ITU Publications
Europe

International Telecommunication Union
Development Sector

5G implementation in non-European Union countries of the Europe region

5G implementation in non-European Union countries of the Europe region

ITU regional initiative for Europe on broadband infrastructure, broadcasting and spectrum management

Disclaimer

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of ITU or its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by ITU in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by ITU to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader.

ISBN

978-92-61-33201-3 (Paper version)

978-92-61-33211-2 (Electronic version)

978-92-61-33221-1 (EPUB version)

978-92-61-33231-0 (Mobi version)

Please consider the environment before printing this report.

Acknowledgements

This report was developed by the ITU Office for Europe within the framework of the ITU Regional Initiative for Europe on "Broadband infrastructure, broadcasting and spectrum management". It was elaborated by the ITU Office for Europe team, under the supervision and direction of the Head of that Office.

The report incorporates comments and amendments from all the Sectors of ITU, including the Radiocommunication Bureau (BR), the Telecommunication Standardization Bureau (TSB) and the ICT Data and Analytics (IDA) and the Future Networks & Spectrum Management (Access) Divisions of the ITU Telecommunication Development Bureau (BDT).

Moreover, important feedback has been provided to this report by:

- Electronic and Postal Communications Authority (AKEP), Albania;
- Ministry of Infrastructure and Energy, Albania;
- Communications Regulatory Agency (CRA), Bosnia and Herzegovina;
- Post and Telecom Administration (PTA), Iceland;
- Ministry of Communications, Israel;
- Office for Communications, Liechtenstein;
- Ministry of Economy and Infrastructure, Moldova;
- National Regulatory Agency for Electronic Communications and Information Technology (ANRCETI), Moldova;
- Ministry of Economy, Montenegro;
- Agency for Electronic Communications and Postal Services (EKIP), Montenegro;
- Ministry of Information Society and Administration, North Macedonia;
- Agency for Electronic Communications, North Macedonia;
- Ministry of Trade, Tourism and Telecommunications, Serbia;
- Information and Communication Technologies Authority, Turkey;
- National Commission for State Regulation of Communications and Informatization, Ukraine;
- Department for Digital, Culture, Media and Sport (DCMS), United Kingdom;
- Dicastero per la Comunicazione – Direzione Tecnologica, Vatican.

The report was prepared as a living document and background contribution to the ITU Regional Forum for Europe on 5G strategies, policies and implementation, held on 22 and 23 October 2020. It builds upon the discussions held and comments received from participants in the ITU Regional Forum for Europe.

As 5G implementation is a dynamic process, this report is treated as a living document that can be amended at any point in time depending on the availability of additional information.

Table of contents

Abbreviations and acronyms

This table contains abbreviations/acronyms relating to international, regional or supranational bodies, instruments or texts, as well as technical and other terms.

Abbreviations/acronyms of national bodies, instruments or texts are explained in the relevant section relating to the country concerned, and are thus not included in this table.

Abbreviation	Meaning
2G	second-generation mobile technology
3G	third-generation mobile technology
3GPP	3rd Generation Partnership Project
4G	fourth-generation mobile technology
5G	fifth-generation mobile
ADSL	asymmetric digital subscriber line
AI	artificial intelligence
BAM	convertible mark (currency of Bosnia and Herzegovina)
BB PPDR	broadband public protection and disaster relief
BBU	baseband unit
BDT	Telecommunication Development Bureau
BPL	broadband over power lines
BR	ITU Radiocommunication Bureau
CA	carrier aggregation
CATV	cable television
CEPT	European Conference of Postal and Telecommunications Administrations
CIRT	computer incident response team
COVID-19	coronavirus disease 2019
CPE	customer-premises equipment
DD1/DD2	Digital Dividend (800 MHz band)/Digital Dividend (700 MHz band)
DSL	digital subscriber line
DSS	dynamic spectrum sharing
DTT	digital terrestrial television
DTV	digital television

(continued)

Abbreviation	Meaning
DVB-T	terrestrial digital video broadcasting
EaPeReg	Eastern Partnership Electronic Communications Regulators Network
EBRD	European Bank for Reconstruction and Development
ECDL	European Computer Driving Licence
EDI	electronic data interchange
EEA	European Economic Area
EIB	European Investment Bank
EMF	electromagnetic field
EU	European Union
EUR	Euro (currency of the Euro zone)
FDD	frequency-division duplexing
FTTB	fibre-to-the-building
FTTC	fibre-to-the-cabinet
FTTH	fibre-to-the-home
FTTN	fibre-to-the-node
FTTP	fibre-to-the-premises
FTTS	fibre-to-the-subscriber
FTTx	fibre-to-the-x (where 'x' indicates the range different possible termination points, e.g. FTTB/C/H/N/P/S)
FWA	fixed wireless access
GDP	gross domestic product
GEL	Georgian lari (currency of Georgia)
GNI	gross national income
GPON	gigabit passive optical network
GSM	Global System for Mobile Communications
HD	high-definition
HFC	hybrid fibre-coaxial
HSPA/HSPA+	high-speed packet access / evolved high-speed packet access
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection

(continued)

Abbreviation	Meaning
ICT	information and communication technology
IEEE	Institute of Electrical and Electronics Engineers
ILS	Israeli Shekel (currency of Israel)
IMT	International Mobile Telecommunications
IoT	Internet of Things
IPTV	Internet Protocol television
IPV6	Internet Protocol version 6
ISK	Icelandic króna (currency of Iceland)
ISP	Internet service provider
ITU	International Telecommunication Union
LoI	letter of intent
LTE	Long-Term Evolution
Ma-MIMO	massive multiple-input multiple-output
MDL	Moldovan leu (currency of Moldova)
MEC	multi-access edge computing
MFCN	mobile/fixed communication networks
MIMO	multiple-input multiple-output
mmWave	millimetre waves
MNO	mobile network operator
MoI	memorandum of intent
MORAN	multi-operator radio access network
MoU	memorandum of understanding
MVNO	mobile virtual network operator
NB-IoT	narrowband IoT
NFV	network function virtualization
NGA	next-generation access
NGO	non-governmental organization
NIR	non-ionizing radiation
OCSE	Organization for Security and Co-operation in Europe
OFDM	orthogonal frequency-division multiplexing

(continued)

Abbreviation	Meaning
PoC	proof of concept
R&D	research and development
RAN	radio access network
RF	radio frequency
RF-EMF	radio-frequency electromagnetic field
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SDGs	United Nations Sustainable Development Goals
SDL	supplemental downlink
S-RAN	single radio access network
TDD	time-division duplexing
TRY	Turkish lira (currency of Turkey)
TSB	Telecommunication Standardization Bureau
TV	television
UAH	Ukrainian hryvnia (currency of Ukraine)
UAV	unmanned aerial vehicle
UNESCO	United Nations Educational, Scientific and Cultural Organization
URLLC	ultra-reliable low-latency communications
VDSL	very high-speed digital subscriber line
VoLTE	voice over Long-Term Evolution
VR	virtual reality
WBIF	Western Balkans Investment Framework
WHO	World Health Organization
WiMAX	worldwide interoperability for microwave access
WRC	World Radiocommunication Conference
xDSL	Generic term for the whole range of DSL technologies (e.g. DSL, ADSL, VDSL, etc.)

1 Introduction

1.1 The recent landscape

Discussion of IMT-2020 (5G)[1] implementation has been rife over the past three years, during which time the first auctions and trials have been carried out and commercial services have been rolled out. This trend has gained pace with the COVID-19 pandemic. Administrations' responses all over the world have ensured continuity of operations while strengthening the digital transformation within countries, which testifies to the importance of broadband services, both fixed and mobile, in our societies.

During lockdowns, the importance of mobile connectivity has become evident as a fundamental complement to fixed broadband, which is still lacking in almost 14 per cent of households across the 46 countries of the Europe region, according to ITU data.[2] In this context, it is critical to ensure that mobile communications are resilient and support citizens by facilitating access to the Internet.

1.2 Purpose of the report

As the European Union (EU) moves ahead with harmonious IMT-2020 (5G) development, as demonstrated by the recent 5G Action Plan seeking to launch 5G services in all Member States by the end of 2020 as well as to ensure uninterrupted 5G coverage in urban areas and along main transport paths by 2025, non-EU countries of the Europe region that are proceeding independently risk being left behind or not being monitored appropriately.

ITU's goal is not only to ensure that existing gaps are reduced, but also that they are not widening or that new ones are not being created. In order to accelerate countries' digital transformation and support attainment of the United Nations Sustainable Development Goals (SDGs), ITU seeks to promote a favourable environment for investment in 5G technology and the infrastructure underpinning it.

To this end, as part of ITU Regional Initiative EUR 1 on 'Broadband infrastructure, broadcasting and spectrum management', the ITU Office for Europe has developed a series of 5G country profiles in respect of non-EU countries, thereby offering a clearer picture of the status of 5G implementation in non-EU countries of the Europe region.

As each country has its own specificities, the 5G country profiles seek to draw attention to the main drivers of 5G from different angles, but in a structured way. In particular, each country profile comprises the following sections:

1 Information and communication technology (ICT) background and current status of broadband.
2 Broadband and mobile telecommunication sector data.
3 Current progress on 5G: Consultations and national strategies.
4 Spectrum assignment for 5G and market development.
5 Electromagnetic field levels and implementation dynamics.
6 5G commercial launches: Announcements, trial cities and digital cross-border corridors.

Overall, this paper seeks to offer a better and comparable picture of 5G implementation across 18 non-EU countries of the Europe region, namely Albania, Bosnia and Herzegovina, Georgia,

Iceland, Israel, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, San Marino, Serbia, Switzerland, Turkey, Ukraine, United Kingdom and the Vatican. The paper also seeks to aggregate data so as to enable the identification of key trends characterizing the development of 5G across these countries, in order to provide all stakeholders operating in the region with the necessary information for effective decision-making.

A first draft of this report had been published in the context of the ITU Regional Forum for Europe on 5G strategies, policies, and implementation held virtually on 22–23 October 2020.

Endnotes

1 IMT stands for International Mobile Telecommunications and "IMT-2020" is the nomenclature chosen to define the fifth-generation technology standard for broadband cellular networks, otherwise known as "5G": https://www.itu.int/net/pressoffice/press_releases/2015/27.aspx. For the purposes of this paper, "IMT-2020" will be referred to as "5G".

2 See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "xHH6_IDI" and "I99H").

2 Executive summary

2.1 ICT background and current status of broadband

To sustain the transition from 2G to 3G, 4G and now 5G, governments have adopted a number of regulatory and policy measures setting clear goals for digital development which have driven the process over the past 20 years. Through national broadband plans, 'digital agendas' or other more specific activities, all governments and regulators have collaborated to provide clarity to the market, thus spurring investment in the development of electronic communications, of which 4G and 5G are only the latest steps, creating endless opportunities for businesses and empowering millions of citizens.

2.2 Broadband and mobile telecommunication sectors data

According to the latest ITU data from the ITU World Telecommunication/ICT Indicators Database,[1] the countries considered in this report have increased their collective Internet penetration from 52.7 per cent[2] in 2010 (as compared with 63.2 per cent in the wider ITU Europe region)[3] to 82.5 per cent[4] in 2019 (84.4 per cent in the ITU Europe region).[5]

Since 2010, the number of Internet users in these 18 countries has grown by 78 million. However, in 2019 more than 33 million people remain unconnected across these countries. This illustrates the potential for further development in the coming years, not only to improve connectivity but also to connect the unconnected, especially in countries with a young population.

Looking specifically at broadband, between 2015 and 2019 both fixed and mobile subscriptions per 100 inhabitants have been growing steadily, at rates beyond 7 per cent per year. In particular, mobile-broadband subscriptions per 100 inhabitants have risen from 56.2 in 2015[6] to 77.9 in 2019,[7] a 39 per cent composite increase over the four-year period. The average for the Europe region as a whole shows an increase from 69.6 per 100 inhabitants in 2015[8] to 78.9 in 2019.[9] The shrinking gap suggests that mobile connectivity is a strong contributor to countries' Internet penetration rates and to their transition towards digital economies overall.

Moreover, a 10-fold increase in mobile-broadband traffic within this group of countries since 2010, to an estimated 6 exabytes in 2019,[10] and a yearly average growth rate of 44.6 per cent over the past two years, complete the positive picture for mobile broadband. This figure exceeds the growth rate of 41.6 per cent for the Europe region taken as a whole.

It must be noted that the growth in data traffic for the Europe region as a whole is enabled by Long-Term Evolution (LTE) coverage, which now reaches 96.8 per cent of the region's population, up from the 73.7 per cent in 2015.[11] Similarly, 4G/LTE coverage for the 18 non-EU countries has risen from 41.62 per cent of the population to 91.92 per cent, therefore enabling an additional 57 million people to enjoy high-speed mobile connectivity over the past five years.[12] This clearly shows how a big gap has been consistently reduced in a limited time span.

Finally, as cost is a fundamental component of mobile-broadband uptake, the average mobile-data basket cost[13] for the non-EU countries averaged 0.9 per cent of GNI per capita in 2019 for a minimum monthly allowance of 1.5 GB, while the Europe region average was 0.8 per cent for the same year.[14] Affordability is a fundamental enabler of service uptake and a key component of the virtuous circle of investment, market development and return on investment.

2.3 Current progress on IMT-2020 (5G): Consultations and national strategies

As at October 2020, 12 of the 18 countries considered in this report have undertaken specific 5G consultations, while 10 have adopted ad hoc 5G strategies or incorporated 5G provisions in broader broadband plans, and seven have assigned frequencies for IMT-2020 (5G). Table 1 below illustrates the status in each country.

Snapshot of 5G dynamics in non-EU countries

	Albania	Bosnia and Herzegovina	North Macedonia	Montenegro	Serbia	Georgia	Moldova	Turkey	Ukraine	Israel	Iceland	Liechtenstein	Monaco	Norway	San Marino	Switzerland	United Kingdom	Vatican
Held 5G Consultations	✓		✓	✓	✓	✓	✓	✓			✓	✓		✓		✓	✓	
Adopted *ad hoc* 5G strategies or Incorporated 5G provisions in existing policy frameworks	✓		✓	✓	✓	✓		✓	✓		✓			✓			✓	
Allocated frequencies for 5G			✓ (2020)							✓	✓		✓	✓		✓	✓	

Source: ITU

These actions have been carried out in various ways and according to practices which are country-specific. In all cases, they have been driven by governments and/or regulators, in some cases with strong involvement of the private sector. It should, however, be underlined that civil society is generally excluded from the process of elaborating these actions.

In some cases, it can be observed that the consultative processes between administrations, operators and other stakeholders has led to the creation of hubs or working groups focused on advancing IMT-2020 (5G) implementation in the country. These often include the involvement of academia and research centres, and are a very good example of the collaborative practices needed to achieve integrated and organic development of mobile ecosystems at the country level.

2.4 Spectrum assignment for IMT-2020 (5G) and market development

In all the countries considered, spectrum for IMT has been identified following the outcomes of the ITU World Radiocommunication Conference (Sharm el-Sheikh, 2019) (WRC-19) and decisions of the European Conference of Postal and Telecommunications Administrations (CEPT). International and regional organizations play a significant role in providing guidance on spectrum harmonization and continue acting as reference points for the international community and private-sector stakeholders, laying the foundations for standards and interoperability that are crucial at the international level.

With regard to the specific bands identified for IMT-2020 (5G), it is important to highlight that the 3.6 GHz band is already being allocated to the land mobile service (or in some cases identified for IMT following the technology-neutrality principle) across almost the all countries. This is undertaken either through licensing for commercial roll-out or through temporary testing licences giving operators the chance to test new technology and develop their services.

In countries where spectrum auctions have not yet taken place, the IMT pioneer bands (the 26 GHz band and the 700 MHz band) are usually being held back for various reasons.

One of the challenges most commonly encountered with regard to the 700 MHz band is the process of freeing up the DD2 digital dividend and re-purposing spectrum from broadcasting services to land mobile services (in some cases identified for IMT systems). This process is facing substantial delays across the region, and even within the EU.

For the 26 GHz band, on the other hand, one of the main challenges is the moderate interest on the part of the industry in the short term. As no disruptive IMT-2020 (5G) application has emerged in the context of smart cities or smart manufacturing, operators tend to refrain from betting on a frequency band which does not seem favourable for market development given the current status of adoption of devices and applications.

Finally, it is important to note that COVID-19 has delayed planned spectrum auctions in many of the 18 non-EU countries, suggesting that 2021 will be a very intensive year for allocation of spectrum in the region.

2.5 Electromagnetic field levels and implementation dynamics

When it comes to radio-frequency electromagnetic field (RF-EMF) exposure limits, the countries considered in this report mainly take one of two approaches. Some transpose Guidelines from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) into law; whereas others prefer to adopt the precautionary principle and opt for more restrictive limits, in the order of 10 to 100 times more stringent than those recommended by the relevant scientific bodies.

This often results in a double negative outcome of increasing cost of deployment (because more antennas are needed) and increasing the number of antennas visible to the public, thereby heightening the concerns harboured by some of the public. Considering the attention that RF-EMF has gained in relation to 5G, a trend which has been further exacerbated by the misinformation associated with the spread of COVID-19, this may lead to delays in 5G deployment in the short term.

Countries have responded in different ways, either by strengthening collaboration and communication with government departments in areas of public health and/or environment to better address the general public's concerns, or by strengthening the monitoring and reporting power of regulators to gather, analyse and present measurement data.

In the light of the foregoing, in coordination with all its three Sectors, ITU is in the process of publishing a report on Implementing 5G for Good: Do electromagnetic fields matter?, which provides policy-makers with a point of reference on the status of scientific evidence and recommendations on the topic.[15]

2.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

While IMT-2020 (5G) non-standalone services are already available in some of the countries considered in this report, as they are in some EU countries, all of them have seen their major operators announce operations relating to 5G. Moreover, in all of the 18 countries at least one

operator has carried out trial tests in cities, and in most of them such tests have been carried out by multiple operators.

In this regard, it is possible to observe numerous partnerships arising between telecom operators and network equipment suppliers. In some notable cases the collaboration goes as far as to include academia, research institutions or other vertical industries, creating veritable 5G ecosystems supporting innovation in the field.

As far as cross-border cooperation on 5G is concerned, no formal corridor has been established as yet. However, within the context of the EaPeReg network[16] for Eastern Partnership countries,[17] and RCC[18] for the Western Balkans, multiple activities focusing on frequency coordination are in place and will contribute to harmonized development of 5G in the future.

Endnotes

[1] See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en

[2] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i61" and "I99H")

[3] Ibid. Note: Sample missing data for Iceland, Liechtenstein, Luxembourg, Moldova, Monaco, North Macedonia and Ukraine. Sample covering 79.71% of the population.

[4] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i61" and "I99H"). Note: Missing value for San Marino and Vatican. Sample of 99.99% of total population.

[5] Ibid. Note: Missing values for Andorra, Iceland, Israel, Ireland, Italy, Liechtenstein, Luxembourg, Moldova, Monaco, North Macedonia, San Marino and Vatican. Sample of 83.29% of total population.

[6] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i61" and "I911mw"). Note: Missing data for Albania, Liechtenstein, San Marino and Vatican.

[7] Ibid. Note: Missing data for Ukraine, United Kingdom and Vatican.

[8] Ibid. Note: Missing data for Albania, Andorra, Liechtenstein, San Marino and Vatican.

[9] Ibid. Note: Missing data for Andorra, Luxembourg, Netherlands, Norway, Ukraine, United Kingdom and Vatican.

[10] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "I136mwi"). Note: Data only for Albania, Georgia, Iceland, Moldova, Monaco, Montenegro, North Macedonia, Norway, Serbia, Switzerland and Turkey.

[11] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i61" and "I271GAi"). Note: Data for 2019 excludes Andorra, Latvia, Norway, United Kingdom and Vatican.

[12] Ibid. Note: Data for 2019 excludes Andorra, Norway, United Kingdom and Vatican.

[13] Note: The mobile-data basket uses the cheapest price with the largest operator for a data plan with a monthly allowance of at least 1.5 GB, irrespective of the device used, over a 3G or higher data-transmission network.

[14] See: ITU Measuring digital development: ICT Price Trends 2019: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf. Note: Data missing for Liechtenstein, Monaco, San Marino and Vatican. It should be noted that this indicator provides for a 1.5 GB allowance as a minimum common denominator, but operators often offer higher data traffic packages.

[15] (forthcoming) See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Pages/Publications/Publications.aspx

[16] Eastern Partnership Electronic Communications Regulators network: http://eapereg.org/

[17] Eastern Partnership (EaP): Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine.

[18] Regional Cooperation Council: https://www.rcc.int/

3 5G country profiles

3.1 Republic of Albania

3.1.1 ICT background and current status of broadband

The development of broadband in Albania has been a government priority for years, largely aligned with the integration perspective of the European Union. In 2003, the Albanian Government underlined the need to introduce and develop the ICT sector in order to achieve higher economic growth through the National ICT Strategy.[1] Several policies and programmes have been in place ever since, and notable improvements have been achieved in terms of access, infrastructure and affordability. Nowadays, the broadband market is one of the most vibrant markets in the telecommunication sector in Albania.[2] Despite the recent ICT developments in the country, rural connectivity remains a challenge, since in rural areas costs can be high and penetration low.[3]

Albania saw significant developments as a result of its first National Broadband Plan (NBP), adopted in 2013, which provided a set of directions and goals to be pursued by the government, public agencies and other regulatory agencies for the period 2013–2020. The NBP for 2013–2020 was focused on: i) Improving and further developing broadband infrastructure throughout the country; ii) Increasing Internet penetration; iii) Providing Internet with high speed and reliability at local, regional and national level, including in rural and remote areas; iv) Increasing competition and lowering prices; v) Improving quality of service; vi) Expanding the number of electronic services (e-services) available to Albanian citizens and digitalization of all public services; and vii) Raising the awareness of society, including people with special needs, regarding the benefits arising from the use of broadband services.

