX 9. INTERNATIONAL CAPACITY NEEDS

The total capacity required to ensure certain connectivity speed S_C per household is calculated as follows:

$$\text{Total capacity} = \frac{(S_C \times N_h \times C_p \times C_d),}{C_r}$$

where N_h is the number of households in the country, C_p is the share of households exhibiting peak traffic usage, C_d is the share of traffic that remains domestic, and C_r is the contention ratio.[1]

According to Ukrstat, there are N_h=14.88 million households in Ukraine.[2] Assume that the peak use is in C_p=50% of all households and that C_d=50% of the traffic remains domestic.

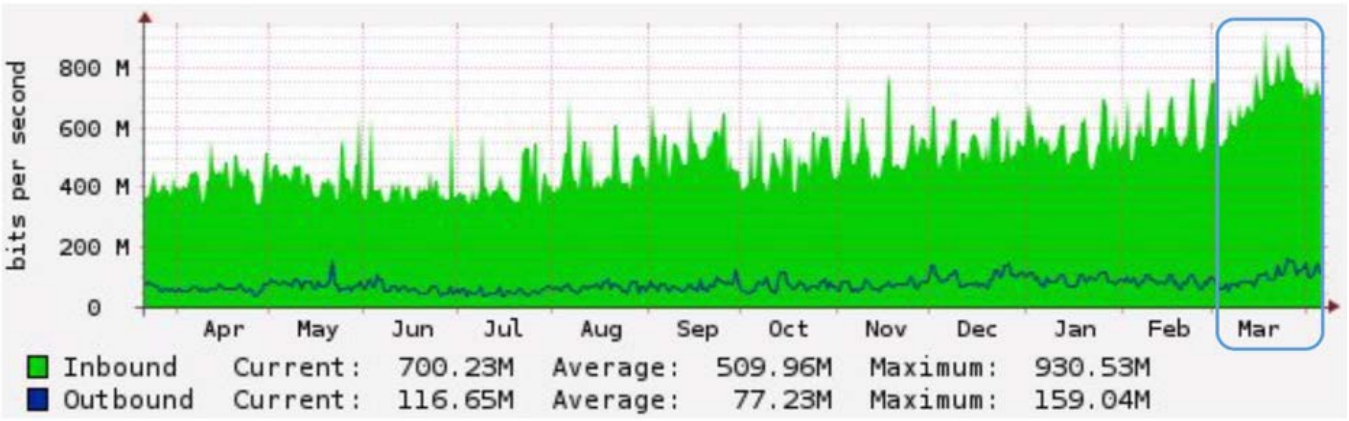
Current situation

The Ookla® Speedtest® for Ukraine—as of March 2020—reported fixed broadband download of S_C=51.83 Mbps.[3] Consider a typical uplink port with 40 connected switches, serving 20 users on average. The figure below illustrates the traffic data gathered from a Kyiv-based local operator[4] representing this kind of realistic scenario (during the COVID-19 quarantine).

From the figure it is seen that the peak inbound traffic is roughly 930.53 Mbps. Assuming that a 100 Mbps limit is secured per authenticated user, the actual contention ratio can be calculated as

$$C_r = \frac{40 \times 20 \times 100 \text{ Mbps}}{1.54 \text{ Gbps}} = 86{:}1$$

FIGURE A9.1.
Hourly Traffic Distribution of an Uplink Port[5]



[1] See http://www.telecomabc.com/c/contention-ratio.html.

[2] Information can be found at http://www.ukrstat.gov.ua/druk/publicat/kat_u/2019/gb/07/gb_sdhdu2019.pdf (in Ukrainian).

[3] Based on analysis by Ookla® of Speedtest Intelligence® data for March 2020. Ookla trademarks used under license and reprinted with permission.

[4] It is noteworthy that when inspecting the figure, one observes a spike in traffic of around 25 percent in late March (see the highlighted blue region). This is attributed to the effects of the COVID-19 outbreak in Ukraine, which has forced many people to stay home, where they are working and entertaining themselves online.

[5] Interview with a local Kyiv-based operator, April 2020.