In June 2020, the Albanian Government approved and adopted the National Plan for Sustainable Development of Digital Infrastructure, Broadband 2020-2025.[4] Albania's new National Broadband Targets (NBTs) are as follows:[5]

- By the end of 2025, to have broadband penetration of 100 per cent of households, businesses and public institutions with:
    - 50 per cent having high-speed access of at least 1 Gbit/s (urban areas – Tirana);
    - 50 per cent having access at a speed of at least 100 Mbit/s.
- By the end of 2025, to have 100 per cent of households in rural and remote areas connected with broadband access of at least 100 Mbit/s.
- By the end of 2025, to have 100 per cent of schools connected with high-speed broadband connectivity of 1 Gbit/s and access in every classroom.
- By the end of 2025, to have 100 per cent of universities connected with high-speed broadband connectivity of 1 Gbit/s.
- By the end of 2025, to have 100 per cent of health centres and hospitals connected with a high-speed 1 Gbit/s broadband connection.
- By the end of 2025, to have one major city, the major transport corridors and strategic locations covered with 5G connectivity.
- By the end of 2023, to bring free access to Wi-Fi connectivity in 50 per cent of the biggest public spaces like parks, libraries and squares in all cities and villages.

The major supporting targets (SNBTs) for 2020-2025 are as follows:[6]

- By the end of 2020, to have established a clear process with clear responsibilities regarding the application and issuing of construction permits.
- By the end of 2022, to have freed up the 700 MHz band from media broadcast operators and re-assigned the 700 MHz band to mobile network operators (MNOs).
- By the end of 2020, to have established competent broadband offices (CBOs) and assigned responsibilities at municipality level.
- By the end of 2021, to have established the national regulator as the sectoral computer incident response team (CIRT).
- By the end of 2021, to have established a universal service fund, including a public funding mechanism and clear rules for disbursement.
- By the end of 2021, to have adopted regulations for State aid.
- By the end of 2020, to have updated Atlas to include all active infrastructure operators and alternative infrastructure providers (utilities).
- By the end of 2020, to have created an inventory of alternative infrastructure that can be used for broadband, including utilities and passive infrastructure owned by municipalities.
- By the end of 2022, to have established financing, funding and provision mechanisms for public Wi-Fi networks.
- By the end of 2022, to have addressed any given anticompetitive practices that undermine the development of broadband infrastructure.

In the context of the Western Balkans Investment Framework (WBIF),[7] a feasibility study and cost-benefit analysis for regional broadband development in Albania was completed. The closure workshop was held on 28 July 2020.[8] Moreover, the European Investment Bank (EIB) is in the preparation phase of providing a EUR 48 million grant to Albania's Ministry of Infrastructure and Energy (MIE) to develop broadband. This project aims to achieve the following results and benefits in the country: i) 500 health facilities with at least a 30 MB fixed-broadband connection; ii) 3 000 educational facilities with at least a 30 Mbit/s fixed-broadband connection; iii) 61 public institutions with at least a 30 Mbit/s fixed-broadband connection; and iv) An increase in the share of households with broadband connection across the country to 70 per cent.[9]

Additionally, the Electronic and Postal Communications Authority (AKEP) is continuously cooperating with local authorities to grant permits for operators for the deployment of broadband infrastructure to offer fixed and mobile services, especially in underserved areas, as part of the AKEP Action Plan 2019.

Other relevant broadband-related policies include the Economic Reform Programme 2019–2021, Albania's 5G Strategy, regional strategies – Including SEE-2020 and MAP-REA WB6 and the Balkans Digital Highway – and Albania's National Cybersecurity Strategy.[10]

3.1.2 Broadband and mobile telecommunication data

According to ITU data, 69.6 per cent of individuals in Albania used the Internet in 2019.[11] In 2010, the corresponding estimate for Albania was 45 per cent, and in 2000 only 0.1 per cent.[12] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 15.1.[13] Between 2013 and 2020, fixed-broadband penetration for both population and households increased more than twofold, although it remains well below the average for the EU and neighbouring countries, despite growing by 10-15 per cent annually.[14] Europe's average basket cost was 1.5 per cent of GNI per capita in 2019, while Albania's corresponded to 1.6 per cent for an

unlimited Internet data allowance.[15] In spite of the significant increase, ITU data show that the proportion of households with Internet access at home stood at 32.9 per cent.[16]

According to the Albanian Digital Agenda for 2015-2020, the physical extent of Albania's fibre-optic infrastructure reached 5 000 km in 2015, and the network has been growing ever since.[17] Broadband is currently supplied through myriad fixed and mobile technologies, including DSL, FTTH/FTTB, FTTx in combination with NGA. Most DSL lines are combined with fibre-optic and copper networks (FTTN/FTTB). Broadband is also supplied via coaxial cable (HFC) and electricity lines (BPL). Increased investments in fibre optics (FTTH and FTTB) are being made by fixed-network operators. Yet broadband speeds, according to AKEP's reports and feasibility study results, are low: the existing bandwidth in fixed and mobile networks is less than 30 Mbit/s.[18]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants stood at 91.3.[19] The number of active mobile-broadband subscriptions per 100 inhabitants was 62.1 in the same year.[20] There are 240 ISPs authorized by AKEP in Albania, and three mobile-network operators that offer 3G and 4G services: Vodafone, Telekom Albania and ALBtelecom. Most of the 4G coverage is concentrated in urban areas, an observation supported by the most recent findings of the WBIF19 Digital Diagnostics Report. In total, 63 per cent of Albanians use mobile broadband.[21] The country's mobile-data basket cost corresponded to 1.1 per cent of GNI per capita in 2019 for a monthly data allowance of 3 GB,[22] while the Europe region average was 0.8 per cent for the same year.[23]

In terms of mobile technologies, broadband is supplied via 3G/HSPA/HSPA+ and 4G/LTE networks, as well as satellite technologies. In 2019, 99.2 per cent of the population had 3G network coverage, while 4G covers about 95 per cent of the population in Albania.[24] During the same year, mobile-broadband Internet traffic within the country totalled 0.069 exabytes.[25]

3.1.3 Current progress on 5G: Consultations and national strategies

4G services were launched in July-September 2015, using the 1 800 MHz frequency band, covering between 65 per cent and 85 per cent of the population.[26] 4G infrastructure is present in most cities but not in all rural areas, though AKEP issued two authorizations to two operators in the 800 MHz band (4G) in 2018 to improve coverage.

Stakeholders and telecom investors expect 5G to play a crucial role in Albania's national infrastructure. While the expansion of broadband has seen a steady growth over the past few years, 5G development in the country is in its initial phase. As the country is proceeding towards granting extensive 4G coverage, the government has already considered 5G as a future step in broadband infrastructure development. In recent policy documents, 5G infrastructure development is mentioned in Objective 1 of the 'Digital Agenda of Albania' in relation to appropriate spectrum-policy development.

Furthermore, Albania's MIE and external experts held a 5G ecosystem workshop in July 2019, as well as drawing up an 'Expert Report: 5G Strategy for Albania', which generated a roadmap and five key recommendations for 5G development, yet to be finalized.[27] Put forward by AKEP and MIE, together with experts and market stakeholders, these recommendations are as follows:[28]

- Recommendation 1: Facilitate the timely availability of spectrum
    - Make spectrum available in the 5G bands according to the ITU spectrum roadmap and consultation with operators' plans.

- Clear 700 MHz for broad 5G coverage.
- Adopt national spectrum policy measures to encourage long-term heavy investments in 5G networks.
- Address synchronization issues with other networks, including those with neighbouring countries.
- Ensure effective spectrum-pricing policies, which are vital to support better-quality and more affordable 5G services.
- Make test frequencies available.

- Recommendation 2: Simplify processes to reduce administrative complexity for building permits
  - Reduce the complexity of the application process to avoid additional overhead costs and minimize the application time.
  - Consider adding 'small cells' in the list of construction, installation and works defined by the Development Regulation as works that do not require building permits and are subject to a preliminary declaration (Article 41, Law 107/2014) – the same approach may apply for rooftop sites as well.
  - Allow flexibility from the Territorial Development Agency (AZHT) on interpretation of the law regarding the number of sites to be included in one application.
  - Review the procedure for payment of construction tax, so as to avoid steps that delay the process and entail additional cost for operators, e.g. remove the need for additional confirmation from the municipality to AZHT, and require simply that certification of the payment from the operator be uploaded for the process to be closed.
- Recommendation 3: Facilitate network roll-out
  - Facilitate access to lamp posts, street furniture and public buildings for small cell deployments.
  - Bring into effect new building regulations which require all new buildings to have infrastructure capable of delivering superfast broadband.
  - Facilitate additional deployment and access to fibre.
  - Support and challenge local government in their plans to enable the delivery of digital infrastructure, in terms of ensuring both that these plans help Albania to meet its national objectives and that local authorities develop consistent approaches to support the deployment of mobile infrastructure across the country.
  - Recommend the promulgation of guidelines on infrastructure sharing spanning both passive (common site space, towers/ducts) and active (antennas, BBUs, etc.) infrastructure components.
  - Consider a proportionate fee regime for site rental to foster the deployment of a larger number of antennas.
- Recommendation 4: Address any environmental considerations
  - Promote network densification with small cells to ensure low radiation levels.
  - Re-evaluate the accuracy of exposure limits, considering the new technological developments along with the potentially large number of intelligent antennas using MIMO and beamforming techniques.

  - Pursue efforts regarding transparency by making authorizations and measurement results publicly available.

- Recommendation 5: Promote awareness on opportunities and benefits of 5G
  - Organize 5G events where applications that address different user cases might be presented and experiences from other countries on successful 5G deployment can be shared.
  - Initiate a 5G dialogue forum to intensify the dialogue with the user industries.
  - Introduce structured skills-development programmes.

Moreover, to achieve the goals of 5G service provision in 2021 as set out in the 5G Strategy, the 3.5 GHz band should be auctioned as soon as possible and be a key part of the National Broadband Plan.[29]

While the government is in the process of finalizing a draft strategy on 5G, a spectrum policy paper was approved by Government Decision No. 636 dated 29 July 2020, on 'Approval of the multi-annual spectral policy programme and action plan'.

In October 2020, during the Western Balkans Digital Summit, the Western Balkans nations signed an MoU on regional interoperability and trust services in the Western Balkans region and an MoU on a roadmap for the 5G digital transformation of the six economies of the Western Balkans. The document expresses the intention of all economies in the region to provide a legislative and regulatory framework that will simplify administrative procedures, stimulate investment through competitive market competition and ensure the application of the latest technologies to continue the accelerated digital transformation. The whole process will be implemented in a way that is fully harmonized with European regulations, standards and best practices in this area.[30]

3.1.4 Spectrum assignment for 5G and market development

AKEP claims that the main barrier to 5G development in Albania is the 'clash' of frequencies in the country. The 700 MHz band (694–790 MHz) is being used by TV broadcasters, making it challenging for the development of 5G networks,[31] in line with the requirements for Region 1 agreed at the World Radiocommunication Conference (Sharm el-Sheikh, 2019) (WRC-19). In this context, regulators affirm that they are prepared to intensify work towards migrating Albanian digital television frequencies to the 470-694 MHz band in order to release the 700 MHz band (694-790 MHz) for use by mobile telecommunication networks.

Microwave links using the V-band – or the E-band – are a good and more cost-effective alternative to optical fibre and well suited to supporting 5G (and broadband in general). Private-sector stakeholders have raised the issue that high spectrum fees for microwave links in the V- and E-bands act as a disincentive to invest, particularly so in the context of 5G,[32] and would like to see a downward review of current fees for these bands per link to boost deployment.

Furthermore, the challenges for policy-makers, regulators, industry and operators remain, with spectrum allocation and regulatory policies likely to continue to be one of the critical issues in this process.[33]

At present, there are no specific 5G regulations and strategies put in place by the government. The 800 MHz tender has been concluded with two assignments of 10 MHz (paired) to Vodafone

Albania and Telecom Albania. In addition, there is still a part of the 800 MHz band (10 MHz paired) available for mobile broadband.[34]

Currently, the stakeholders hope to proceed with testing of DVB-T2 DTT broadcasting, whose adoption will involve migrating DTT providers from the 700 MHz frequency band to a lower range, freeing up the 700 MHz band for subsequent 5G mobile spectrum licensing. As in other nations in the region, the 700 MHz band is currently in use by analogue and digital operators for audiovisual transmission.[35]

As mobile networks are more advanced in Albania than fixed networks in terms of penetration and speeds, the private-sector stakeholders stress that the auction of the 3.5 GHz band needs to be accelerated and the band auctioned as soon as possible, in addition to becoming a key part of the NBP.[36]

More commercial as well as government-led developments on 5G are expected to be rolled out in 2020 and in the years to come.

3.1.5 Electromagnetic field levels and implementation dynamics

In Albania, the competent bodies dealing with the main issues of non-ionizing radiation are the Commission for Radiation Protection (CRP) and the Office for Radiation Protection (ORP), in accordance with Law No. 10469 dated 13 October 2011 on 'Protection from non-ionizing radiation'. These bodies are responsible for drafting regulations setting the radiation limits as well as for conducting studies to prevent and maintain public health in Albania.

In 2018 and 2019, AKEP conducted a frequency monitoring campaign in public institutions such as schools, kindergartens and hospitals. The results, also published on AKEP's website, were sent to ORP, which calculated the EMF levels. Measurements were also carried out near transmitting antennas where requested by ORP.[37]

AKEP conducts measurements of EMF transmission points, which are a concern, ensuring compliance with the guidelines published by ORP and the ICNIRP. The results of the measurements recorded so far indicate that the levels of radiation emitted by mobile antennas do not exceed the safety threshold set by ORP and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ORP has assessed that no tested installation has exceeded the specified radiation safety limit.

In the face of the social concerns surrounding EMF and 5G, AKEP, supporting the mission of the competent bodies CRP and ORP, will continue to perform antenna transmission power measurements, in order to ascertain EMF values, and will monitor any changes in power stemming from the implementation of 5G technology.

Albania does not belong to the group of European countries applying stringent EMF limits, these being perceived as a barrier to swift 5G implementation.

3.1.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In October 2019, AKEP granted Vodafone Albania permission to kick off 5G technology testing in the country. As the largest and most stable telecommunication supplier in Albania, supplying GSM services in the country since 2001, Vodafone was given the authorization to use the

frequencies 3 600–3 700 MHz in the 3 600–3 800 MHz band for measurement, research and testing, all of which would need to be reported to AKEP at the end of the two-month testing period.[38] Pursuant to this commitment, Vodafone Albania managed to use these allocated frequencies to test new 5G technology, including Ma-MIMO, maximum speeds with LTE carrier aggregation and 5G, and latency.

During a public event to celebrate the spectrum allocation for 5G research in the country, Vodafone Albania demonstrated the potential of 5G networks by introducing high-level politicians to a remote electric car in Tirana, thus becoming the operator to bring the first 5G experience in the country.[39] After the testing period in December 2019, however, Vodafone Albania did not continue with the trials.

In addition to Vodafone Albania, there have also been commercial announcements by Telekom Albania, now One Telecommunications,[40] and Ericsson, who have signed agreements to modernize the country's transmission network, which may have consequences for 5G development as well as for the ways in which it will be regulated or how stakeholders will compete or collaborate. The agreement between these two companies provides for Ericsson to upgrade Telekom Albania's network capabilities to Gigabit LTE while also making the network 5G-ready using the latest Ericsson Radio System equipment.[41]

Endnotes

1 See: https://danube-inco.net/object/document/11073/attach/0120_ict_strategy_Albania.pdf

2 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets (unpublished). Please contact ITU Office for Europe for more information.

3 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

4 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

5 Both of Albania's national broadband plans were developed with the support of ITU under the regional initiatives for Europe. See more: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets.

6 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets.

7 See: https://www.wbif.eu/about/about-wbif

8 See: https://eeas.europa.eu/delegations/albania/83464/regional-broadband-infrastructure-development-albania-closing-workshop_en

9 See: https://www.wbif.eu/project/PRJ-ALB-DII-001

10 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets, p.24.

11 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H")

12 Ibid.

13 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b")

14 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

15 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI")

17 See: Albanian Digital Agenda 2015-2020, https://issuu.com/miap4/docs/booklet_m-inovacionit_preview

18 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

[19] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911")

[20] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw")

[21] See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

[22] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[23] The data-only mobile-broadband basket is based on a monthly data usage of a minimum of 1.5 GB. For plans that limit the monthly amount of data transferred by including data volume caps below 1.5 GB, the cost for the additional bytes is added to the basket. The minimum speed of a broadband connection is 256 kbit/s. The data-only mobile-broadband basket is based on the most common contract modality (prepaid or postpaid) in the economy in question, i.e. if more than 50 per cent of subscriptions are prepaid, then prepaid is selected. Otherwise, a postpaid plan is selected.

[24] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA")

[25] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi")

[26] See: Policy Paper Update: National Broadband Plan 2020-2025 for Albania, ITU.

[27] See: ITU, 2020: Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets, 2020. Annex: "5G Strategy for Albania – Roadmap for the 5th generation of mobile communication in Albania."

[28] See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets, 2020.

[29] See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf. Note that the draft on 5G is still to be finalized. For more information, contact the Ministry.

[30] See: https://www.rcc.int/events/1400/rcc-supports-one-of-the-regions-most-prominent-events-western-balkans-digital-summit

[31] See: https://cms.law/en/int/expert-guides/cms-expert-guide-to-5g/albania

[32] See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania, p.34.

[33] See: http://ijcsn.org/IJCSN-2017/6-3/The-Way-to-5G-Networks-and-Spectrum-Policies-to-Cope-with-High-Data-Communication-Consumption-The-Albanian-Case.pdf

[34] For more information, contact AKEP.

[35] See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania, ITU, p.34.

[36] See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania, p.35.

[37] See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

[38] See: https://akep.al/wp-content/uploads/2019/10/VKD-nr.-34-date-14.10.2019-Vodafone-Albania-Autorizim-Individual-3600-3700-MHz-per-prove.pdf [in Albanian].

[39] See: https://www.vodafone.al/per-median/publikime-zyrtare/vodafone-albania-sjell-eksperiencen-e-pare-5g-ne-shqiperi/

[40] See: https://one.al/kompania/media/news/telekom-albania-is-rebranded-to-one/article71002

[41] See: https://www.ericsson.com/en/news/3/2020/ericsson-to-modernize-telekom-albania-core-and-radio-networks

3.2 Bosnia and Herzegovina

3.2.1 ICT background and current status of broadband

In 2003, Bosnia and Herzegovina approved the first national law specifically targeting communication-related affairs, with a particular focus on electronic communications and ICTs. The 2018 ITU Measuring Information Society Report and ITU's Digital Innovation Profile for Bosnia and Herzegovina show that hard infrastructure in the country is evolving rapidly: there is fixed- and mobile-broadband connectivity in rural areas as well as in towns and cities.[1] Moreover, competition in the telecommunication market together with pro-growth regulatory measures have had an effect on the overall progress of services in the country.[2]

One of the country's milestones in ICT has been the adoption of the Electronic Communications Sector Policy for Bosnia and Herzegovina for 2017–2021,[3] which is aligned with the Digital Agenda for Europe.[4] This policy elaborates on the requisite measures and the activities that will lead to their implementation, including maintaining market competitiveness which will increase quality of services and promote price reduction, as well as an expansion of broadband infrastructure in less developed and populated areas.[5] Additionally, it identifies support for the ICT sector and innovation as a central element in driving the country's economy forward on a range of fronts – enhancing competitiveness within Europe, increasing productivity and efficiency in business, and improving public and e-government services. The policy's action plan includes the following measures: [6]

- Construction of broadband networks that will enable high-speed transmission and provision of new services, thus ensuring reliable access to multimedia and interactive content.
- Stimulating the application of broadband wireless access networks in rural areas to reduce the digital divide among the population.
- Encouraging the development of digital content and services as well as translating conventional content into digital format.
- Harmonization of EC and media regulations that will be technology-neutral and ease convergence of information-society and media services.
- Ensuring technical preconditions for the implementation of broadband Internet access for all users, especially schools and educational institutions.
- Improving cooperation with all scientific institutions in the country and enabling their cooperation on important projects for the development of the information society as well as other projects of common interest.
- Involvement and active participation of Bosnia and Herzegovina in international projects related to broadband access.

The country introduced the 4G network in 2019, but lacks a national broadband strategy, which remains one of the most pressing issues for the development of broadband in the country in terms of market competitiveness and growth in the ICT sector.[7] Furthermore, an assessment by the European Commission argues that the policy for 2017–2021 is a prerequisite for the further development of the regulatory framework on radio-frequency spectrum.[8] Recommendations from the European Union have highlighted that efforts should be made to further align this policy with the EU digital single market strategy as well as the Digital Agenda for the Western Balkans. Another point addressed is the need to improve the collection of statistical data on digital performance and digital competitiveness in order to critically assess Bosnia and Herzegovina in relation to some of the existing compliances with the EU rules pertaining to electronic communication services.

3.2.2 Broadband and mobile telecommunication data

Bosnia and Herzegovina's Agency for Statistics indicates that, in 2019 alone, 69.9 per cent of individuals in the country used the Internet, up from 42.7 per cent in 2010.[9] Despite the ICT divide still being present, data estimates show a significant increase in Internet penetration over the years, particularly from 2013 onwards.

In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 22.6.[10] According to the Communication Regulatory Agency (RAK), Bosnia and Herzegovina currently has 67 ISPs.[11] In 2019, ITU data show that the proportion of households with Internet access at home was 72 per cent,[12] a situation comparable with other countries in the Western Balkans region. In terms of affordability, the price of the representative fixed-broadband basket was equivalent to 1.5 per cent of monthly GNI per capita, which is on a par with the average cost of 1.5 per cent in Europe. The price of an unlimited Internet data allowance is equivalent to 2.5 per cent of GNI per capita.[13] RAK data also show that the dominant type of Internet access remains xDSL, which accounted for 56.8 per cent of total broadband subscribers, followed by cable access at 33.4 per cent.[14] The regulator also stated that further liberalization of the telecommunication market and the introduction of new technologies are expected in the coming years.

Concerning the mobile sector, Bosnia and Herzegovina registered a penetration of 111.9 mobile-cellular subscriptions per 100 inhabitants in 2019,[15] while the number of active mobile-broadband subscriptions came to 59.1.[16] The country's mobile-data basket cost corresponded to 1.5 per cent of GNI per capita in the same year for a monthly allowance of 2 GB, as against the Europe region average of 0.8 per cent.[17] In terms of coverage, 3G covered 96 per cent of Bosnia and Herzegovina's population in 2019, while 4G/LTE coverage stood at 82 per cent of the population.[18]

3.2.3 Current progress on 5G: consultations and national strategies

The market-development section of the Electronic Communications Sector Policy for Bosnia and Herzegovina 2017-2021 stipulates that the implementation and development of new technologies that enable wireless-broadband access for a large number of potential users throughout the country will be encouraged.[19] The government plans to provide the necessary frequency bands in order to support wireless-broadband access in urban, suburban and rural areas in the country, while respecting the principle of technology neutrality.

In the light of the 4G trials started in 2014, the decision on the conditions governing the provision of 4G network services in the country was adopted in March 2019 by the Council of Ministers, and the corresponding licences were issued by RAK, thus enabling existing mobile operators BH Telecom d.d. Sarajevo, Telekom Srpske a.d. Banja Luka and JP Hrvatske telekomunikacije d.d. Mostar to market the service as from April 2019.[20] In adopting the decision, the Council of Ministers' aim was to complete 4G coverage by licensing at a low price while demanding stricter requirements in order to reduce the length of the 4G investment cycle and make it possible to start the 5G investment cycle earlier.[21] Coverage obligations specifying territorial and main-road coverage have been set for periods of 1/3/5 years of operation. In the context of 4G development, no particular reference has yet been made to 5G. However, the decision prescribed the allocation of spectrum at 800 MHz, 900 MHz, 1 800 MHz, 2 100 MHz and 2 600 MHz on a technology-neutral basis, thus giving the operators the possibility even to deploy 5G technology in the available frequency ranges.

Recent public statements by RAK show a positive outlook vis-à-vis the development of 5G in the country in the context of business opportunities and services for smart cities.[22]

3.2.4 Spectrum assignment for 5G and market development

RAK highlights that the volume of investment in the 5G network requires multimillion funding and that the success of 4G implementation will directly shape the development of 5G. Given the late adoption of 4G and the potential delay for effective development of 5G infrastructure and regulation, very little information is public concerning the additional spectrum assignment for 5G.

In April 2019, Bosnia and Herzegovina's major telecom operators – BH Telecom d.d. Sarajevo, Telekom Srpske a.d. Banja Luka and JP Hrvatske telekomunikacije d.d. Mostar – announced they would start implementing the 4G network in the cities of Sarajevo, Banja Luka and Mostar, after obtaining 15-year licences from the Council of Ministers. Through that agreement, the government recognized the importance of 4G for the State budget and that investments in network infrastructure of mobile operators, including the introduction of new services, will all be in the best interests of end users. The plan was that more than 40 per cent of Bosnia and Herzegovina's territory would be covered by 4G networks in 2020 and 75 per cent by 2024. The licences also meant that allocated frequencies for 4G would allow coverage of rural areas with lower population density, and operators will be able to plan the development of their networks more efficiently.[23]

Telecom operators were obliged to pay a fee of BAM 17.5 million (USD 10.06 million) into the budget of the country's institutions in the early implementation period between 2019 and 2023.[24] In this way, 4G licensing paved the way for establishing the conditions for the transition to 5G.[25]

BH Telecom claims that the company adopted a master plan for the implementation of 5G back in 2017.[26] It also states that its investments during 2019 in 4G and 5G have been higher than in the three previous years. In particular, replacement of the broadband infrastructure in 2019 has opened the door for testing and pre-commercial trials of 5G networks. Similarly, HT Mostar claims that the company has already started fulfilling the procedures related to the introduction of 5G networks.

3.2.5 Electromagnetic field levels and implementation dynamics

As yet, Bosnia and Herzegovina has no specific guidelines for EMF limit levels for 5G, since only one operator has started testing 5G networks, while others are focusing primarily on continued 4G expansion in the country.

Nonetheless, RAK has adopted the 'Rule on Restricted Electromagnetic Radiation' – which implies that all users of the radio spectrum, which do not only include telecom operators, must harmonize the operation of their systems in accordance with this rule. The Rule on Restricted Electromagnetic Radiation refers to EMF level limits from valid international recommendations, such as ITU-T K.83, ICNIRP (2020) and IEEE C.95-1.

In addition, RAK is preparing a campaign to check the technical parameters of licensees in terms of protecting the general population from potential harmful effects. RAK's plan is also to

provide transparent information to the public about current electromagnetic exposure as the early phases of 4G and 5G in Bosnia and Herzegovina continue to take shape.[27]

3.2.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

A few months after the 4G kick-off, in August 2019, Sarajevo-based BH Telecom – along with its partners Huawei, Ericsson and Samsung – presented the capabilities of 5G networks, including opportunities and applications of new technologies.

While 4G has not been fully provided throughout the country, BH Telecom has claimed that investments in infrastructures have enabled R&D for the 5G network, although RAK had previously indicated that telecom operators would likely need to wait until 2024 to obtain the necessary return on the investment from 4G to undertake the infrastructural development for 5G networks.[28]

In May 2019, national media coverage reported that BH Telecom had successfully tested 5G technology, achieving downlink speeds of 1.4 Gbit/s in Sarajevo.[29] BH Telecom announced the development in a press release, noting that the test had taken place in a multivendor environment; and thus becoming the first operator in Bosnia and Herzegovina to test 5G technology. On the same occasion, BH Telecom made it public that the company hopes to use 5G technology to support the production and distribution of audiovisual content, in cooperation with TV companies in the country. No further activities have since been carried out by the company on expansion or commercialization of the 5G network.

Without revealing a specific timeline for commercial roll-out, BH Telecom indicated that such development would arrive when the demand was sustainable for the business model in place and upon the introduction of appropriate regulatory measures. BH Telecom also stated its intention to utilize 5G to provide FWA service in rural areas. In the face of the COVID-19 pandemic, BH Telecom also reiterated that 5G would help open up new business opportunities while also helping to bridge the existing divide between rural and urban areas.[30]

In response to the wave of misinformation surrounding 5G development, in August 2020 BH Telecom issued a press release informing the public that the operator does not have a 5G base unit installed in its base stations in Bosnia and Herzegovina, and that it does not install equipment and base stations without notice.[3131]

Endnotes

[1] See: https://www.itu.int/en/ITU-D/Innovation/Documents/Publications/eBAT_Brochure%E2%80%93DIP%20BosniaH_431106_.pdf

[2] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

[3] See: http://www.sluzbenilist.ba/page/akt/WBr1TX3CmYY= [in Bosnian].

[4] See: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20190529-bosnia-and-herzegovina-analytical-report.pdf

[5] See: please contact the Ministry for more information http://www.mkt.gov.ba/Content/Read/komunikacije-informatizacija

[6] See: http://www.sluzbenilist.ba/page/akt/WBr1TX3CmYY= [in Bosnian].

[7] See: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20190529-bosnia-and-herzegovina-analytical-report.pdf

[8] See: https://data.consilium.europa.eu/doc/document/ST-8544-2019-INIT/en/pdf

[9] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

[10] See: https://www.itu.int/net4/ITU-D/icteye/#/countries

[11] See: https://www.ripe.net/participate/forms/uploads/fobi_plugins/file/see8/20190415%20-%20CRA%20BH%20-%20Regulatory%20Challenges%20in%20the%20Internet%20space%20in%20BiH_c84b20b9-cdcc-4c16-bd10-faecff78b36f.pdf

[12] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI")

[13] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf. Unlimited data allowances are Internet service providers' offers providing access to Internet without cutting service at a data cap.

[14] See: https://www.sarajevotimes.com/bh-communications-regulatory-agency-issues-report-on-number-of-internet-users/

[15] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[16] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[17] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[18] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

[19] See: http://www.sluzbenilist.ba/page/akt/WBr1TX3CmYY= [in Bosnian].

[20] See: https://www.sarajevotimes.com/bihs-major-telecom-operators-to-start-implementing-4g-network-in-april/

[21] See: https://archive.vn/ovyVM#selection-3793.111-3793.149 [in Bosnian].

[22] See: https://ba.ekapija.com/people/2864850/aleksandar-mastilovic-savjetnik-direktora-rak-a-5g-je-samo-protocna-tacka-u [in Bosnian].

[23] See: https://rak.ba/en/news/613

[24] See: https://www.sarajevotimes.com/bihs-major-telecom-operators-to-start-implementing-4g-network-in-april/

[25] See: https://docs.rak.ba/documents/d0e3f02b-c260-42e2-953f-e55919d33762.pdf

[26] See: https://hayat.ba/evo-kada-ce-bh-telecom-uvesti-5g-mrezu/5359/ [in Bosnian].

[27] See: https://startbih.ba/clanak/5g-mreza-i-zdravlje-rak-priprema-servis-u-cilju-informisanja-javnosti-o-trenutnom-elektromagnetnom-zagadenju-u-bih/126358 [in Bosnian].

[28] See: https://www.sarajevotimes.com/bh-telecom-claims-it-is-technologically-ready-to-launch-5g-network/

[29] See: https://www.youtube.com/watch?v=f55m5paA0hw [in Bosnian]

[30] See: https://www.oslobodjenje.ba/vijesti/bih/testirana-5g-mreza-u-bih-ova-mreza-ce-omoguciti-gigabitne-brzine-na-cijelom-podrucju-nase-zemlje-557304 [in Bosnian]

[31] See: https://www.sarajevotimes.com/bh-telecom-issues-important-notice-about-installation-of-5g-base-stations/

3.3 Republic of North Macedonia

3.3.1 ICT background and current status of broadband

The Republic of North Macedonia is one of the fastest-growing ICT markets in the Western Balkans region, with a robust telecom infrastructure. In 2018, the ICT sector was valued at around EUR 862 million, contributing some 4 per cent of the country's GDP.[1] North Macedonia experienced rapid development of the electronic communications market as a result of the opening up of the telecommunication sector to competition,[2] attracting investment from foreign actors in telecommunications and IT by virtue of the country's low corporate tax and free economic zones.[3]

Broadband is on the rise, as the government continues to promote digital infrastructure developments. With a less developed fixed network, mobile plays an important role in the country, with mobile-cellular and mobile-broadband penetration rates that are relatively high and likely to continue increasing.[4] 3G licences were first awarded in 2008 to MakTel and Vip (now named A1 Macedonia). At the end of 2013, LTE services were launched commercially. Currently, North Macedonia benefits from substantial 2G, 3G, and 4G infrastructure that covers more than 98 per cent of the population.[5] Mobile market revenue in 2018 totalled EUR 136 million.[6]

Building upon the previous ICT-related policy frameworks established by the National Strategy for the Development of Electronic Communications with Information Technologies and the National Strategy for Information Society Development and Action Plan, in 2019 the government adopted the National Operational Broadband Plan for 2019-2029 (NOBP). This new plan was founded, *inter alia*, on information from the national broadband mapping as well on the expected investments by telecom operators in the near future. Aligned with the strategic objectives of the Digital Agenda for Europe and the EU's Gigabit Society, the NOBP articulates a 5G roadmap with the following targets:[7]

- By the end of 2023, at least one larger city shall be covered with a 5G signal.
- By the end of 2025, the main corridors foreseen in the Treaty establishing the Transport Community on the basic and comprehensive road network in the country should be covered with an uninterrupted 5G signal.
- By the end of 2027, all towns in the country shall be covered with uninterrupted 5G signal.
- By the end of 2029, anyone shall have the opportunity to access the Internet through 5G with a minimum Internet access speed of at least 100 Mbit/s.
- By the end of 2029, at least 50 per cent of the total number of household subscription contracts across the country shall be for Internet access of at least 100 Mbit/s.
- By the end of 2029, all households shall have the opportunity to access an affordable network that allows for a download speed of at least 100 Mbit/s, with the possibility of an upgrade to Gigabit speed.
- By the end of 2029, all public institutions (schools, universities, research centres and other educational institutions, healthcare facilities, ministries, courts, local self-governments and other State authorities and bodies) shall have symmetrical Internet access with a speed of at least 1 Gbit/s.

There are four pillars in place to support the measures and activities for achieving the targets in the NOBP: i) Use of State aid; ii) Additional measures for encouraging the use of access to ultrafast Internet; iii) Improved legal framework and regulation; and iv) 5G introduction and development plan.

While broadband services continue to expand in the country, a 2018 domestic mapping of current commercial networks and operators' future plans indicate that 30 per cent of households are located in 'white zones'. These white zones correspond to areas that lack the capacity for access to super/ultrafast Internet (with a download speed higher than 100 Mbit/s), and where there are no plans to invest in such networks in the foreseeable future.[8]

To tackle this issue, and in line with the NOBP, the Ministry of Information Society and Administration announced a collaboration with the World Bank to develop a National Transport Fibre Network. The government expects such a network to provide access in these white zones, as well as a fibre network in these specific areas, which would be available for operators to use in order to provide services to citizens. The only condition for this plan is that retail prices for superfast Internet access for households should not exceed 2 per cent of the average monthly income in the respective planning region concerned.[9]

3.3.2 Broadband and mobile telecommunication data

ITU data show that 79.2 per cent of individuals in North Macedonia used the Internet in 2018.[10] In 2010, the corresponding estimate for the country was 51.9 per cent, and in 2000, 2.5 per cent. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 21.3.[11] ITU also estimates that the proportion of the population with Internet access at home in North Macedonia was 79.3 per cent.[12] Moreover, according to the latest Broadband Competence Office report[13] on the country's broadband development, North Macedonia exhibits the following indicators:

- Fixed-broadband coverage (% of households): 97.87 per cent.
- Fixed-broadband take-up (% of households): 72.95 per cent.
- 4G coverage (% of households): 99.38 per cent.
- Preparedness for 5G (% of harmonized spectrum): 22.2 per cent (14 July 2020).
- Fast broadband (NGA) coverage (% of households subscribed to broadband with at least 100 Mbit/s download speed; affected technologies include FTTH, FTTB, cable Docsis 3.0 and VDSL): 78 per cent.
- Fast broadband take-up (% of households): 27.43 per cent.
- Ultrafast broadband (NGA) coverage (% of households): 43.8 per cent.
- Ultrafast broadband take-up (% of households): 1.74 per cent.

Information detailed in the NOBP shows that coverage with fast broadband networks is roughly the same as the average in the European Union. However, existing coverage with ultrafast broadband networks (43.8 per cent) is lower than the EU average (58 per cent).[14] For enterprises (with 10 or more employees), in 2019 85.8 per cent of them had a fixed-broadband connection, an increase of 4.3 percentage points compared to the previous year.[15] In addition, the wholesale broadband market in North Macedonia is highly concentrated, with few providers, and the high wholesale broadband prices prevent investment, especially among the smaller or regional operators.[16] From the regional perspective, the fixed-broadband basket cost for North Macedonia corresponded to 3.8 per cent of GNI per capita in 2019 for a 50 GB Internet data allowance,[17]compared to an average of 1.5 per cent of monthly GNI per capita for the Europe region as a whole.

In the mobile sector, the number of active mobile-cellular subscriptions was 98.65 per 100 inhabitants in 2019, while mobile-broadband subscriptions per 100 inhabitants stood at 69.9.[18] Moreover, according to ITU data, 3G population coverage in North Macedonia is 99.9 per cent, while 4G/LTE coverage is 99.5 per cent.[19] In terms of prices, the country's mobile-data

basket cost corresponded to 1.9 per cent of GNI per capita in 2019 for a monthly allowance of 1.5 GB,[20] as against the Europe region average of 0.8 per cent for the same year. In 2019 alone, mobile-broadband Internet traffic within North Macedonia was equivalent to 0.045 exabytes.[21]

3.3.3 Current progress on 5G: Consultations and national strategies

As part of the NOBP, operators are expected to invest in two critical areas in the country in order to facilitate 5G development: [22]

- Infrastructure investments: Mainly to build a denser fibre-optic network infrastructure, thus ensuring 5G connectivity of base stations by funding their installation. The next generation of 5G wireless networks will support applications requiring high speeds. One of the solutions, in this case, is to allow a higher density of base stations by deploying small cells.
- Investments in service innovation: Mainly to stimulate the emergence of new 5G services. Such a focus on innovation includes the financing of pilot projects through which potential 5G features will be demonstrated and tested, thus allowing the development of new services.

Moreover, under the NOBP, the new government is called upon to establish inter-ministerial working groups for mutual harmonization and amendment of the laws and bylaws related to construction and electronic communications, taking into account the proposals submitted by operators and the measures outlined in the national broadband plan. Representatives of ministries, regulatory bodies, operators, universities, chambers of commerce, equipment manufacturers, independent experts, civil-society associations, private companies and others participate in the working groups.[23]

As a result, a dedicated webpage has been created to host relevant information on 5G development as well as proposals by stakeholders.[24] Moreover, in accordance with the NOBP, government representatives should engage in discussions with stakeholders to ensure:[25]

- joint use of the existing physical infrastructure;
- intensified coordination of construction works;
- use of free optical fibre for aggregation associated with the development of 5G procedures that will enable quick and simple acquisition of approvals for construction of electronic communication networks, and in particular for deploying fibre-optic infrastructure and base stations for the new 5G network;
- deployment of 5G equipment on existing lighting poles, at bus stops, on transmission-line towers, etc.; and
- subjecting the deployment of small-size and low-output equipment for mobile networks to the regulations governing the installation of urban equipment (i.e. without an approval/decision) and a very simple and quick procedure.[26]

The document articulates that 5G implementation in North Macedonia should guarantee the building of a nationwide ecosystem for wireless connectivity, with a focus on quality of user experience not only in terms of increased speed and reliability and reduced communication latency but also in terms of significantly expanding the number of services offered and improving overall quality of life.

Accordingly, one aspect of the central government's strategy for achieving these 5G-related targets focuses on maximizing the benefits of 5G implementation for financial return through governmental support. This includes the development of a thriving economic market through

support and advancement of new services in various vertical market segments that may be offered to end users through a diverse niche of possible industries and services.

To accomplish that, according to the NOBP, government representatives should engage in discussions with vertical sectors, industry and the telecommunication operators[27] to the following end:

- Signing an MoU for 5G development and digital transformation in all spheres of society through the use of 5G technology.
- Possible financing of pilot projects through which the potential 5G features will be demonstrated and tested, thus fostering the development of new services.
- Raising the level of digital skills within the industry, as well as among citizens.

3.3.4 Spectrum assignment for 5G and market development

The 2019 NOBP recognizes that one of the prerequisites for the promotion of 5G networks is providing sufficient and adequate radio-frequency spectrum as early as possible to stimulate investment, innovation and competition in the development of 5G services.

The Agency for Electronic Communications (AEK) expected to assign 5G spectrum in the second half of 2020, with plans to initially award 5G-suitable spectrum in the 700 MHz and 3.6 GHz bands.[28] To facilitate this process, AEK launched a public consultation in February 2020, so that interested parties could provide their input regarding the terms and conditions of the spectrum auction, demand for spectrum, the optimal method of allocating the airwaves, and time-frames commensurate with operators' return on investments.[29]

From February 2020, the 700 MHz band is freed up from terrestrial digital video broadcasting (DVB-T) and will enable nationwide and indoor 5G coverage. In view of the favourable propagation conditions they offer, AEK states that the 700 MHz frequencies will provide the opportunity for network operators to develop comprehensive 5G coverage early, based on their existing network infrastructure.[30]

Furthermore, AEK expects to award 2 × 10 MHz of spectrum in the 700 MHz band per operator, while in the 3.6 GHz band it plans to distribute 300 MHz (100 MHz per operator) nationally and 68.5 MHz regionally.[31] Some of the conditions proposed by AEK for the allocation of these two bands address both territorial and population coverage. One condition stipulates that at least one North Macedonian city needs to have uninterrupted 5G coverage by the end of 2023, and all remaining cities by 2027; while the second condition expects that all citizens must be provided with 5G access with a minimum downlink speed of 100 Mbit/s by 2029.[32]

Additionally, AEK plans to reserve 2 × 10 MHz in the 700 MHz band and 100 MHz in the 3.6 GHz band for a new network operator, with a lower one-time fee and less stringent coverage obligations. For the 24.25–26.5 GHz frequency band, if needed, AEK may conduct re-planning by 2023 and allocate it for land mobile services.

3.3.5 Electromagnetic field levels and implementation dynamics

Having issued temporary licences to both MNOs for testing 5G for a period of 12 months in the 3.6 GHz band, AEK conducted measurements of non-ionizing radiation in order to determine the contribution of the new 5G NR technology from the test network of Makedonski Telekom. During the measurements, two base stations were active, one from the building of Makedonski

Telekom and the other from the building of TK Centar. The measuring point was located in front of the AEK building, 160 metres from the first base station. Limit values for EMF are taken from the recommendations of the International Commission for Non-ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz) (1998), which are implemented in the European legislation contained in CEPT Recommendation ECC REC(02)04 – Measuring non-ionizing electromagnetic radiation (9 kHz – 300 GHz). In accordance with these recommendations, basic limit values and reference limit values are defined.

The full report on the measurements was published on 18 December 2019 on AEK's official webpage.[33] The final result of the measurement is that the contribution of 5G as a share of all technologies is 32 per cent, whereas, for example, LTE contributes 49 per cent in relation to the maximum allowed value. 5G's contribution to the total power density of electromagnetic energy is 38 per cent, as against 47 per cent for LTE. Another important observation of this report is the fact that these measurements and calculations were carried out for the worst-case scenario, when 5G sites were active 100 per cent and the whole beams were directed towards the measurement equipment.