The total capacity required to **maintain the current average speed** per household is obtained as

$$\text{Total capacity} = \frac{51.83\ \text{Mbps} \times 14.88\ \text{mil} \times 50\% \times 50\%}{86} = 2.14\ \text{Tbps},$$

which is well below Ukraine's current bandwidth numbers as reported in Section 5.1.

Improved situation - Gigabit Society goals

A more ambitious target would be to ensure S_C=100 Mbps speed per household. Typical home-user quality of service corresponds to a contention ratio of C_r=50:1. The required total capacity for such a scenario is:

$$\text{Total capacity} = \frac{100\ \text{Mbps} \times 14.88\ \text{mil} \times 50\% \times 50\%}{50} = 7.1\ \text{Tbps},$$

Looking to the future

To reach per-household speeds of S_C=1 Gbps—and ensure enterprise-level quality of service—we take a more aggressive contention ratio of C_r=20:1. The calculations thus yield the following required total capacity:

$$\text{Total capacity} = \frac{1\ \text{Gbps} \times 14.88\ \text{mil.} \times 50\% \times 50\%}{20} = 181.64\text{Tbps},$$

ANNEX 10. NETWORK OF GEO-MAPPED OBJECTS OF SOCIAL INFRASTRUCTURE

Central Executive Body	Name of the Network	Number of Layers of Geolocational Data	Number of Objects in the Network
Ministry of Education and Science	Pre-school education institutions	Kindergartens	15,000
	General secondary education institutions and hub schools	1. Hub schools 2. Affiliate hub schools 3. General secondary education institutions – project hub schools 4. General secondary education institutions	15,500
	Professional and technical education institutions	1. Professional (professional-technical) education institutions 2. Other educational institutions that provide professional education	1,050
	Inclusive resource centers	1. Inclusive resource centers	600
Ministry of Health	Primary health institutions	1. Outpatient group practice 2. Outpatient clinics 3. Center for Primary Health Care 4. Paramedic-midwife poin	18,800
	Secondary, tertiary health care institutions and emergency medical care	1. Oblast health care institutions 2. Municipal and rayon health care institutions 3. Emergency medical care and ambulance stations 4. Other health care institutions	2,050
Ministry of Culture and Sports	Youth clubs	1. Culture houses 2. Clubs 3. Community halls 4. Centers of culture, leisure, and sports 5. Palaces of culture	15,600
	Libraries	1. Public libraries 2. Public libraries for children 3. Public libraries for youth	16,700
	Arts schools	1. Musical schools 2. Arts schools 3. Fine arts schools 4. Choreography schools	1,250

Central Executive Body	Name of the Network	Number of Layers of Geolocational Data	Number of Objects in the Network
Ministry of Culture and Sports	Cinema houses	1. Cinema houses 2. Movie installations	300
	Children's Youth Sports School and youth centers	1. Children's Youth Sports School 2. Youth centers	1,500
	Sports installations	1. Stadiums 2. Soccer fields 3. Gyms 4. Playgrounds 5. Shooting ranges 6. Swimming pools 7. Sports complexes 8. Other	14,000
Ministry of Economic Development	Centers for administrative services	1. Centers for administrative services of rayon state administration 2. Centers for administrative services of cities of oblast importance 3. Centers for administrative services of cities of rayon importance 4. Centers for administrative services of amalgamated territorial communities (ATCs) 5. Centers for administrative services of village councils	800
Ministry of Social Policy	Social care institutions and their hospitals	1. Local centers of social care 2. Services for children 3. Social service centers for family, children, and youth 4. Boarding houses 5. Homeless childcare centers 6. Reintegration centers 7. State centers for complex rehabilitation 8. Orphanages	2,300
	Facilities for social service provision	1. "Transparent" offices 2. Department of social protection for the population 3. Employment centers 4. Social insurance fund	1,600
Ministry of Interior/ State Emergency Service of Ukraine	Local fire and rescue teams	1. Local fire and rescue teams	600
	State fire and rescue units	1. State fire and rescue units	1,700
	Police stations and security centers	1. Police stations 2. Security centers	170
Altogether	**18**	**61**	**109,520**


WORLD BANK GROUP
Digital Development