3.3.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

As at August 2020, there is no commercial availability of 5G products, although commercial pre-release and tests have occurred.

In September 2018, Makedonski Telekom, which has the largest share of the broadband market in North Macedonia, announced that it had performed the first 5G demonstration in the country, claiming that the results of the tests reached the highest Internet speed registered. On that occasion, the operator also claimed that the provider had planned investments in the next two years in order to meet all prerequisites for the commercial launch of 5G.[34]

In May 2019, Makedonski Telekom and the Faculty of Electrical Engineering and Information Technologies (FEEIT) of Ss. Cyril and Metodius University, which is also the ITU Centre of Excellence, announced a partnership for testing 5G networks. The press release stated that the 5G-related tests would occur in the FEEIT's '5G Evolution Laboratory' within the Wireless and Mobile Networks Lab at the institution based in Skopje, which is equipped with a 5G core network emulation and virtual wireless access. The provider announced that the partnership's plan included furthering engagement with researchers in performing real-scenario tests while conducting experiments.[35]

In July 2019, AEK issued two temporary frequency authorizations for testing 5G networks. Frequency authorizations were issued to A1 Makedonija for the frequency band 3.7–3.8 GHz (100 MHz) with a validity date until 14 July 2020 and to Makedonski Telekom for the frequency band 3.6–3.7 GHz (100 MHz) with a validity date until 31 October 2020.

In November 2019, Makedonski Telekom set up a trial 5G network in the centre of Skopje, with tests scheduled to be carried out during 2020 prior to a full commercial launch. The provider said that it was aiming to test 5G performance in real time, thus enabling new services for users. These services included the following: superfast fixed-wireless Internet, virtual reality (VR) 360 live video, VR gaming in real time and ultra-HD multivideo streaming.[36]

Endnotes

1 See: ITU Report, Investing in the North Macedonia Mobile Communications Market, 2020, p. 4 (unpublished). Please contact ITU Office for Europe for more information.

2 See: http://documents1.worldbank.org/curated/en/348431571341516627/pdf/Concept-Project-Information-Document-PID-North-Macedonia-Digital-Economy-NODE-P170993.pdf

3 See: http://ukrexport.gov.ua/i/imgsupload/file/ICT%20web.pdf

4 See: https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Republic-of-North-Macedonia.pdf

5 See: ITU Report, Investing in the North Macedonia Mobile Communications Market, 2020, p. 20. (unpublished). Please contact ITU Office for Europe for more information.

6 Ibid. p. 9. (unpublished). Please contact ITU Office for Europe for more information.

7 See: https://mioa.gov.mk/sites/default/files/pbl_files/documents/reports/north_macedonia_national_operational_broadband_plan_final_en.pdf

8 See: https://mioa.gov.mk/?q=en/node/2624

9 Ibid.

10 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

11 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

12 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

13 See: http://bco.mioa.gov.mk/wp-content/uploads/2020/10/Извештај-на-НКБК-бр.2-усвоен-на-29.9.2020-eng.pdf)

14 See: https://mioa.gov.mk/sites/default/files/pbl_files/documents/reports/north_macedonia_national_operational_broadband_plan_final_en.pdf

15 See: http://www.stat.gov.mk/publikacii/2020/Macedonia%20in%20figures-2020-web.pdf

16 See: http://documents1.worldbank.org/curated/en/348431571341516627/pdf/Concept-Project-Information-Document-PID-North-Macedonia-Digital-Economy-NODE-P170993.pdf

17 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

18 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

19 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

[20] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[21] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[22] See: https://mioa.gov.mk/sites/default/files/pbl_files/documents/reports/north_macedonia_national_operational_broadband_plan_final_en.pdf

[23] Ibid.

[24] All relevant documents and stakeholder proposals can be found here: https://mioa.gov.mk/?q=mk/node/1552

[25] See: https://mioa.gov.mk/sites/default/files/pbl_files/documents/reports/north_macedonia_national_operational_broadband_plan_final_en.pdf

[26] Ibid.

[27] Ibid.

[28] Ibid.

[29] See: https://aek.mk/javen-povik-za-mislenje-za-izdavanje-odobrenija-5g/ [in Macedonian].

[30] See: https://mioa.gov.mk/sites/default/files/pbl_files/documents/reports/north_macedonia_national_operational_broadband_plan_final_en.pdf

[31] See: https://aek.mk/wp-content/uploads/2020/02/20200205_Javna_rasprava_5G.pdf [in Macedonian].

[32] Ibid.

[33] See: https://aek.mk/wp-content/uploads/2020/06/Izvestaj_od_merenje_na_nejoniziracko_zracenje-AEK-5G-NR.pdf [in Macedonian].

[34] See: https://www.telekom.mk/ns-newsarticle-Makedonski_Telekom_performs_the_first_5G_demo_in_Macedonia.nspx

[35] See: https://www.telekom.mk/ns-newsarticle-5G-Technology-testing-Makedonski-Telekom-and-FEEIT-partnership.nspx

[36] See: https://www.telekom.mk/ns-newsarticle-makedonskitelekom-set-up-the-first-test-5g-network-in-the-center-of-skopje.nspx

3.4 Montenegro

3.4.1 ICT background and current status of broadband

The electronic communications, information and communication technologies sectors in Montenegro are regulated by the 2013 Law on Electronic Communications. This law has been enacted to ensure that telecommunication services are provided to Montenegrin users at fair prices, with adequate stimulation of market competition and reduction of monopolies when it comes to high-speed Internet access.[1] Stakeholders from both the public and private sectors are working together to implement strategic objectives in order to leverage the potential of digital technologies in the country.[2] Following independence and the accession process to the European Union and the telecommunication *acquis*, the telecommunication sector has grown increasingly independent and competitive, with significant financial investments on the part the country's telecom operators.[3] With many government-led initiatives – such as the Strategy for Information-Society Development (2016–2020) and the Strategy for Innovative Activity (2016–2020) – Montenegro has improved the overall ICT sector and the state of broadband throughout the country.

The Strategy for Information-Society Development (2016–2020) encompasses three major components: i) Infrastructure; ii) Cybersecurity; and iii) E-economy, which involves e-business, e-inclusion, e-government and research, and innovation and development in the field of ICT. Harmonized with the EU 2020 Digital Agenda for Europe, the strategic priorities for ICT and broadband development in Montenegro include the following:[4]

- Expansion of broadband access by reaching:
    - 100 per cent of the population with basic broadband coverage by 2018;
    - 100 per cent of the population with fast broadband coverage (30 Mbit/s or more) by 2020;
    - 50 per cent of households with ultrafast broadband usage (100 Mbit/s or more) by 2020.
- Strengthening capacities of the national computer incident response teams (CIRT) for protection against, prevention of and combating Internet incidents, raising the number of team experts to 20 by 2020.
- Improving the structure of local CIRTs.
- The proportion of ICT graduates in the total number of graduates in any year should amount to 10 per cent by 2020.
- The number of European Computer Driving Licence (ECDL) certification issued should reach 15 000 by 2020.
- The share of ICT in GDP should reach 6 per cent, which will be reflected in economic growth and job creation in other sectors of the economy.
- The share of e-commerce in total commerce should reach 1.5 per cent.
- In the context of e-education, the computer-student ratio should be 1:10 by 2020.
- The proportion of teachers trained to work on computers should be 30 per cent of the total teaching staff, whilst the proportion of teachers skilled in the field of cybersecurity should be 20 per cent of the total teaching staff.
- The proportion of e-prescriptions and e-referrals issued should reach 60 per cent of all medical prescriptions/referrals. Online medical appointments should surpass traditional appointments and reach 70 per cent of the total number of appointments.
- Elimination of the digital divide between urban and rural areas.

- Elimination of the income-based digital divide, and the divide based on social and demographic characteristics.
- The proportion of citizens who use e-services should be 50 per cent.
- The proportion of legal entities using e-services should be 30 per cent.
- The proportion of scientific and research institutions in the field of ICT should reach 30 per cent.

Montenegro has made its regulatory and legislative framework in the field of ICTs compliant with EU regulations. The government asserts that the legal framework has been implemented thoroughly, thus providing operators with a more stable business environment, which benefits domestic customers as they can now access providers and telecom services at affordable prices.[5]

In 2019, the European Union awarded EUR 600 000 to Montenegro at the 20th meeting of the Management Board of the Western Balkans Investment Framework (WBIF) on 25–26 June 2019, to fund the 'Broadband Infrastructure Development in Montenegro' project (PRJ-MNE-DII-001), which is currently being implemented.[6] Based on a complete mapping of the infrastructure, the goal of this project is to analyse the current situation and examine the potential of the market to eliminate the existing infrastructure gap. There are three expected results and benefits:[7]

- Extend broadband coverage and availability of new-generation broadband networks to the currently uncovered (mostly rural) areas in Montenegro.
- Offer an adequate infrastructure for fast and secure Internet for all households, businesses and educational and health institutions in order to support the digital transformation of society and the economy.
- Increase the proportion of households with NGA network from 70 to 95 per cent.

3.4.2 Broadband and mobile telecommunication data

ITU data show that 73.5 per cent of individuals in Montenegro used the Internet in 2019.[8] In 2010, that percentage was 37.5 per cent. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 28.5.[9] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2018, while Montenegro's fixed-broadband basket cost corresponded to 1.8 per cent of GNI per capita for an unlimited Internet data allowance at 2 Mbit/s[10] in 2019.[11] The country's mobile-data basket cost came to 0.8 per cent of GNI per capita in the same year for a monthly allowance of 1.5 GB, which is the same as the average for the Europe region as a whole.[12]

The northern region of Montenegro remains the least connected, having about 64.8 per cent of households with some kind of Internet use.[13] The same report also shows that while 80 per cent of households in urban areas were connected in 2019 (representing a 3.7 per cent increase compared to 2018), the figure for rural areas was 62.8 per cent. In terms of household connectivity, data from the country's State Statistical Office show that 74.3 per cent of surveyed households had access to the Internet in 2019, which represents an increase of 2.1 per cent in relation to the previous year.[14]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants stood at 183.3,[15] while mobile-broadband subscriptions came to 80.5 per 100 inhabitants.[16] In 2019 alone, the proportion of households connected via mobile increased by 5.1 per cent as compared to 2018.[17] Three MNOs have secured spectrum in the multiband auction in Montenegro: Crnogorski Telekom (T-Mobile Montenegro), M:tel, and Telenor Montenegro. In terms of the quality of mobile networks, Montenegro's Agency for Electronic Communications and Postal

Services (EKIP) has recently made public that Crnogorski Telekom's mobile network offers the highest download speed in urban areas, at 47.5 Mbit/s, followed by Telenor (43.5 Mbit/s) and M:tel (22.5 Mbit/s).[18] As at 2019, 4G/LTE networks cover 97.7 per cent of the population of Montenegro,[19] with an average download speed of 10 Mbit/s.[20] 3G coverage is available to 98 per cent of the population.[21] In 2019 alone, mobile-broadband Internet traffic within the country was equivalent to 0.041 exabytes.[22]

3.4.3 Current progress on 5G: Consultations and national strategies

As at 2020, there is no public information regarding national strategies for Montenegro's 5G development. However, EKIP is set to launch a 5G roadmap with national strategies and goals by the end of 2020, with an eye on holding spectrum auctions for assigning radio frequencies in the second half of 2021.

Alongside the national strategy for the implementation of 5G, EKIP plans to elaborate a new regulatory framework for spectrum, which is set to be completed by the end of 2020. This will be based upon consultation with stakeholders on 5G pilot projects (MNOs, public institutions at both State and local levels, as well as vertical industries, and universities). EKIP predicts an information document to come out in the first quarter of 2021, with an auction process to take place in the third quarter of the same year – five years after the previous one.[23]

3.4.4 Spectrum assignment for 5G and market development

In the past years, the country's major telecom operators have continued to modernize and upgrade their networks, reaching a total investment of EUR 91.5 million in 2018 and EUR 78 million in 2019 for the country's electronic communications sector.[24] In particular, the fibre sector in Montenegro, which is critical in terms of backhaul to support 5G development, has shown particularly strong growth since 2010 as the incumbent has invested in infrastructure upgrades, albeit mainly to serve apartment blocks in the main towns.[25] Between 2017 and 2018, for example, an increase of 36.04 per cent was observed in the number of users who accessed the Internet via optical fibre (between 2018 and 2019, the increase was 32.77 per cent), followed by an increase in overall Internet data traffic.[26]

In terms of mobile-network signal, Montenegro is comparable to the most developed countries in Europe. By the end of 2018, 97 per cent of populated areas were covered by 4G networks offered by two operators.[27] At the end of 2019, more than 97 per cent of populated areas were covered by the 4G network offered by Crnogorski Telekom, around 97 per cent were covered by the 4G network offered by Telenor, and some 94 per cent were covered by the 4G network offered by M:tel. Over the past years, the quality and availability of mobile-broadband data transmission services have improved significantly in urban and rural areas, mostly thanks to increased LTE coverage of all three mobile operators and the introduction of LTE-Advanced technology (2CA and 3CA) with LTE carrier aggregation from two or three bands at a large number of locations.[28] As a result, the wide availability of LTE has made mobile broadband a viable alternative to fixed-line broadband access in many of the country's rural areas.

The last spectrum auction in Montenegro took place in 2016. Currently, there are five bands in use by three MNOs: 800 MHz, 900 MHz, 1 800 MHz, 2 GHz and 2.6 GHz. With 15-year licences starting from mid-2022, the spectrum to be auctioned for 5G in Montenegro in 2021 comprises: (i) 700 MHz band: 2 x 30 MHz FDD + up to 20 MHz TDD; (ii) Band 3 400–3 800 MHz: 400 MHz;

(iii) 26 GHz band: 1 000 MHz. EKIP articulates the following current configuration for RF spectrum for initial 5G implementation in Montenegro:[29]

Band 694–790 MHz:

- The 700 MHz band is free.
- Usage for 5G is possible only in the northern region due to DTV signals from Albania, Italy and Croatia.
- Regional harmonization of the deadline for release of the 700 MHz band for mobile/fixed communication networks (MFCN) is of crucial importance. Predicted deadline not before 30 June 2022.

Band 3 400–3 800 MHz:

- Part of the 3 400–3 600 MHz band is licensed to BWA until April 2022.
- The whole 3 600–3 800 MHz band is free and can now be used for 5G.

Band 24.25–27.5 GHz:

- The band 24.5–26.5 GHz is currently used for fixed-satellite links (gradual migration into other bands, depending on market demand for spectrum for 5G).
- The band 26.5–27.5 GHz (1 GHz) is free and can now be used for 5G.

As a 5G-related strategy, EKIP and Albania's Audiovisual Media Authority (AMA) signed an MoU in 2019 to cooperate in the harmonization of radio-frequency spectrum management.[30] The agreement focuses on the 700 MHz band. Both EKIP and AMA expressed their readiness to step up work to migrate Albanian digital television frequencies from the 470–694 MHz band to release the 700 MHz band for use by mobile telecom networks.

In July 2020, EKIP determined that Crnogorski Telekom (CT) must cut the cost of calls from its fixed network to mobile networks and to fixed networks by 10 per cent and 5 per cent, respectively. EKIP has also examined the relative market dominance of the country's operators alongside their pricing models. Following this, it has ordered CT, Telenor and M:tel to lower their wholesale call-termination fees by 11.8 per cent for mobile networks and 15.5 per cent for fixed networks.[31]

In September 2020, EKIP outlined plans to launch an auction for frequencies in the 5G-mobile spectrum in the fourth quarter of 2021. The regulator submitted a draft financial plan to Montenegro's parliament on 29 September. The document states that EKIP plans to launch a single auction for the frequencies in the 694-790 MHz and 3 400–3 800 MHz bands, as well as 1 GHz of the 24.25–27.5 GHz band.[32]

3.4.5 Electromagnetic field levels and the implementation dynamics

Permitted EMF levels in Montenegro are set by the ministry responsible for environmental protection, which is the Ministry of Sustainable Development and Tourism. Pursuant to the 'Rules on the limits of exposure to electromagnetic fields' adopted 2015,[33] the applicable limits in Montenegro are the limits recommended by relevant ICNIRP guidelines for general-public exposure, but reduced by 50 per cent for sensitive areas (schools, hospitals, kindergartens and buildings in which people live).

3.4.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

As at 2020, there have been no announcements related to 5G commercial launches in Montenegro. Nevertheless, EKIP has stated that it anticipates that 5G-mobile networks will not be commercialized before 2022.[34] The regulator has also informed the press that operators have expressed an interest in conducting 5G trials in 2020.[35] For the near future, EKIP claims that the country's mobile operators are keen to carry out 5G pilot projects 2020, which will provide an opportunity to showcase the technology's benefits to the public and businesses.[36]

Endnotes

[1] See: http://www.mid.gov.me/ResourceManager/FileDownload.aspx?rid=148089&rType=2&file=Law%20on%20Electronic%20Communications%20ispravka.pdf

[2] See: https://www.itu.int/dms_pub/itu-d/opb/inno/D-INNO-PROFILE.MONTENEGRO-2020-PDF-E.pdf

[3] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

[4] See: http://www.mid.gov.me/ResourceManager/FileDownload.aspx?rid=251855&rType=2&file=StrategijaMID_finalENG.pdf

[5] See: https://unctad.org/meetings/en/Contribution/tdb_ede2018_c12_Montenegro_en.pdf

[6] See: https://balkaneu.com/eur-600-000-for-the-montenegro-digital-infrastructure-sector/

[7] See: https://wbif.eu/project/PRJ-MNE-DII-001

[8] See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

[9] See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Fixed_broadband_2000-2 018_Dec2019.xls

[10] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[11] See: 2019 Annual Report – Agency for Electronic Communications and Postal Services (EKIP), Montenegro.

[12] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[13] See: https://www.monstat.org/userfiles/file/ICT/2019/ICT%20USAGE%20IN%20HOUSEHOLDS%20IN%202019.pdf

[14] See: https://www.monstat.org/userfiles/file/ICT/2019/ICT%20USAGE%20IN%20HOUSEHOLDS%20IN%202019.pdf, and: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

[15] See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Mobile_cellular_2000-2018_Dec2019.xls

[16] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[17] See: 2019 Annual Report – Agency for Electronic Communications and Postal Services (EKIP), Montenegro.

[18] See: https://www.commsupdate.com/articles/2019/04/26/ekip-publishes-report-on-4g-coverage-and-speed/

[19] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271GA").

[20] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2019/Regulatory%20Forum/3.%20EKIP.pdf.

[21] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271G").

[22] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi")

[23] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2019/Regulatory%20Forum/3.%20EKIP.pdf

[24] See: Please contact EKIP for more information: https://www.ekip.me/

[25] See: https://www.marketresearch.com/Paul-Budde-Communication-Pty-Ltd-v1533/Montenegro-Telecoms-Mobile-Broadband-Statistics-13202843/

[26] See: Please contact EKIP for more information: https://www.ekip.me/

[27] See: Please contact EKIP for more information: https://www.ekip.me/

[28] See: Please contact EKIP for more information: https://www.ekip.me/

[29] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2019/Regulatory%20Forum/3.%20EKIP.pdf

[30] See: https://seedig.net/seesummary-june-2019/

[31] See: https://www.developingtelecoms.com/telecom-business/telecom-regulation/9698-montenegro-regulator-tells-crnogorski-telekom-to-cut-call-prices.html

[32] See: https://seenews.com/news/montenegro-considering-5g-frequencies-auction-in-q4-2021-715895

[33] See: Please contact EKIP for more information: https://www.ekip.me/

[34] See: https://www.vijesti.me/vijesti/drustvo/431051/5g-stize-u-crnu-goru-za-dvije-godine [in Montenegrin].

[35] See: https://www.developingtelecoms.com/telecom-technology/wireless-networks/9461-montenegro-eyeing-5g-rollout-in-2022.html

[36] See: https://www.commsupdate.com/articles/2020/04/21/5g-to-launch-in-montenegro-by-end-2022/

3.5 Republic of Serbia

3.5.1 ICT background and current status of broadband

Serbia has made significant progress in the ICT sector over the past years, and recently achieved the status of the country with the highest average Internet speed in the Balkans.[1] Despite Serbia being a predominantly rural country, the ICT sector is growing, with many business opportunities. For example, between 2008 and 2015, export revenues from IT services tripled, while the revenues from computer services have increased fourfold.[2] Challenges in the ICT sector persist in some areas: broadband access across the country's regions, fixed-broadband networks in rural areas, and coordination mechanisms for connecting the actions of different stakeholders remain some of the prevailing challenges in the ICT sector in the country.[3]

The Digital Agenda for Serbia consists of two documents: the 'Strategy for the Development of the Information Society in the Republic of Serbia to 2020' and the 'Strategy for the Development of Electronic Communication in the Republic of Serbia from 2010 to 2020'. These documents cover various aspects of socio-economic development in relation to ICT, such as education, business and security, as well as e-government, e-health and e-justice. Concerning broadband, these two strategies include the following goals and targets that Serbia needs to attain by 2020:[4]

- Increase network availability to all users.
- Provide broadband access by FTTH/B/C to all users.
- Offer broadband services with a speed of at least 100 Mbit/s.
- Proceed with harmonization of the radio-frequency allocation plan with international actors (EU Plan.
- Allocate 120 MHz of digital-dividend frequencies for mobile-broadband access.
- Improve tariff policy by applying the cost model for the pricing of services by operators with significant market share.
- Harmonize the tariffs of operators with significant market share through application of the cost model, analysing and defining relevant retail and wholesale markets.
- Establish the National Network, based on IP technology and according to the principles of open networks and open services, which connects all available State-owned network infrastructure.
- Provide access to the network with special-purpose connections, i.e. functional systems, at the level of the passive optical network; the approach for the resources of such a network should follow the principle of wavelength-division multiplexing.
- Ensure the distribution of digital television programmes over the National Network by expanding it with microwave links.
- Define the framework for sustainable development and operation of broadband networks and services.

The strategies state that these goals shall be based on the following principles: i) Technology neutrality of networks and services; ii) Broadband access as a universal service; and iii) Development of next-generation networks.[5]

As part of the EU accession process, a 2019 report by the European Commission contains three recommendations for Serbia, to the effect that its government should:[6]

- Harmonize its legislative framework in electronic communications with the 2009 EU regulatory framework.
- Ensure financial and operational independence of the regulators for electronic communication and postal services (Republic Agency for Electronic Communications

and Postal Services – RATEL) and for electronic media (Regulatory Authority for Electronic Media – REM).

- Take measures to ensure the implementation of competitive safeguards and facilitate market operators' access to telecommunication infrastructure (ducts, antennas, fibre optics and fixed-telephony infrastructure).

Furthermore, the 'Next-Generation Broadband Connectivity for Rural Schools in White Zones' project, planned within the context of the Western Balkans Investment Framework (WBIF), is in the preparation phase and will benefit from a EUR 72 million loan provided by the European Bank for Reconstruction and Development (EBRD).[7] This project will enable infrastructure development and interconnection of the two existing operators' networks and schools in rural (white) zones. Schools will obtain fibre connectivity (≥1 Gbit/s), while neighbouring households (private investment part that will follow middle-mile CAPEX investment by the government) will obtain ≥30 Mbit/s connectivity.[8]

3.5.2 Broadband and mobile telecommunication data

ITU data show that 77.4 per cent of individuals in Serbia used the Internet in 2019.[9] In 2010, the corresponding ITU figure for the country was 40.9 per cent.[10] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 18.5,[11] the majority being through xDSL (about 37.8 per cent) or cable access (about 44.8 per cent)[12] – although the number of xDSL users has been slowly decreasing over the years.[13] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019, while Serbia's came to 2.9 per cent for an unlimited Internet data allowance.[14]

Serbia's xDSL subscriber structure has changed significantly over the years, with a substantial increase in the number of users of VDSL technology, which account for 42 per cent of the total number of xDSL users, owing to greater demand for packages with bigger throughput.[15] Wireless-broadband access, however, has remained stable in the period 2013-2018,[16] although the average data rates improved for all operators in 2019.[17] While the north districts of Belgrade and South Bačka record the highest household penetration rates in terms of broadband subscriptions, the south districts Jablanica and Pčinja have the lowest.[18] ITU data from 2019 show that 80.1 per cent of households in Serbia had Internet access at home.[19]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was 96.4 per cent,[20] which makes Serbia the country with the highest penetration rates for mobile services in the Balkans.[21] There are three MNOs – Telekom Srbija, Telenor and VIP Mobile – that currently have licences for the use of radio-frequency spectrum. In 2019, the number of active mobile-broadband subscriptions per 100 inhabitants stood at 71.3.[22] In terms of price, the country's mobile-data basket cost corresponded to 1.3 per cent of GNI per capita in 2019 for a monthly allowance of 5 GB, as against the Europe region average of 0.8 per cent for the same year.[23] With a relatively equally distributed market share, the total revenue of all MNOs has been constant over the last three years, but at the same time the individual net profits realized are declining.[24]

For the first quarter of 2020, RATEL reports that the majority of mobile subscribers (around 47 per cent) connected to the Internet benefited from a connectivity speed of over 50 Mbit/s, while around 42 per cent accessed the Internet at between 10 Mbit/s and under 30 Mbit/s.[25] In comparison to the previous year, data transmission over mobile networks has shown growth, and amounted to 101.3 million GB in Q1 2019, meaning that a mobile-broadband subscriber

used on average 183 MB daily, or almost 5.6 GB a month.[26] In total, mobile-broadband Internet traffic within Serbia in 2019 represented 0.3 exabytes.[27]

Furthermore, according to data from RATEL published in the market overview for 2018, all three MNOs display a high 3G and 4G/LTE mobile network coverage, covering respectively 99 per cent and 97 per cent of the population[28] and between 72 and 78 per cent of the territory[29] of Serbia.

3.5.3 Current progress on 5G: consultations and national strategies

In line with the strategic framework of the European Union, Serbia's 'Strategy for the Development of New-Generation Networks until 2023', adopted in 2018, sets out measures to ensure infrastructure development for a Single Digital Market in the country.[30] The introduction and expansion of cloud computing and IoT, as well as the development of mobile systems pertaining to 5G are central points of discussion in this national strategy.[31]

The document acknowledges the need to update the necessary regulatory framework to support the development of 5G in Serbia. Guided by the notion that 5G, among future-generation networks, is linked to an overall increase in GDP and socio-economic development, the document specifies targets and goals, focusing specifically on:[32]

- Developing a backbone for the broadband network by consolidating the infrastructure that is State-owned.
- Developing broadband access networks by:
    - Providing conditions to make it easier to construct broadband infrastructure through the enactment of a broadband law: this will help telecom operators reduce the cost of building such infrastructure by sharing existing infrastructure and facilitating the acquisition of necessary permits.
    - Providing State aid to operators or other legal entities that agree to build their networks in areas where there is little economic viability for the construction of broadband infrastructure.
- Preparing for spectrum auctions for the development of new technologies, and 5G in particular.

Other targets and goals that are relevant to 5G to a greater or lesser extent include:

- Strengthening broadband capacities for the needs of State/public institutions.
- Offering a larger set of IP addresses by switching to IPv6.
- Providing State aid incentives for operators that switch to IPv6.
- Promoting the introduction and use of IoT.
- Promoting the introduction and use of smart services in all sectors of the economy.
- Promoting cloud computing and expanding data centres in the country.
- Adopting interoperability standards that would support the exchange of large amounts of data between different entities, with the aim of introducing smart services.
- Developing mechanisms for improving the safety of work on the Internet.
- Improving the conditions for education of the population in the field of ICT at all educational levels.

3.5.4 Spectrum assignment for 5G and market development

Serbia is the one of the few countries that has released both digital dividends at the time of its switchover to digital broadcasting. The 800 MHz (DD1) band was sold, and the 700 MHz (DD2) band was earmarked for use by 5G systems.

The Government of Serbia has adopted the Radio-Frequency Spectrum Allocation Plan (Official Gazette No. 89/20). In line with the decisions of the ITU World Radiocommunication Conference (Sharm el-Sheikh, 2019) (WRC-19), this plan has allocated 700 MHz (694–790 MHz) and 26 GHz (24.25–27.5 GHz) for IMT-2020 purposes. Besides these two bands, the band 3 400-3 800 MHz has already been allocated for IMT. Bearing in mind the need for testing of the new technologies, the 3 400–3 500 MHz band has been reserved for new projects to that end for the next three years. The Allocation Plan has reserved 5 + 5 MHz for smart-city applications in the 1 800 MHz band.

Spectrum assignment plans for the bands 2 500–2 690 MHz and 3 400–3 800 MHz are in the process of adoption in the Ministry of Trade, Tourism and Telecommunications (MTTT). Moreover, the ministry is preparing the Rulebook on minimum requirements for issuing individual licences for the use of radio frequencies according to the tendering process, in the radio-frequency band 3 500–3 800 MHz. The 5G network is expected to be rolled out in 2021.

The Serbian Government adopted, in 2019, the 'Bases for Development of Initial Network for Testing of New Technologies Necessary for Inclusion into Digital Single Market'. This serves to achieve the goals set in the Strategy for Development of New-Generation Networks and Services until 2023. Hence, the initial network has been launched for pre-commercial tests, under a licence issued by RATEL for temporary 5G spectrum usage in the 3.4-3.8 GHz band (100 MHz: 3.45–3.55 GHz) with LTE anchor in the 2.6 GHz band (2 x 20 MHz: 2.64–2.66 GHz DL, 2.52–2.54 GHz UL).

In accordance with the Strategy for the Development of Next-Generation Networks by 2023, the ministry, in cooperation with the Organization for Security and Co-operation in Europe (OSCE), has organized workshops intended for local government representatives on the territory of Serbia, which have highlighted the importance of new technologies in broadband access and their impact on the development of industry.[33] Workshops were held at which representatives of the ministry, RATEL and academics presented data and challenges related to the establishment of base stations. Data on the limits for levels of exposure to electromagnetic radiation produced by mobile systems and the measured results were presented. The workshops produced a positive response and the organizers have been asked to expand the number of cities covered by future workshops. Due to the COVID-19 pandemic, the ministry and OSCE plan to organize virtual workshops from the beginning of the next year.

Bearing in mind the importance of future 5G networks and the challenges raised by this technology, OSCE has begun elaborating a study that will cover major aspects of 5G introduction, regulation and operation. This study is not only aimed at experts, but is also designed to give the public an insight into the main performances of 5G as well as obstacles that could slow down the establishment of a new network.[34]

OSCE provided funds for the study, on: 'Fifth generation of mobile systems (5G) – electromagnetic radiation and its effect on humans and the environment; how 5G is going to be regulated and monitored; how it functions and why it is necessary for us'. The study will be carried out by independent experts in the field of mobile communications and is planned for the end of 2020.

For its part, RATEL has commissioned a feasibility study which recommended that a spectrum auction for a minimum of 15 years should be scheduled for early 2021 on a technology-neutral basis, pursuant to the Law on Electronic Communications, and with a national allocation. The study also recommended that the licence fulfilment requirements should be related to the quality of service provided and independent of technology used.

However, due to the regional and local impacts of the COVID-19 pandemic, MTTT informed the local press in July 2020 that the 5G spectrum auction will be postponed and it is likely that will be held in the first quarter of 2021.

3.5.5 Electromagnetic field levels and implementation dynamics

In Serbia, the limits on levels of exposure to electromagnetic fields for the general public are set in the Rulebook on the limits of exposure to non-ionizing radiation (Official Gazette No. 104/2009). They are approximately two and a half times lower and more stringent than the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommendations on limits of exposure to EMFs in radio-frequency bands 100 kHz – 300 GHz.[35]

As part of the 'EMF RATEL' project, which is a system for continuous monitoring of EMF levels, RATEL has been continuously monitoring changes in EMF levels, as well as exposure of the population to electromagnetic radiation.[36] Currently, a total of 57 sensors performing continuous measurements are installed nationwide.[37] RATEL also indicates that the results obtained through measurements to date have been far below the permitted EMF level values. No field levels deviating from the prescribed values and applicable standards were recorded at any time.

3.5.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

During the 2018 Digital Assembly in Sofia, Bulgaria, Greece and Serbia (represented by its MTTT) signed a letter of intent (LoI) to work together on the Thessaloniki–Sofia–Belgrade 5G cross-border corridor for connected and automated mobility (e.g. driverless vehicles over hundreds of kilometres of motorways).[38] The LoI proposes action in respect of data exchange, common approaches on regulations and coordinated policy action.

This ratification builds on a number of previous agreements among European countries, and highlights that a pan-European network of 5G corridors is under development.[39] Within the context of the Serbia-Greece-Bulgaria agreement, there are three major guiding goals:[40]

- The corridor will provide a technologically neutral hub for industry, research centres, academia and any other stakeholders for testing and evaluating innovative mobility technologies.
- A 'learning by experience' approach and exchange of information will be key features in the use of the corridor.
- Recognition and coordination in specific regulations on automated driving testing will be key aspects in the collaboration.

In June 2019, the operator Telenor launched a test service from the first 5G station in Serbia, utilizing a temporary licence for spectrum in the 2 600 MHz and 3 500 MHz frequency bands, previously assigned by RATEL for 5G tests.[41] Housed in the Science-Technology Park Belgrade, Telenor's 5G network became available in September 2019 to students at the School of Electrical Engineering, University of Belgrade, who are the first partners of this project.[42]

Relying on the 5G test environment enabled by Telenor, other companies are developing 5G-related products and research. For instance, local start-ups (Novelic and DigitalWorx) have performed presentations on development solutions related to smart manufacturing and IoT simulations.[43]

Additionally, a United States-based Drone Company, Easy Aerial, now has a development centre in the Science-Technology Park Belgrade called 'Startup Aerial d.o.o. Serbia'. The start-up is performing research and tests on 5G-enabled drones for advancing reliable videosurveillance and integration with other security-based systems, which may have applications for emergency services systems.[44]

Within the context of 5G as an enabler of the smart-city projects and IoT ecosystem, the Serbian Government signed an agreement between the country and Huawei Technologies, encompassing the country's largest cities: Belgrade, Novi Sad and Nis (which will serve as the pilot project).[45] This project entails the building of a system of transmitters and the development of an information system which should enable economic implementation of various services (sensors, lights and counters for collecting and analysing data – traffic signage, parking spaces, water-meter control, public lighting, etc.).[46] The special goal of this cooperation is the opening of the Huawei Innovation Centre for Digital Transformation.[47]

In December 2019, the Bechtel-ENKA joint venture was selected by the Government of Serbia to build the Morava motorway – Serbia's first 5G-ready digital motorway and flood-defence system in the West Morava river valley, due to be completed by the end of 2023.[48] With construction set to start in 2020, the dual carriageway will cost EUR 783 million. The road will be 112 kilometres long and is set to create 10 000 jobs in central Serbia. Alongside the road infrastructure, a telecommunication corridor will be built beneath the side of the motorway to allow for future 5G fibre and tower installations, which will pave the way for broadband to leverage the economic development zones along the route between Preljina and Pojate.[49] The road will also connect to the north-south motorway running between Hungary and North Macedonia, in addition to linking with trans-European corridors X and XI, which connect Austria with Greece and Italy with Romania.[50]

Endnotes

1 See: https://www.itu.int/en/ITU-D/Innovation/Documents/Publications/eBAT_Brochure%E2%80%93DIP%20Serbia_432746_.pdf

2 See: https://mtt.gov.rs/en/download/Strategy%20on%20Development%20of%20Information%20Technology%20Industry%20for%20the%20period%20from%202017%20go%202020.pdf

3 See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2016/Broadband%20Mapping/6.%20Tomic%20Serbia_BB_map_2.pdf

4 See: https://mtt.gov.rs/download/3/Strategija_razvoja_informacionog_drustva_2020.pdf [in Serbian].

5 See: https://www.ratel.rs/uploads/documents/pdf_documents/documents/Regulativa/Strategije/Serbia_bb_development_strategy.pdf

6 See: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20190529-serbia-report.pdf

7 See: https://www.ebrd.com/work-with-us/projects/psd/51835.html

8 See: https://wbif.eu/project/PRJ-SRB-DII-005

9 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

10 Ibid.

11 See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Fixed_broadband_2000-2018_Dec2019.xls

12 See: https://www.ratel.rs/uploads/documents/empire_plugin/Q1%202020%20ENG%20pdf.pdf

13 See: https://www.ratel.rs/uploads/documents/empire_plugin/An%20Overview%20Of%20The%20Telecom%20And%20Postal%20Services%20Market%20In%20The%20Republic%20Of%20Serbia%20In%202018.pdf

14 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

15 See: https://www.ratel.rs/uploads/documents/empire_plugin/An%20Overview%20Of%20The%20Telecom%20And%20Postal%20Services%20Market%20In%20The%20Republic%20Of%20Serbia%20In%202018.pdf

16 Ibid.

17 See: http://benchmark.ratel.rs/en/trend-analysis-2019

18 See: https://www.ratel.rs/uploads/documents/empire_plugin/An%20Overview%20Of%20The%20Telecom%20And%20Postal%20Services%20Market%20In%20The%20Republic%20Of%20Serbia%20In%202018.pdf

[19] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI")x.

[20] See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Mobile_cellular_2000-2018_Dec2019.xls

[21] See: https://www.itu.int/en/ITU-D/Innovation/Documents/Publications/eBAT_Brochure%E2%80%93DIP%20Serbia_432746_.pdf

[22] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[23] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[24] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2019/Regulatory%20Forum/5.%20RATEL%205G%20in%20Serbia%20-%20challenges%20and%20opportunities.pdf

[25] See: https://www.ratel.rs/uploads/documents/empire_plugin/Q1%202020%20ENG%20pdf.pdf

[26] Ibid.

[27] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[28] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA".

[29] See: Please contact RATEL for more information: https://www.ekip.me/

[30] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2018/5G%20Greece/Session%201%20Irini%20Reljin%20-SERBIA%20-%20Serbia_5G%20plans_Athens_2018%20IR.pdf

[31] See: https://mtt.gov.rs/en/releases-and-announcements/networks-of-new-generations-for-a-single-digital-market/

[32] See: https://mtt.gov.rs/en/download/Predlog%20strategije%20razvoja%20mreza%20nove%20generacije%20do%202023.%20godine.pdf [in Serbian].

[33] See: https://mtt.gov.rs/download/informator-o-radu/informator%20o%20radu%20CI-nov.pdf, p.96 [in Serbian].

[34] The study is in the process of development. For more information, contact OSCE or the Ministry of Trade, Tourism and Telecommunications.

[35] See: https://www.ratel.rs/en/blog/5g-networks-and-public-health-protection

[36] See: https://emf.ratel.rs/eng/index

[37] See: https://emf.ratel.rs/results/index/eng/2/0

[38] See: https://ec.europa.eu/digital-single-market/en/news/new-5g-cross-border-corridor-connected-and-automated-mobility-announced-digital-assembly-2018

[39] See: https://5gobservatory.eu/info-deployments/pan-eu-5g-corridors/

[40] See: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53070

[41] See: https://www.commsupdate.com/articles/2019/06/25/telenor-launches-5g-trial-site/

[42] See: https://ntpark.rs/2019/06/21/telenor-pustio-u-rad-prvu-5g-baznu-stanicu-u-ntp-beograd/ [in Serbian].

[43] See: https://www.telenor.rs/en/about-telenor/news/news-and-press-releases/telenor-rolled-out-first-5g-base-station-in-serbia/

[44] See: http://www.diplomacyandcommerce.rs/surveillance-drones-for-the-first-time-over-telenor-5g-test-network/

[45] See: http://rs.n1info.com/Biznis/a478184/Plan-saradnje-Srbije-sa-Kinom.html [in Serbian].

[46] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2019/Regulatory%20Forum/5.%20RATEL%205G%20in%20Serbia%20-%20challenges%20and%20opportunities.pdf

[47] See: https://industryeurope.com/huawei-to-open-innovation-centre-in-serbia/

[48] See: https://www.newcivilengineer.com/the-future-of/future-of-roads-multipurpose-morava-motorway-09-03-2020/

[49] See: https://industryeurope.com/bechtel-enka-to-build-5g-ready-digital-motorway-in-serbia/

[50] See: https://serbia-business.eu/bechtel-and-enka-team-up-to-build-5g-motorway-in-serbia/

3.6 Georgia

3.6.1 ICT background and current status of broadband

Since 2010, Georgia has strengthened its support to ICTs through a variety of public-private partnerships and digital-related initiatives and programmes, such as zone tax exemption, foreign investments and projects to improve the labour force. The 2014 document 'Georgia 2020 – Social Economic Development Strategy' outlines several target areas to enhance the digital ecosystem, including high-speed broadband Internet for future development, e-literacy and capacity building, innovation and high-tech, and e-government.[1] With a competitive sector largely driven by private investment, the telecommunication market remains among the fastest growing, and in 2017 represented between 5 and 7 per cent of the country's GDP.[2]

In 2014, the Georgian Government announced its plans to provide high-speed Internet throughout the country through a programme called 'Broadband Internet to Every Citizen', executed by the NNLP 'OpenNet'. Established by the government in 2015 as the National Programme for Broadband Development, as a non-entrepreneurial and non-commercial legal entity, OpenNet has performed its activities in accordance with previous development-related resolutions which were approved by the Georgian Government on 28 July 2016.[3]

More recently, Georgia's 'National Broadband Network Development Strategy for 2020–2025'[4] mandates that schools, highways and public facilities must be provided with Internet access at a download speed of 1 Gbit/s by 2025, in line with EU plans, and also aligned with plans for 5G development in the country.[5] The strategy aims not only at creating infrastructure, but also establishing Georgia as a digital and information hub in the region between Europe and Asia, while also upgrading knowledge and skills, leading to employment growth.[6]

Within the framework of the OpenNet project and Georgia's National Broadband Network Development Strategy for 2020–2025, the World Bank is supporting the development of broadband through the 'Log-in Georgia' project, a EUR 32.7 million support package[7] which aims to expand access to affordable broadband in rural settlements and to support the development of Georgia's digital economy.[8] The three major project outcomes include: i) Increasing access to affordable broadband Internet; (ii) Promoting the use of broadband-enabled digital services; and (iii) Project implementation support.[9] The project expects to connect up to 1 000 villages, including settlements in mountainous regions, to high-quality and affordable broadband service. Nearly 500 000 people residing in locations currently unserved by high-quality broadband services stand to benefit from deployment of the broadband infrastructure envisaged by the Log-in Georgia project.[10]

In the context of rural areas, and under the Harmonized Digital Market (HDM) EU4Digital 'Eastern Partnership Countries (EaP) Broadband Infrastructure Development Strategy' project, other development goals in Georgia focus on enhancing the relevant legal and regulatory framework for broadband development in line with the EU norms and overcoming the digital divide across the country's regions.[11]

The urban-rural divides are intertwined with the development of ICT in the country. Approximately 83 per cent of urban households benefit from fixed-broadband services, while in rural areas the figure drops to 5 per cent.[12] Over the past years, growth in mobile broadband has been steady, supported by the auctioning of spectrum in the 800 MHz and 2 100 MHz bands which has enabled the network operators to expand the reach and capabilities of LTE services, which now

cover the vast majority of the population.[13] At the regional level, the construction of the Black Sea and the Caspian Sea submarine fibre-optic cable backbone is currently under discussion in the Ministry of Economy and Sustainable Development.[14]

3.6.2 Broadband and mobile telecommunication data

ITU data show that 68.8 per cent of individuals in Georgia used the Internet in 2019.[15] In 2010, the corresponding ITU figure for the country was 26.9 per cent, and in 2000, 0.5 per cent. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 23.6.[16] ITU data also indicate that 79.3 per cent of households in Georgia had Internet access at home in 2019.[17] Fixed-broadband networks (using fibre-optic or cable networks) are limited in their reach outside of urban areas.[18] The country's data from May 2020 published by the Georgian National Communications Commission (GNCC) show that that Tbilisi and Adjara are the regions with the highest Internet penetration in the country, while the north-western region of Abkhazia exhibits the lowest penetration rate.[19] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019 (CIS region: 3.7 per cent), while Georgia's corresponded to 3.4 per cent of GNI per capita in 2019 for an unlimited Internet data allowance.[20]

Since 2014, fibre infrastructure has been steadily expanding in the country, while xDSL has been contracting. In 2018, 75 per cent of total subscriptions used FTTx technology, as compared to only 31 per cent in 2010 (when xDSL accounted for 59 per cent of total subscriptions). Nowadays, fibre is by far the most used technology in Georgia, and Wi-Fi the second most common, mostly in rural parts of Georgia where FTTx connections are not available.[21]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants stood at 134.7.[22] At the present time, there are three MNOs operating in Georgia – Magticom, Beeline (Veon Georgia) and Silknet – that currently hold licences for commercial use of radio-frequency The number of active mobile-broadband subscriptions per 100 inhabitants was 79.9 in 2019.[23] During the same year, Georgia's mobile-data basket cost corresponded to 0.8 per cent of GNI per capita for a monthly allowance of 2 GB,[24] which is the same as the Europe region average of 0.8 per cent, while the CIS region average is 2.2 per cent. With extremely low prices compared to many other regional and European countries, 2G and 3G networks cover approximately 99.98 per cent of Georgia's population,[25] while 4G/LTE covers 99.72 per cent.[26] Although all of the MNOs have been investing to expand the reach and capabilities of LTE infrastructures to areas outside of Tbilisi,[27] Magticom and Veon Georgia are the operators with most mobile Internet traffic in the country.[28]

Due to the significant investments made by Georgian MNOs to improve telecom infrastructure and achieve higher coverage, Internet traffic has grown from 1.5 million GB in 2013 to 63.7 million GB in 2018.[29] In 2019, Georgia recorded 0.09 exabytes of mobile-Internet traffic.[30]

Although the majority of mobile subscribers are individuals, data show that the number of corporate subscribers is growing.[31]A nationally representative survey found that out of the 97.5 per cent of firms in Georgia that had access to the Internet in 2016, about 40 per cent had broadband, 31 per cent used DSL connections and the remainder accessed the Internet on their mobile phones (typically using a GSM connection) – although only 9.5 per cent engaged in e-commerce.[32]

3.6.3 Current progress on 5G: consultations and national strategies

Since 2016, Georgia has been actively involved in the work of the Spectrum Expert Working Group (SEWG) established within the EaPeReg network to advance implementation and harmonization of next-generation networks. In regard to the progress of 5G in the country, GNCC acknowledges that the development of broadband services and 5G technology plays an important role in the further development of the country and has accordingly formulated a strategy to introduce 5G, incorporating elements such as coverage obligations, network access and the possibility of joint ventures to build the network.[33]

This initial plan seeks to achieve the following: [34]

- By 2020, in case of adjustments by the operators, GNCC should have the opportunity to ensure temporary use of the frequency spectrum allocated to 5G.
- By 2020, based on the strategy and action plan developed and approved, 5G-based services will be launched in test mode in at least one geographical area.

GNCC's preliminary strategy also includes a list of industries that are likely to be impacted by 5G development in the country, such as transportation, infrastructure management, media, energy, public safety, smart cities and e-health.

On 8 July 2019, GNCC started a 5G consultation process with operators in order to ascertain their views and plans in regard to 5G. The document outlined a plan for frequency allocation for 5G and the regulation of related issues.[35] Two out of the three operators shared their position, all were in favour of development of the 5G network being a necessary feature of the country's telecommunication sector – in terms of both the country's technological progress and advancement of the digital economy.[36] Despite the plan, there is no clear roadmap for 5G frequency allocation.[37]

According to private-sector stakeholders, LTE technology will be sufficient for the foreseeable future to meet the country's existing needs. Operators also identified a few existing obstacles, such as the costs associated with deploying a new generation of telecommunication infrastructure, that need to be overcome in order to facilitate the introduction of 5G network in a relatively short time-frame. To solve this problem, operators considered the possibility of non-discriminatory access to passive infrastructure to be used for State-owned (and not only) telecommunication purposes. GNCC notes that a legislative initiative has already been prepared for sharing of the infrastructure used for telecommunication purposes, based on EU Directive 2014/61/EU.[38]

In December 2019, GNCC developed and published the 'Strategy for Promoting the Development of 5G Network and Services'.[39]The document contains information about the Commission's plans, vision and goals, including: i) 5G Frequency Band Release, Coordination and Harmonization Plan; ii) Expected sequence of transmission for temporary use of 5G frequency bands; iii) List of liabilities; iv) Plan for legislative changes that will affect 5G; v) Development in Georgia; and v) Examples of future use of 5G in Georgia.[40] This document has been created with the aim of making the spectrum dedicated for mobile-broadband services available for operators in the first half of 2020. The spectrum plan allows operators to develop and expand 5G networks and products for future commercial use.

In April 2020, GNCC published the '5G Frequency Resource Fee Consultation Document'. The regulator received questions regarding this document from MagtiCom and Silknet. As part

of the consultation regime, an online meeting was held to discuss questions related to the calculation of fees.[41]

In December 2020, GNCC published the '5G Terms and Conditions Consultation Paper'. The consultation builds upon the previous consultations and on the previously calculated reserve prices, to present a vision regarding the obligations and licensing conditions for 5G service frequencies in the forthcoming auction.[42]

3.6.4 Spectrum assignment for 5G & market development

In 2014, Georgia agreed to gradually harmonize the existing legislation in the field of electronic communications with the regulatory norms existing within the EU. With the assistance of the European Bank for Reconstruction and Development (EBRD), GNCC analysed where Georgian legislation's regulatory norms failed to comply with European directives. As a result, a two-stage package of legislative changes for radiocommunication was developed. The first stage involves the introduction of general fundamental liberal approaches, while the second involves individual licensing. [43]

GNCC states that the main inconsistencies that hinder rapid technological development in the country are:[44]

- Lack of conceptual approaches to the use of frequency resources based on general authorization and individual licensing.
- Inflexible regime for determining the licence period.
- Freedom of choice of frequency resource use and proportional selection criteria.
- Absence of a formal written consultation procedure for the allocation and assignment of frequency resources.
- Lack of opportunity to use frequency resources in test mode in a limited geographical area for a specified period on a non-commercial basis.

Due to the high importance attached to 5G in the country, GNCC plans to hold an auction in 2021 to allocate the necessary spectrum. It states that, when determining the basic requirements for the 700 MHz and 3 400–3 800 MHz frequency bands, it is recommended that providers draw up a specific coverage plan, which will include a specific list of cities and major roads to be covered under the 5G licence. Besides, the regulator notes that the licence should impose certain obligations regarding the coverage of specific settlements, as well as in terms of investment and network development.

Current Georgian legislation recognizes individual licensing through auctions as the preferred method for the use of frequency resources. GNCC documents show that this often creates barriers to market access with new technologies, affects resource costs, and prevents the spread of new, diverse technologies and services across the country.

The law states that spectrum is an inexhaustible resource, which is fundamentally the opposite of EU approaches. According to this rationale, the resource is limited only in those ranges where there is excess demand for individual licences. This is largely because the Georgian market is not particularly saturated in terms of the consumption of high-speed mobile-broadband services and part of the spectrum for broadband services remains untapped.[45]

The regulator is working with different network operators to ensure network synchronization and eliminate potential risks such as errors regarding data transmission in asynchronous

network mode; the need for geographical division of neighbouring and same channels; and a continuous mode of service delivery to subscribers using various wireless networks. Accordingly, GNCC states that that synchronized operation eliminates any interference between base stations (BS-BS) and between mobile stations (MS-MS), allowing neighbouring networks to coexist without additional filters and shielding frequency bands. This mode of operation facilitates expansion of the mobile network while reducing interference.[46] GNCC considers it appropriate to impose a network synchronization obligation as one of the conditions of the licence, in order to avoid undesired interference and to ensure the sustainability of the service.[47]

According to the '5G Terms and Conditions Consultation Paper' presenting the vision for the 2021 auction, a total of 400 MHz will be available under the auction for frequencies in the 700 MHz, 800 MHz, 3 400–3 800 MHz frequency bands, distributed as follows:

- 703–733/758–788 MHz (2 x 30 MHz – 700 MHz band)
- 816–826/852–862 MHz (2 x 10 MHz – 800 MHz band)
- 3 400–3 800 MHz (5 x 50 MHz, 1 x 40 MHz, 1 x 30 MHz, 3 400–3 800 MHz).

Within the scope of the auction, the regulator plans to make available the following lots of spectrum in the 700 MHz, 800 MHz and 3 400–3 800 MHz frequency bands:

- 4 lots of category A bundles, composed as follows:
    - 700 MHz: 2 x 5 MHz;
    - 3.4–3.8 GHz: 50 MHz.
- 7 lots of category B standalone lots, as follows
    - 700 MHz: 2 x 5 MHz (2 lots);
    - 3 600–3 650 MHz: 50 MHz (1 lot);
    - 3 650–3 690 MHz: 40 MHz (1 lot);
    - 3 770–3 800 MHz: 30 MHz (1 lot);
    - 816–821/852–857 MHz: 2 x 5 MHz (1 lot);
    - 821–826/857–862 MHz: 2 x 5 MHz (1 lot).

The spectrum cap will be 2 x 10 MHz in both the 700 MHz and 800 MHz bands and 100 MHz in the 3.4–3.8 GHz band. Moreover, the reserve price will be GEL 363 000/1 MHz in the 700 MHz band, GEL 741 000/1 MHz in the 800 MHz band and GEL 52 000/1 MHz in the 3.4–3.8 GHz band.

With regard to the licensing period, pursuant to Georgia's Law on Electronic Communications, the licences issued will be valid for 15 years from the date of issue, with the obligation to start operation within six months after that date. Regarding coverage obligations, incremental obligations over time are foreseen, with the first obligations expected to be applicable two years from the date of award of the licence. Finally, the document also sets out technical terms of operation.

The consultation was open until 22 December 2020, and also specifically requested feedback on the following topics:

- Whether access to national and/or local roaming should be considered within the framework of the licences, and in what form.
- Whether additional obligations for the standalone lots should be determined.
- Whether there should be one bundled lot reserved for a new entrant.

- Whether coverage commitments for the newcomer and the existing MNOs should be different.
- Whether so-called MVNO access for 5G network should be regulated.
- Present your vision for infrastructure sharing and joint venture possibilities (unified 5G network).

3.6.5 Electromagnetic field levels and implementation dynamics

In the past, GNCC has studied the effects of mobile-phone electromagnetic radiation.[48] The research aimed to advise the public about the harmful effects of and permissible norms for mobile-phone electromagnetic radiation, as well as to inform the population about measures to protect against electromagnetic radiation.[49] However, no further information is available in English regarding the broader EMF limits in Georgia.

3.6.6 Commercial launches: Announcements, trial cities and digital cross-border corridors

In April 2020, GNCC informed the local press that it had already carried out large-scale work to install 5G Internet infrastructure and would soon be announcing a tender for operators.[50]

The Georgian Association of Small and Medium Operators has indicated to the local press that Internet tariffs will decline after 5G is introduced in the country, provided that GNCC sets optimal prices for operators leading up to the frequency spectrum auction in the country.[51] As at August 2020, however, there has been no 5G-related testing or commercial launch in the country, although Beeline Georgia has already expressed its interest in 5G networks.[52]

Endnotes

1 See: https://eufordigital.eu/countries/georgia/#events

2 See: https://www.itu.int/en/ITU-D/Statistics/Documents/bigdata/Georgia.pdf

3 See: https://matsne.gov.ge/ka/document/view/3355632?publication=0

4 See: http://www.economy.ge/uploads/files/2017/legislation/sainformacio_teqnologiebi/fartozolovani_qselebis_ganvitarebis_strategia_da_misi_ganxorcielebis_gegma.pdf [in Georgian].

5 See: https://comcom.ge/uploads/other/3/3939.pdf [in Georgian].

6 See: https://eufordigital.eu/georgia-approves-broadband-development-strategy-2020-2025/

7 See: https://www.worldbank.org/en/news/press-release/2020/08/28/1000-villages-to-get-better-internet-connectivity-as-part-of-world-bank-support-to-georgia-digital-transformation

8 See: http://www.opennet.ge/eng/list/show/50-World-Bank-will-co-finance-the-State-Program-of-the-broadband-infrastructure-development

9 See: http://documents1.worldbank.org/curated/en/316241571855041161/pdf/Concept-Project-Information-Document-PID-Log-In-Georgia-P169698.pdf

10 See: https://www.worldbank.org/en/news/press-release/2020/08/28/1000-villages-to-get-better-internet-connectivity-as-part-of-world-bank-support-to-georgia-digital-transformation

11 See: http://www.economy.ge/?page=projects&s=18&lang=en

12 See: http://documents1.worldbank.org/curated/en/316241571855041161/pdf/Concept-Project-Information-Document-PID-Log-In-Georgia-P169698.pdf

13 See: https://www.budde.com.au/Research/Georgia-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses

14 See: http://www.economy.ge/?page=projects&s=18&lang=en

15 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

17 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

18 See: http://documents1.worldbank.org/curated/en/316241571855041161/pdf/Concept-Project-Information-Document-PID-Log-In-Georgia-P169698.pdf

19 See: https://analytics.comcom.ge/en/statistics/?c=internet&f=subscribers&exp=penetrationbyregion&sid=801631

[20] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[21] See: https://analytics.comcom.ge/en/statistics/?c=internet&f=subscribers&exp=technologies&sid=801640

[22] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[23] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[24] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[25] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271G").

[26] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271GA").

[27] See: https://www.itu.int/en/ITU-D/Statistics/Documents/bigdata/Georgia.pdf

[28] See: https://analytics.comcom.ge/en/statistics/?c=mobiles&sid=801641&f=mobinttraffic&exp=traffic

[29] See: https://galtandtaggart.com/upload/reports/11688.pdf

[30] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[31] See: https://galtandtaggart.com/upload/reports/11688.pdf

[32] See: http://pubdocs.worldbank.org/en/352521517860642922/pdf/Broadband-for-Development-in-Georgia-clean.pdf

[33] See: https://www.budde.com.au/Research/Georgia-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses

[34] See all documents: https://5g.gov.ge/

[35] See: https://5g.gov.ge/public-discussion-of-5g-development-support-document/ [in Georgian].

[36] See: http://5g.gov.ge/wp-content/uploads/2019/09/5G-%E1%83%99%E1%83%98%E1%83%97%E1%83%AE%E1%83%95%E1%83%90-%E1%83%9E%E1%83%90%E1%83%A1%E1%83%A3%E1%83%AE%E1%83%98-final.pdf [in Georgian].

[37] See: https://5g.gov.ge/public-discussion-of-5g-development-support-document/ [in Georgian].

[38] See: https://5g.gov.ge/wp-content/uploads/2019/09/5G-%e1%83%99%e1%83%98%e1%83%97%e1%83%ae%e1%83%95%e1%83%90-%e1%83%9e%e1%83%90%e1%83%a1%e1%83%a3%e1%83%ae%e1%83%98-final.pdf [in Georgian]

[39] See: https://5g.gov.ge/5g-sixshiruli-resursis-safasuris-gaangarishebis-sakonsultacio-dokumenti/ [in Georgian].

[40] See: https://comcom.ge/uploads/other/5/5671.pdf [in Georgian].

[41] See: https://5g.gov.ge/wp-content/uploads/2020/07/5G-Frequency-valuation-consultation-paper.pdf

[42] See: https://5g.gov.ge/wp-content/uploads/2020/12/5g-terms-and-conditions.pdf

[43] See: https://comcom.ge/uploads/other/3/3939.pdf [in Georgian].

[44] Ibid.

[45] Ibid.

[46] Ibid

[47] Ibid.

[48] See: https://comcom.ge/en/momxmareblis-uflebebi/useful-infomation/mobile-informer

[49] See: http://www.ena.ge/gncc-sar

[50] See: https://agenda.ge/en/news/2020/1184

[51] See: https://www.cbw.ge/economy/ucha-seturi-5g-establishment-will-lower-internet-tariffs

[52] See: https://navigator.ge/2018/06/29/vioni-saqarthvelos-mekhuthe-thaobis-5g-kavshiris-danergvis-gegmebi/ [in Georgian]

3.7 Republic of Moldova

3.7.1 ICT background and current status of broadband

The Republic of Moldova has a dynamic and competitive telecommunication market which is characterized by high Internet access speeds, good mobile-service accessibility and robust nationwide infrastructure. There is a clear interest and drive on the part of both the Government of Moldova and the regulator to provide a strong role for ICT-centric innovation in support of the economy.[1] The fixed-line and mobile-broadband sectors have seen years of solid growth, but between 2016 and 2019 the sector experienced a decline in revenue.[2] The mobile market is currently responsible for generating a larger share of the telecom revenue in the country. Furthermore, Moldova's legislation in the ICT sector is largely aligned with the European Union legal framework.[3]

The Moldovan Government has implemented a variety of ICT-related strategies at the national level, such as the 2005 'National Strategy for Building an Information Society' ('Electronic Moldova' or E-Moldova), the '2011 Strategic Programme for Technological Modernization of Governance (e-Transformation)' and the '2013 E-Agriculture Strategic Programme',[4] among other strategies and action plans.[5] The creation of the 'IT Park' in 2018 also promoted fiscal and economic incentives,[6] thus enhancing the competitiveness of the IT industry by confronting challenges such as the low regional/international competitiveness, the risk of business relocation to other countries and the migration of a skilled labour force.[7]

The National Strategy for Information Society Development 'Digital Moldova 2020', launched in 2013, currently guides policies directed toward sustainable growth of the ICT sector, and is based on three pillars[8] together with an action plan:[9] i) Infrastructure and access – improving connectivity and access to the various networks; ii) Digital content and electronic services – promoting the generation of digital content and services; and iii) Capacities and usage – enhancing literacy and digital skills to enable innovation and stimulate usage.

In terms of broadband development in the country, the strategy listed the following goals for 2020:[10]

- All localities of the country shall have at least one point of access to broadband with a minimum speed of 30 Mbit/s while at least 60 per cent of households shall be connected to broadband Internet.
- At least 75 per cent of citizens shall be Internet users.
- 100 per cent of public services which may be provided electronically shall be available online.
- 100 per cent of archives, civil-status records and cultural and scientific heritage shall be digitized and available.
- At least 80 per cent of citizens shall be satisfied with the quality of services provided.
- Public services shall be provided under the ID card, including electronic, or through electronic or mobile identification.
- At least 70 per cent of the population shall use electronic services.
- At least 60 per cent of the population shall use digital signature.
- At least 20 per cent of the population shall shop online.
- 100 per cent of the population shall have access to digital terrestrial television.

In 2018, the Government of Moldova launched the 'Strategy for development of the information technology industry and the ecosystem for digital innovation for the years 2018–2023'. Through

this strategy, with a sharper focus on IT and entrepreneurship, the government aims to facilitate the emergence of dynamic ecosystems through close collaboration with entrepreneurs, investors, corporations and other stakeholders, as well as multiplying IT solutions horizontally.[11] As at 2020, there are 2 145 companies with over 27 000 employees working in the IT sector, generating around 7 per cent of the country's GDP.[12]

In response to the COVID-19 pandemic, the Ministry of Economy and Infrastructure, the Ministry of Education, Culture and Research, the National Association of Information Technology and Communications Companies, and the Tekwill ICT Training and Innovation Centre signed an MoU on the 'Development of digital skills, IT and STEM throughout life' in July 2020. This document provides information on the use of digital technologies at all school levels. It also specifies the role of teachers in preparing students for digital transformation, thus ensuring the quality and relevance of ICT skills for professional activity in a digital economy.[13] Within the context of COVID-19, a roadmap with 37 actions for boosting the process of digitalization of the Moldovan economy and the expansion of e-commerce was also prepared by the government.[14]

3.7.2 Broadband and telecommunication data

ITU data show that 72.1 per cent of individuals in Moldova used the Internet in 2017.[15] In 2010, the corresponding ITU figure for the country was 32.3 per cent, and in 2000, 1.3 per cent. A report by the National Regulatory Agency for Electronic Communications and Information Technology in Moldova (ANRCETI) reveals that the country also had one of the lowest fixed-broadband costs in the world in 2015.[16] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 16.6,[17] with 94 active Internet service providers.[18] However, more recent data from ANRCETI indicate that fixed-broadband household subscriptions in Moldova have climbed to 25 for every 100 inhabitants. As the regulator considers an average of three persons per household, it thus estimates that 75 per cent of the population enjoyed fixed access at home in 2019.[19]

In 2019, half the subscriptions to fixed Internet access services benefited from speeds of between 30 and 100 Mbit/s, while 13.8 per cent enjoyed speeds of over 100 Mbit/s.[20] According to ANRCETI, the number of FTTx connections increased by 14.7 per cent, to 452 300, while coaxial-cable connections increased by 20.6 per cent, to 53 500. FTTx technology now represents 66.6 per cent of the total number of subscribers,[21] with a significantly high rate in Chișinău and other major cities, while xDSL technology is most common in smaller towns and rural areas.[22] Moreover, the number of subscribers using xDSL connections fell by 10.5 per cent, to about 163 000.[23]

According to ANRCETI data, in 2019 the number of active mobile-broadband subscriptions per 100 inhabitants was 88.8, an increase in comparison with 2018, when it stood at 79.4.[24] At the time of writing, there are three MNOs operating in Moldova – Orange Moldova, Moldcell and Moldtelecom – that currently have licences for the commercial use of radio-frequency spectrum. The mobile market sector now accounts for the majority of total telecom revenue in the country.[25] In terms of network coverage, 3G covers 99 per cent of Moldova's territory[26] and 4G networks provide coverage to 95 per cent of the territory,[27] serving 98 per cent of the population, according to ITU data.[28] The amount of traffic generated by mobile-broadband users via smartphones rose by 47.2 per cent, up to some 52.4 million GB out of the total data consumed during the reference period in the country of 104.7 million GB, which represented an increase of 24 per cent.

Despite the overall decline in telecom revenues in the period 2016–2019, ANRCETI data show that there has been a significant increase in sales from 2018 onwards, with Orange Moldova registering the largest growth in revenue (63.4 per cent) at the end of 2019.[29] In 2019, the total number of users accessing mobile broadband based on 4G technology recorded a significant increase when compared to 2018.[30] In the same year, the market for fixed-broadband Internet access services in Moldova likewise saw a significant increase, with the volume of sales rising by 6.1 per cent year-on-year to reach MDL 1.16 billion (EUR 59.1 million).[31] In 2019 alone, the total amount of mobile-broadband Internet traffic within the country came to 0.1 exabytes.[32]

3.7.3 Current progress on 5G: Consultations and national strategies

Moldova's Ministry of Economy and Infrastructure is finalizing the draft programme on 5G, which was submitted for public consultation and is to be approved by the government by the end of 2020. Some of the preconditions for the establishment of a 5G allocation and consequent implementation in Moldova set out by the ministry are:[33]

- Creating the legal framework for sustainable development of terrestrial mobile electronic broadband communications and other types of communications for the years 2021–2025 by continuing the Radio Spectrum Management Programme for the years 2013–2020.
- The need to harness the available radio-spectrum resources.
- The need to continue the application of best practice with reference to implementation of the EU's Multi-annual Policy Programme in the field of radio spectrum (Radio Spectrum Policy Programme – RSPP, Decision 243/2012/EU of 14 March 2012.
- Ensuring the possibility of implementing 5G mobile-broadband communication services, which offer citizens and industries the competitive advantages necessary for development in a favourable environment.

In the National Development Strategy 'Moldova 2030', approved by the government on 10 June 2020,[34] it is established that a considerable increase in access speeds is expected through the development and implementation of new access technologies and revamping of networks. The document also establishes the need to promote 5G accessibility at over 100 Mbit/s for any household in the country by 2030.[35]

In June 2020, the government held a public consultation session with operators as well as the National Agency for Public Health, the National Radio-Frequency Management Service and the national regulator to discuss the new Radio Spectrum Management Programme, mobile communication operators' plans in respect of next-generation 5G technologies, and the state of play regarding the protection of public health.[36] MNOs indicated that their investment plans did not foresee the implementation of 5G technology before 2023.[37] During the consultation, it was also agreed to create a working group with all stakeholders to develop the regulatory framework for the implementation of 5G technology in Moldova.

3.7.4 Spectrum assignment for 5G and market development

Moldova's Ministry of Economy and Infrastructure, in partnership with experts from ITU and the Korean Information Society Development Institute, is developing a spectrum-management programme for the period 2021–2025. This new document will continue the ministry's spectrum-management programme for 2013–2020, which had previously freed up the radio-frequency bands 800 MHz, 900 MHz, 1 800 MHz, 2 100 MHz, 2 600 MHz and 3 400-3 800 MHz. [38]

The 3 400-3 800 MHz frequency band is free, while the 700 MHz band is assigned for analogue terrestrial television services and its allocation will be possible once the transition to digital television is completed.[39] Therefore, the new rules are set to continue the harmonization processes established in the previous programme and aligned with the EU. The main tasks and objectives of the new policy programme include:

- Concluding the activities for releasing of the spectrum in the 700 MHz band.
- Creating the legal framework for organization of an objective, transparent, non-discriminatory and proportionate auction process for the targeted spectrum resources.
- Developing long-term spectrum policy and ensuring medium and long-term predictability of radio-spectrum resource usage.
- Maximizing efficiency in the use of limited radio-spectrum resources and stimulating competition on the mobile electronic communications market.

In view of the technical requirements and channel arrangements, which are based on CEPT decisions and recommendations, there are two main stages for the development of the new programme: i) consolidation of the current networks (2021–2022: some spectrum re-farming and consolidation activities on the current bands and technologies); and ii) 2022–2025: creation of the conditions and an enabling environment for the implementation of 5G networks.[40]

The target bands for the new 2021–2025 spectrum-management programme include 700 MHz, 3 600 MHz, 26 GHz, and also 1 500 MHz (L-band) and 2 300 MHz. The programme also targets available spectrum resources from the 450 MHz, 900 MHz, 2 100 MHz and 2 600 MHz bands. With the ongoing strategies on spectrum use that will pave the way for 5G implementation in Moldova, the government plans to:[41]

- Provide stakeholders with sufficient spectrum resources to allow the implementation of 5G networks, and consequently the new applications and business cases that 5G can deliver.
- Implement new broadband technologies and services and increase the capacities of existing networks.
- Attract new investments in the ICT sector of the national economy.
- Increase the turnover of companies in this sector.
- Increase the incomes to the State budget generated by capitalization of the radio-spectrum resources and by economic activities in the mobile electronic communication services market.
- Promote the development of other sectors of the national economy as a result of modernization and continuous development of the radiocommunication infrastructure and diversification of the range of mobile electronic broadband communication services offered.
- Increase the accessibility of broadband mobile electronic communication services to the population as a result of establishing a fair and efficient competitive environment on the mobile electronic communication services market.
- Improve the quality of services provided, reducing the digital divide between rural and urban areas.
- Create new jobs and increase the average wage in the ICT sector.

3.7.5 Electromagnetic field levels and implementation dynamics

There is no public information on EMF limits in Moldova. The country is in talks to participate in WHO's EMF project.[42]

3.7.6 Commercial launches: Announcements, trial cities and digital cross-border corridors

From 2018, the Orange Group has implemented Nokia Voice over LTE technology in Moldova to significantly enhance the quality of its mobile voice services. Orange uses Nokia's cloud-based IP Multimedia 2 Subsystem (IMS), which includes the Telecom Application Server (TAS), a cloud-native application, to deliver full-featured 4G network calls. Through this implementation, Orange is also delivering virtualization of its core network, a key milestone for the launch of 5G.[43]

In a meeting with high-level government representatives in January 2019, the Chinese company ZTE laid out business plans to allow the implementation of 5G technology in Moldova.[44]

In March 2019, Orange Moldova became the first operator to test 5G technology in the country. On that occasion, Orange Moldova shared with the Moldavan public that their 5G strategy is based on improving high-speed mobile bandwidth; establishing high-speed access to the fixed network; and promoting applications to support the local business digital transformation.[45] Several months before the first test, Orange Moldova expressed its interest in 5G implementation and mobile financial services to the Moldovan government.[46]

In April 2019, Moldtelecom displayed its preliminary work on 5G research and development to the public on a mobile truck lab at the Museum of Outdoor Technology of the Technical University of Moldova. The operator's technical experts discussed topics on wireless networks, backhaul, IT and basic network services with hundreds of visitors.[47] There were also interactive presentations on large-scale infrastructures, ecosystems and 5G-related equipment such as robots, vehicles and smart TVs.[48]

In October 2019, ANRCETI hosted the 9th EaPeReg Network (Eastern Partnership Electronic Communications Regulators Network) meeting of the Radio-Frequency Spectrum Expert Working Group (SEWG), which is fostering 5G frequency harmonization across EaP countries.[49]

As at September 2020, there have been no commercial 5G launches, as the national MNOs have not requested authorizations from the national regulator for commercial operation of 5G networks and the necessary equipment.

Endnotes

1 See: https://www.itu.int/dms_pub/itu-d/opb/inno/D-INNO-MD-2018-01-PDF-E.pdf

2 See: https://en.anrceti.md/files/filefield/Raport_trim_III_2019.pdf [in Romanian].

3 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

4 See: http://www.fao.org/3/I8303EN/i8303en.pdf

5 See: https://www.itu.int/dms_pub/itu-d/opb/inno/D-INNO-MD-2018-01-PDF-E.pdf

6 See: https://emerging-europe.com/intelligence/moldovas-ict-sector-is-primed-for-further-growth/

7 Ibid.

8 See: https://eufordigital.eu/wp-content/uploads/2020/01/strategia_moldova_digitala_2020_857.pdf [in Romanian].

9 See: http://mei.gov.md/sites/default/files/anexa_i_hg_857_md.pdf [in Romanian].

10 See: http://old.mtic.gov.md/sites/default/files/transparency/public_consults/strateg_857_en.pdf

11 See: https://eufordigital.eu/wp-content/uploads/2020/01/2018-2023_strategie_aprobata_hg_904_24.09.2018.pdf [in Romanian].

12 See: https://eufordigital.eu/moldova-moves-to-develop-digital-skills-in-schools/

13 Ibid.

14 See: https://mei.gov.md/sites/default/files/foia_de_parcurs.pdf [in Romanian].

15 See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

16 See: https://mei.gov.md/sites/default/files/2._avasant_it_strategic_roadmap.pdf

17 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

18 See: https://www.brodynt.com/business-internet-connectivity-in-moldova/

19 See: https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf [in Romanian].

20 See: https://eufordigital.eu/broadband-access-up-in-moldova-as-users-opt-for-higher-speeds/

21 See: https://eufordigital.eu/market-value-of-fixed-broadband-internet-access-services-in-moldova-exceeded-1-billion-lei-in-first-nine-months-of-2019/

22 See: https://digital.report/moldova-state-of-affairs-report/#_ftn10

23 See: https://www.anrceti.md/news_250320 [in Romanian].

[24] See: https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf [in Romanian] For ITU data, consult the ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[25] See: https://www.brodynt.com/business-internet-connectivity-in-moldova/

[26] See: https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf [in Romanian].

[27] Ibid.

[28] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271GA").

[29] See: https://en.anrceti.md/news_060420en

[30] Ibid.

[31] See: https://en.anrceti.md/news10122019 , exchange rate as at September 2020.

[32] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[33] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2020/Spectrum_EUR_CIS/Andrei%20Gavrisi%20(1).pdf

[34] See: https://www.legis.md/cautare/getResults?doc_id=121920&lang=ro [in Romanian].

[35] See: https://cancelaria.gov.md/sites/default/files/cu_privire_la_aprobarea_proiectului_de_lege_pentru_aprobarea_strategiei_nationale_de_dezvoltare_moldova_2030.pdf [in Romanian].

[36] See: https://eufordigital.eu/when-could-5g-technology-be-rolled-out-in-moldova-ministry-of-economy-holds-public-consultation-with-operators/

[37] See: https://mei.gov.md/ro/content/mei-consultat-furnizorii-de-comunicatii-electronice-mobile-si-institutiile-de-sanatate [in Romanian].

[38] See: https://www.itu.int/net4/ITU-D/CDS/GSR/2018/documents/contributions/Moldova_English.pdf

[39] See: https://www.anrceti.md/news11102019 [in Romanian].

[40] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2020/Spectrum_EUR_CIS/Andrei%20Gavrisi%20(1).pdf

[41] Ibid.

[42] See: https://www.who.int/docs/default-source/radiation-international-emf-project-reports/emf-iac-2015-progress-report.pdf?sfvrsn=e74f20af_2&download=true

[43] See: https://www.itu.int/net4/ITU-D/CDS/GSR/2018/documents/contributions/Moldova_English.pdf

[44] See: https://gov.md/en/content/chinese-company-interested-investing-5g-technology-moldova

[45] See: https://www.moldova.org/r-moldova-fost-testata-premiera-tehnologia-5g/

[46] See: https://gov.md/en/content/network-5g-be-tested-moldova

[47] See: https://www.moldova.org/5g-este-aici-moldtelecom-prezinta-un-laborator-al-tehnologiilor-viitorului/ [in Romanian].

[48] See: https://www.moldova.org/foto-ziua-tehnologiilor-5g-moldova-moldtelecom-prezentat-camionul-tehnologiilor-viitorului-care-fost-disponibil-pentru-toti/ [in Romanian].

[49] See: https://www.anrceti.md/news11102019 [in Romanian.]

3.8 Turkey

3.8.1 ICT background and current status of broadband

Turkey's telecommunication sector has gone through tremendous changes during the last decade, driven by advances in technology and increasing customer demand.[1] The ICT sector is considered a priority sector by the Turkish Government, and various initiatives have been taken to promote investment in the area.[2] Government contributions to the country's ICT ecosystem include programmes and strategies such as the Turkish National Information Infrastructure Plan – TUENA (1999), the e-Turkey Initiative Action Plan (2000), the e-Transformation Turkey Project Short-term Action Plan (2003-2004, 2005), the Information Society Strategy and Action Plan (2006-2010), and the second Information Society Strategy and Action Plan (2015–2018),[3] among others. Turkey's Strategic Vision 2023 sets out important goals for the country, giving special importance to ICTs as an accelerator for achievement of the United Nations 2030 Agenda for Sustainable Development and the SDGs. The country's goals include: i) Expanding the economy to rank among the global top ten; ii) Transformation to a knowledge-based society; iii) Building an intercontinental hub for ICTs; and iv) Providing ICT-based economic growth, enhancing high-speed broadband access for all.

The country's telecom network has been undergoing a fast modernization process, with considerable expansion of its geographical coverage and the provision of various telecom services. On the one hand, communication between cities is largely possible thanks to an advanced, networked inter-city backbone infrastructure that relies on both fibre-optic cable and digital microwave radio relay. On the other, domestic satellites currently cover most of the country's rural areas, and more satellite projects are under way, with expected launches in the years to come.[4]

In terms of broadband development, Turkey's National Broadband Strategy and Action Plan for 2017–2020, which emerged within the framework of the 2015-2018 Information Society Strategy, outlines the following basic principles:

- Improving the broadband infrastructure across the country.
- Expanding fibre access across the country.
- Increasing capacity and speed of broadband connectivity.
- Ensuring development of the sector based on competition and in line with market requirements.
- Developing demand for broadband Internet services.

In terms of private-sector expansion, the country's privatization programme has reduced State involvement and attracted a significant number of international companies to make investments in Turkey's digital market.[5] Today, xDSL and mobile-broadband technologies are the most common Internet technologies in Turkey. Although cable and fibre penetration is low in Turkey, both these connectivity technologies are steadily growing.

Turkey has also experienced steady growth in e-commerce. Data from the Turkish Statistical Institute (Turkstat) show that in 2018 the rate of e-sales in enterprises increased by 1.4 points compared to 2017, to an overall 11.2 per cent. E-sales concern the receipt of orders by electronic methods specifically designed for the purpose, either via electronic data interchange (EDI) or through websites or apps (web sales). They represented 24.4 per cent of total sales in enterprises

with 250 or more employees, 12.9 per cent in enterprises with 50–249 employees and 10.5 per cent in enterprises with 10–49 employees.[6]

3.8.2 Broadband and mobile telecommunication data

Data from Turkey's Information and Communication Technologies Authority (*Bilgi Teknolojileri ve İletişim Kurumu* – BTK) for the first quarter of 2020 show that 79 per cent of individuals in Turkey used the Internet, an increase compared to 2019, when official ITU data[7] put the figure at 74 per cent. In 2010, according to ITU data, the proportion of Internet users had been 39.8 per cent, and 3.8 per cent in 2000.[8] In 2018, the number of fixed-broadband subscriptions per 100 inhabitants stood at 17.06.[9] BTK data show that 90.7 per cent of households in Turkey had Internet access at home in 2020;[10] the ITU figure for 2019 was 88.3 per cent.[11] While 50.8 per cent of households used a fixed-broadband connection (ADSL, cable, optical fibre, etc.), as reported by Turkstat, data show that 98.6 per cent of households accessing the Internet made use of mobile broadband.[12] Over the years, fixed-broadband usage has increased considerably, to a total of around 3.3 million subscriptions relying on fibre technology (FTTH/FTTB) by the first quarter of 2020. In 2019, 93.3 per cent of enterprises used a fixed-broadband connection to access the Internet.[13]

According to recent data from BTK, Türk Telekom has the most extensive fibre infrastructure in the country, with a 308 000 km network, while the total length of other operators' fibre came to 89 000 km in 2020.[14] By comparison with the OECD average fixed-broadband penetration rate of 31.4 per cent of the population, Turkey has important growth potential with its 17.5 per cent penetration rate estimate for 2020;[15] ITU data for 2019 indicate 17.1 fixed-broadband subscriptions per 100 inhabitants.[16]

With regard to mobile, there are three MNOs operating in Turkey, with the following subscriber market shares: Türk Telekom – 28.4 per cent; Turkcell – 40.6 per cent; and Vodafone Turkey – 31 per cent.[17] According to the latest BTK data, in the first quarter of 2020, the number of active mobile-cellular subscriptions per 100 inhabitants stood at 98.4,[18] while official ITU data for the same indicator for 2019 report 96.8 per cent.[19] Moreover, according to ITU statistics, mobile-broadband subscriptions per 100 inhabitants stand at 74.8.[20] 4G LTE networks are well developed and cover some 98 per cent of the population in the country;[21] the official figure for 2019 was 96.7 per cent.[22] In 2019, mobile-broadband Internet traffic within the country amounted to 4.1 exabytes.[23] In 2020, BTK data show that the average monthly mobile data usage per active LTE subscriber in Turkey was 9.1 GB.

3.8.3 Current progress on 5G: Consultations and national strategies

In April 2016, BTK established the 'Turkish 5G Forum', also known as the 5GTR Forum – a baseline programme that brings together Turkey's prominent academics, research and development firms, vendors and operators to discuss 5G development in the country.[24] There are four working groups under the 5GTR Forum's organizational structure, on Core network, Physical network, Service and applications, and Standardization, established to make 5GTR Forum activities efficient and deliver results in a short time-frame.

5GTR Forum organizes different meetings, workshops and cooperation agreements with relevant platforms. In this context, the 'Automotive Sector on the Road to 5G' workshop was organized on 11 May 2017. This workshop, dedicated to one of the sectors that will use 5G technology most, aimed to review the trends, studies, plans and challenges relating to the

vision for the 5G automotive sector and to establish a common working platform between the electronic communication sector and the automotive sector.

Likewise, the 'Turkey-Japan Terahertz Communications Technology' workshop was held on 13 October 2017. The workshop, hosted by BTK, was organized in cooperation with the Japanese National Institute of Information and Communication Technology (NICT) and Medipol University, with the participation of many university and sector representatives. In addition, at the 4th Global 5G Event held in Seoul within the framework of international collaboration, two separate MoUs were signed on 23 November 2017 between the 5GTR Forum and the 5G Forum Korea and between the 5GTR Forum and Japan 5GMF, in order to develop the 5GTR Forum's external relations with counterpart institutions.

In June 2018, the signing ceremony for the 'End-to-End Domestic and National 5G Communication Network' project was held in Ankara, by the Ministry of Industry and Technology, the Ministry of Transport and Infrastructure and BTK. This project, which is supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK) has been carried out by 14 companies under the Cluster of Communication Technologies (HTK) and the three mobile operators. As a result of the project, critical infrastructure components for 5G will be produced locally and nationally, such as: 5G core network, 5G base station, 5G network and business management software.[25]

Since 2016, in addition to providing support for Turkish companies within the framework of the EU HORIZON 2020 programme, the members of the 5GTR Forum have had various meetings and, in 2018, prepared the '5G and Beyond White Book'.[26] This white paper on 5G discusses the possible and necessary work to be performed regarding the network and physical layers, and the services and applications that will run over these layers which form the core 5G network in Turkey.[27] It provides a perspective on the current situation in terms of 5G technologies and studies in other nations, and outlines predictions of 5G architecture and the potential technology building blocks for 5G requirements. In addition, BTK has published the '5G and Vertical Sectors Report', on the use of 5G and its effects on vertical sectors.

As part of the Turkish Government's plan to deploy an advanced telecom infrastructure serving millions of citizens, Turkish operators are moving ahead with more robust software and hardware development. The strategy also predicts that the 5G-related research and development will prioritize domestic production, which will likely increase supply and demand in parallel, and that operators will require incentives and obligations.[28]

An example of this is the 'End-to-End Domestic and National 5G Network' project, which was recently initiated by HTK with the support of BTK, OSTİM and TÜBİTAK. The project's goal focuses on the development of critical network hardware and software that are specific for 5G technology in order to improve Turkey's domestic and national 5G infrastructure. In July 2020, the project's executive board held a digital meeting with high-level government servants and more than 100 participants from public institutions and representing the private sector.

Furthermore, under Turkey's 2023 Goals, several 5G smart-city-related projects are being implemented across various cities. These smart-city projects aim to generate cost savings and provide the infrastructure necessary to fuel future tech developments.[29]

3.8.4 Spectrum assignment for 5G and market development

The GSM frequencies in the Turkish mobile market range from 800 MHz to 2 600 MHz, with Turkcell possessing the most extensive amount of spectrum overall.[30] In August 2015, BTK held an auction for 4G, which represented an important milestone for Turkey's transition to 5G.[31] Excluding value-added tax, the total auction fee for 365.4 MHz of spectrum across 18 packages in five separate frequency bands (800, 900, 1 800, 2 100 and 2 600 MHz bands) amounted to the equivalent of EUR 3.356 billion. Following the auction, the portion of spectrum allocated to mobile operators increased from a total of 184 MHz to 549 MHz.[32]

With regard to 5G, testing licences have been granted to operators for the 3.5, 3.7 and 26 GHz bands.[33] However, no 5G spectrum auctions are anticipated in Turkey in the foreseeable future.[34] The regulator has announced that when the current operators from the 2015 auction renew their infrastructure, 5G will automatically be used without the need for licensing a new service provider.[35]

In BTK's mind, given that operators need wider blocks of spectrum to implement 5G, public announcement of spectrum identified for mobile-broadband services, with release dates, allows operators to plan effectively. This information enables operators to save the cost of installing more base stations to cope with a lack of spectrum and the increase in data usages.

To this end, BTK has prepared a draft mobile-broadband spectrum strategy[36] to lay down the necessary roadmap for achieving the country's targets related to mobile-broadband services (such as increasing minimum downlink rates per user to EU levels, decreasing customers' fees for accessing these services, release of new technologies). Taking into account the assigned mobile spectrum and the level of mobile-service usage, a report on all spectrum identified for IMT services, with assignment dates, and the determination of necessary spectrum for sustainable growth of mobile services has been presented to the stakeholders.

In this draft strategy document, spectrum blocks are classified under three periods in terms of dates of assignment: short, medium and long term. According to the draft report, Turkey plans to assign mainly 694–790 MHz and the remaining spectrum in the 2 500–2 690 MHz, 3 400–3 800 MHz and 24.25–27.5 GHz frequency bands in the short term for IMT. Also, within the 700 MHz frequency band, the 698–703 MHz and 733–736 MHz bands (2 x 8 MHz) are foreseen for BB PPDR services.

In regard to 5G additional spectrum planning, the legal framework for granting right of use of spectrum is set by Electronic Communication Law No. 5809, which designates the Ministry of Transport and Infrastructure as strategy and policy decision-maker and charges BTK with developing strategy proposals. Within this framework, BTK will develop a strategy proposal for granting rights of use of 5G frequencies and present it to the Ministry of Transport and Infrastructure for final revisions. After approval of the document by the Ministry of Transport and Infrastructure, BTK will take the necessary actions to apply all the steps defined.

3.8.5 Electromagnetic field levels and implementation dynamics

In 1999, the Turkish Government held a symposium on 'Electromagnetic Pollution', and since then the country has been involved with EMF, producing studies on the biological effects of electromagnetic radiation and possible ways of providing guidance. While many different radiation frequencies are under consideration, most of the research activities have focused

on 50 MHz TV broadcasting frequencies, 900 MHz, 1 800 MHz, 2 100 MHz and 2 450 MHz. Information on the effects of electromagnetic radiation is frequently shared with the public by universities, the Chamber of Electrical and Electronics Engineers, the Chamber of Medical Physicists and the Technology Information Platform. Some groups also plan to address electromagnetic radiation together with the incidence of ultraviolet and infrared light.[37]

BTK has a special division on EMF, and follows the most recent guidelines released by the International Committee on Non-ionizing Radiation Protection (ICNRP). The Ministry of Transport and Infrastructure, in particular, has published regulations based on ICNIRP's standards and regulations. In 2011, it had drawn up regulations on 'Limiting, controlling and directing electromagnetic field intensity caused by electronic communication devices by taking the international limits',[38] which mandate four times stricter limits than those indicated by ICNIRP.[39] Then, with several revisions of this regulation, as of April 2018 the name was changed to 'Electronic Communication Devices Safety Certificate Regulation'. Based on the principle of precaution, the permitted limit values for cellular systems to protect the environment were set at 70 per cent of the limit values given by ICNIRP, thus maintaining the general practice of applying stricter limits than those indicated by ICNIRP.

Furthermore, the Ministry of Health is paying attention to raising public awareness of the health effects of electromagnetic fields. Non-governmental organizations (NGOs) like Temkoder, the Turkish Electrical and Electronics Chamber and the Chamber of Physicians are sensitive to the issue of health effects of EMFs. Working groups have been formed within these NGOs, which have organized public awareness meetings to inform society about the effects of EMFs on health. The Turkish Electrical and Electronics Engineering Society is organizing meetings on recent electrical, electronics and computer engineering issues, including the effects of EMFs.[40]

3.8.6 Commercial launches: Announcements, trial cities and digital cross-border corridors

Turkey is making great strides with its 5G evolution, and operators have conducted significant 5G trials and engaged in commercial negotiations. 5G is considered as an investment worth approximately TRY 253 million (approximately EUR 40 million)[41] in Turkey, and private stakeholders such as Türk Telekom, Turkcell and Vodafone Turkey are the major investors in the networks.

In 2016, Türk Telekom signed an MoU with Nokia to accelerate the development of 5G radio access network technology and the applications driving IoT and other sectors as diverse as healthcare, smart cities, etc.[42] In the same year, Vodafone Turkey reported that it was testing 10 Gbit/s 'E-band' point-to-point radio-link technology in densely populated urban areas, saying that the tests paved the way for 5G commercial launches using the 71–86 GHz range.[43] Since 2016, Turkcell has also established partnerships with Ericsson, Samsung and Huawei,[44] becoming the telecom operator exhibiting the greatest 5G-related expansion as at September 2020.

In 2017, Turkcell rolled out an NB-IoT network across Turkey. The operator announced that the technology could be used by industries such as energy and logistics as well as healthcare and education, allowing machines to communicate with each other via Turkcell's LTE-A infrastructure, extending possible smart-city applications.[45]

In February 2018, Turkcell and Samsung signed an MoU that resulted in Turkey's first 'live 5G trial' – a live trial of the technology organized in Istanbul in November 2018. The 5G experience zones featured ultra-high-definition live streaming, cloud gaming and 360-degree camera and virtual reality streaming using Samsung's 5G FWA solutions, combined with the operator's network infrastructure.[46]

In March 2018, during the Mobile World Congress, the Turkish Government signed a protocol to test the latest communication technologies with the Open Networking Foundation,[47] a non-profit operator-led consortium funded by Deutsche Telekom, Facebook, Google, Microsoft, Verizon and Yahoo. The consortium, in collaboration with the ministry, is working on Turkey's network infrastructure and carrier business models to help the country resolve its network coverage.[48] In July 2018, an MoU for the installation of test-network infrastructures was signed between the stakeholders of the 5G Valley Open Test Bed at the campuses of Middle East Technical University, Bilkent University, Hacettepe University and BTK.[49] The area between these three universities and BTK headquarters is a developing region with a dynamic population and various vertical sector components such as hospitals and shopping malls. In November 2018, BTK launched the country's first '5G Open Test Site' at the BKT Market Surveillance Laboratory located in Ankara's Hacettepe University.[50] Academics, researchers and start-ups can utilize the 5G Valley Open testbed for R&D tests for 5G and beyond technologies.[51] Tests were carried out on various issues such as 5.9 GHz C-V2X channel measurement, energy harvesting, 28 GHz intravehicular channel measurement, power amplifier modelling efficiency and linearization, V2X, MIMO and spectral efficiency in the 5G Valley.

BTK also established the '5G and Beyond Joint Graduate Programme' between universities and disciplines to contribute to cultivating the qualified human resources that Turkey will need in 5G and Beyond in the short, medium and long term. The programme aims to yield sustainable competence on advanced communication technologies and to produce outputs in a wide variety of forms, such as patents, projects, articles, spin-off companies and thesis studies. Currently, 38 students are employed in the operators while continuing their academic studies at the same time.

In January 2019, Turkcell succeeded in setting up Turkey's first end-to-end, 3GPP-compliant, multivendor 5G data call in the 2.5 GHz band in partnership with Ericsson. The call used Ericsson Radio System solutions and Ericsson Cloud Core and test devices from ecosystem partners over Turkcell's 5G test network. The tests in Istanbul used the 5G systems over Turkcell's existing Gigabit LTE (4.5G) network.[52]

In February 2019, BTK approved applications from the country's three MNOs Turkcell, Vodafone and Türk Telekom (TT Mobil, formerly Avea) to conduct 5G trials in different frequency bands in the three largest cities – Istanbul, Izmir and Ankara.[53] In August 2019, the local press reported that Turkcell had broken the world 5G speed record, attaining a speed of 2.283 Gbit/s on a 5G-enabled smartphone in the allocated 3.5 GHz frequency band using 1 000 MHz of bandwidth.[54]

In February 2020, Turkcell showcased Turkey's first 5G live TV broadcast with high quality and capacity combined with low latency, covering a soccer match at the Trabzonspor stadium. The broadcast also relied on a local software, which was used along with Turkcell's 5G test network.[55]

Co-financed by the European Commission within the framework of the Horizon 2020 programme, 5G-MOBIX is developing and testing automated vehicle functionalities using 5G

core technological innovations along multiple cross-border corridors and urban trial sites.[56] The project envisions a Greek-Turkish cross-border trial corridor as one of the eight trial sites having a strategic geopolitical environment.[57]

With the participation of the two largest MNOs in Greece and Turkey and the guaranteed cell-edge conditions to be created at the border, 5G-MOBIX will also offer a unique opportunity to address 5G cross-border deployment issues when driving across a hard border where trucks have to stop and are subject to human control. It will also provide important insights into the coverage and performance limits that can be expected with 5G technology and the level of support provided for CCAM (Connected, Cooperative and Automated Mobility) use cases.[58]

In March 2020, the Ministry of Transport and Infrastructure announced that it is preparing to launch 5G services at Istanbul airport through its 5G indoor network.[59]

Endnotes

1 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

2 See: https://www.invest.gov.tr/en/sectors/pages/ict.aspx

3 See: http://www.bilgitoplumu.gov.tr/en/wp-content/uploads/2016/03/Information_Society_Strategy_and_Action_Plan_2015-2018.pdf

4 See: https://www.satellitetoday.com/innovation/2020/06/18/space-ambitions-turkey-prepares-to-compete-and-capture/

5 See: https://www.brodynt.com/business-internet-connectivity-in-turkey/

6 See: http://www.turkstat.gov.tr/PreTablo.do?alt_id=1048

7 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

8 Ibid.

9 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

10 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

11 Ibid.

12 See: http://www.turkstat.gov.tr/PreHaberBultenleri.do?id=30574

13 See: http://www.turkstat.gov.tr/PreTablo.do?alt_id=1048

14 See: http://www.ttyatirimciiliskileri.com.tr/Documents/en/ICTA-Q1-2020-Market-Data.xlsx

15 See: http://www.ttyatirimciiliskileri.com.tr/en-us/turk-telekom-group/investing-in-turk-telekom/pages/turkish-telecom-sector.aspx#:~:text=Total%20broadband%20subscribers%20exceeded%2077.4,subscribers%20increased%20to%2014.6%20million

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

17 See: http://www.ttyatirimciiliskileri.com.tr/Documents/en/ICTA-Q1-2020-Market-Data.xlsx

18 See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Mobile_cellular_2000-2018_Dec2019.xls

19 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

20 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

21 Data submitted to BTK by cellular-mobile network operators. It will be incorporated into the ITU World Telecommunication/ICT Indicators Database online (http://handle.itu.int/11.1002/pub/81550f97-en)

[22] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271GA").

[23] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[24] See: https://www.itu.int/en/ITU-D/Conferences/GSR/2019/Documents/Turkey_Contribution-GSR-19.pdf

[25] See: https://www.mondaq.com/broadcasting-film-tv-radio/901520/5g-spectrum-auctionsi-in-kinstellar-jurisdictions

[26] See: https://www.uab.gov.tr/haberler/bakan-turhan-dan-5g-cagrisi [in Turkish].

[27] See: https://www.btk.gov.tr/uploads/announcements/5g-ve-otesi-beyaz-kitap/beyaz-kitap-son.pdf [in Turkish].

[28] See: https://www.uab.gov.tr/haberler/her-yerden-herkese-genis-bant [in Turkish].

[29] See: Presentation delivered on 26 November 2018. Please contact 4yfn for more information: https://www.4yfn.com/

[30] See: https://www.export.gov/apex/article2?id=Turkey-Information-and-Communications-Technology

[31] See: https://www.itu.int/web/pp-18/uploads/turkey-council-brochure.pdf

[32] See: http://www.ttyatirimciiliskileri.com.tr/en-us/turk-telekom-group/investing-in-turk-telekom/pages/turkish-telecom-sector.aspx#:~:text=Total%20broadband%20subscribers%20exceeded%2077.4,subscribers%20increased%20to%2014.6%20million

[33] See: https://www.trthaber.com/haber/turkiye/5g-denemeleri-basliyor-404503.html [in Turkish]

[34] See: https://www.btk.gov.tr/uploads/announcements/5g-ve-otesi-beyaz-kitap/5gtr-beyazkitap.pdf [in Turkish]

[35] See: https://www.mondaq.com/broadcasting-film-tv-radio/901520/5g-spectrum-auctionsi-in-kinstellar-jurisdictions-

[36] The draft strategy has been submitted for stakeholder consultation and is not yet publicly available. For more information, contact BTK.

[37] See: https://www.who.int/peh-emf/project/mapnatreps/TURKEY_2014.pdf?ua=1

[38] Ibid.

[39] Ibid.

[40] Ibid.

[41] Exchange rate as at September 2020.

[42] See: https://www.nokia.com/about-us/news/releases/2016/04/15/nokia-and-turk-telekom-collaborate-to-advance-development-of-5g-and-internet-of-things-technologies/

[43] See: https://5g-ppp.eu/5g-trials-2/#1512735201378-378a772f-b5c0

[44] See: https://www.globenewswire.com/news-release/2020/06/22/2051453/0/en/5G-and-fibre-infrastructure-important-to-the-future-in-Turkey.html

[45] See: https://www.smartcitiesworld.net/news/news/turkey-opens-the-door-to-5g-2040

[46] See: https://www.rcrwireless.com/20181109/5g/turkcell-samsung-electronics-carry-out-live-5g-trial-turkey

[47] See: https://www.uab.gov.tr/haberler/yeni-nesil-iletisim-teknolojileri-dunyada-ilk-turkiye-de-test-edilecek [in Turkish].

[48] See: https://internationalfinance.com/5g-network-vision-turkey-is-at-a-turning-point/

[49] See: https://www.itu.int/en/ITU-D/Conferences/GSR/2019/Documents/Turkey_Contribution-GSR-19.pdf

[50] See: https://www.aa.com.tr/tr/bilim-teknoloji/5g-vadisi-acik-test-sahasi-acildi/1305986 [in Turkish]

[51] See: Presentation delivered on 26 November 2018. Please contact 4yfn for more information: https://www.4yfn.com/

[52] See: https://www.ericsson.com/en/news/1/20192/turkcell-and-ericsson-achieve-turkeys-first-standard-compliant-5g-call

[53] See: https://www.commsupdate.com/articles/2019/02/12/regulator-permits-5g-trials-in-ankara-istanbul-izmir/

[54] See: https://www.aa.com.tr/en/science-technology/turkeys-turkcell-breaks-world-5g-network-speed-record/1551008

[55] See: https://www.businesswire.com/news/home/20200204005639/en/

[56] See: https://www.5g-mobix.com/about

[57] See: https://ec.europa.eu/digital-single-market/en/cross-border-corridors-connected-and-automated-mobility-cam

[58] See: https://www.5g-mobix.com/x-border-trials/greece-turkey

[59] See: https://sigmatelecom.com/5g-mobile-internet-will-be-launched-in-istanbul-airport/

3.9 Ukraine

3.9.1 ICT background and current status of broadband

Ukraine has designated the ICT sector as a policy priority and implemented several ICT programmes on education and public health.[1] With 4G being implemented in 2018, the government is rapidly improving network coverage while promoting e-services in the public and private sectors,[2] and recently signed a memorandum with operators to provide 4G coverage for 90 per cent of Ukraine's territory by 2022.[3] Some of the main challenges in the ICT sector include updating the legislative framework for electronic communications and creating an accurate up-to-date interactive map of broadband coverage of the territory.[4]

In January 2018, the government and the State Agency for E-Governance of Ukraine published the new 'Digital Agenda for Ukraine 2020',[5] which aims to guide the country's digital development. The agenda has seven main pillars: i) Telecommunication and ICT infrastructure; ii) Digital skills; III) E-market; iv) Digital governance; v) Innovation and R&D; vi) Trust and cybersecurity; vii) Benefits from ICT for society and the economy.[6]

To enact implementation of this Digital Agenda and to remove barriers to sustainable digital transformation in the country, by Ordinance No. 67-p in 2018 the Cabinet of Ministers of Ukraine approved the 'Concept for developing the digital economy and society in Ukraine for 2018-2020' and adopted the 'Action Plan implementing the Concept'.[7]

The implementation of measures under the concept should pursue the following objectives:[8]

- Stimulating the country's economy and attracting investment.
- Creating the basis for the transformation of domestic industries towards increased competition and efficiency through digitalization.
- Solving the domestic problem of the digital divide, thus bringing digital technologies closer to citizens and providing them with access to broadband Internet, especially in villages and small towns.
- Creating new opportunities for the realization of human capital and the development of innovative, creative and digital industries and businesses.
- Developing more exports of digital products and services – IT outsourcing.

The document also establishes the priority sectors and suggestions for digital development in Ukraine, with a particular focus on bridging the digital divide through the development of digital infrastructures; developing digital competencies; implementing the concept of digital workplaces; digitalizing the country's economic systems; implementing digital transformation projects; supporting public security, education, healthcare, tourism, e-democracy, ecology and environmental protection and life of cities; e-payments; and harmonization with European and world initiatives as well as governance.

The accelerated digital development scenario envisages the following actions to facilitate pursuit of the above-mentioned objectives and priorities:[9]

- Removal of legislative, institutional, fiscal and other barriers to the development of the digital economy.
- Introduction of incentives and motivations to encourage business and industry in general to digitalize.

- Creation of demand and formation of needs among citizens for digitalization, by the State initiating large-scale digital transformation projects , based on modern models of public-private partnership.
- Creation and development of digital infrastructures as a basis for exploiting the advantages of the digital world in everyday life and a platform for achieving economic efficiency in general.
- Development and deepening of citizens' digital competencies to ensure they are ready to take advantage of digital opportunities, as well as to overcome the associated risks.
- Development of digital entrepreneurship coupled with the creation of appropriate (including analogue) infrastructures to support and develop innovation, as well as the introduction of funding mechanisms, incentives, and support.

In coordination with the ministries and in line with international practices, the Action Plan identifies the requisite indicators and methods for assessing digital development. Ukraine's implementation plan has also been supported by private stakeholders. Increasingly, the government is offering incentives and motivations for the private sector to foster business and empower citizens to consume and use information, communication and digital technologies.[10]

With specific reference to broadband development in Ukraine, and in the context of the plan's focus towards a national hard digital infrastructure, the 'Concept for developing the digital economy and society in Ukraine for 2018-2020' calls for a national broadband plan that contains appropriate indicators of i) Internet access coverage in the country; ii) Specifications on the technical requirements for broadband Internet access services; and ii) Models for using the existing physical infrastructures (highways and railways, gas pipelines, power lines) for the development of telecommunication networks.

In this regard, the document argues that particular attention should be paid to broadband Internet access in rural areas.[11] In April 2020, Iskratel, PJSC Ukrtelecom and SID Bank signed an agreement to build a fibre-optic Internet network (GPON) to connect the rural areas of Ukraine under a two-year network construction project. This project has received total investment of almost UAH 200 million (around EUR 6.1 million).[12] The project will include the manufacture of more than 2 000 km of fibre-optic cables and the installation of modern certified telecommunication equipment.[13] Other initiatives concerning rural areas and Internet connectivity are currently under way under the auspices of the Ministry of Education and Science, the Ministry of Digital Transformation and the Ministry of Finance,[14] as well as the Ministry of Culture and Information Policy, which recently collaborated with the World Bank on the fixed-broadband market and connectivity maps.[15]

3.9.2 Broadband and mobile telecommunication data

ITU data show that 62.55 per cent of individuals in Ukraine used the Internet in 2018,[16] the majority being in urban areas. In 2010, the corresponding ITU figure for the country was 23.3 per cent, and 0.7 per cent in 2000.[17] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 16.2,[18] whereby DSL remains the most used technology platform while fibre continues to grow as a result of the operators' efforts to build networks based on FTTP.[19] Whereas most cities have access to fibre-optic networks operated by several private stakeholders, the urban-rural gap in terms of Internet coverage is significant in Ukraine, given that the country has more than 17 000 settlements not covered by this technology.[20] The government recently announced that about 65 per cent of Ukrainian villages are not covered by high-quality broadband, which corresponds to about 5.75 million citizens;[21] according to

ITU data, 61.9 per cent of households had Internet access at home in 2018.[22] For rural areas that are not covered by optical fibre, the cost of connection exceeds the average market cost by about 150 per cent. From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita (3.7 per cent for the CIS region) in 2019, while Ukraine's stood at 1.8 per cent for an unlimited Internet data allowance.[23] Continued growth in community wireless platforms based on Wi-Fi and WiMAX technologies is expected to attract investment and shape the average price for Internet connectivity.[24]

In 2019, the proportion of mobile-cellular subscriptions per 100 inhabitants stood at 130.6.[25] In 2018, the number of active mobile-broadband subscriptions per 100 inhabitants was 47.7.[26] There are three major MNOs that dominate the market in Ukraine: Vodafone Ukraine (formerly MTS), Kyivstar (VEON) and Lifecell (Turkcell). The country's mobile-data basket cost came to 1.2 per cent of GNI per capita in 2019 for a monthly allowance of almost 2 GB. The average 1.5 GB mobile-data basket price in the Europe region was 0.8 per cent (2.2 per cent in the CIS region) for the same year.[27] Over the past years, significant investment has been made in extending 3G infrastructure, while operators have more recently concentrated on LTE. Kyivstar, Ukraine's largest operator, announced that 3G coverage reached nearly 80 per cent in 2018, although a large portion of the territory still lacks 4G/LTE coverage.[28] With the recent expansion of LTE in Ukraine, it is expected that the majority of the country's territory will be covered in the coming years.[29]

Additionally, data from ITU show that in 2019, 78.1 per cent of the population in Ukraine enjoyed 4G/LTE coverage, while 3G population coverage corresponded to 89.1 per cent.[30] In August 2020, the government announced that 4G is now available in nearly half of the underground stations of the Kyiv metro, as a result of a partnership between the country's MNOs and Huawei.[31]

3.9.3 Current progress on 5G: Consultations and national strategies

In May 2019, on World Radio Day, the Ukrainian President signed a decree to roll out 5G network in the country,[32] following a similar government approach to that adopted in the past for the launch of 3G and 4G.[33] While the decree sets a timetable which states that 5G will be launched in 2020, it provides no details regarding conversion of frequencies or freeing up new frequencies for the new networks.

The decree was sent to the regulator, the National Commission for the State Regulation of Communications and Informatization (NCCIR), by the State Service for Special Communication and Information Protection of Ukraine, on 25 October 2019.[34] Pursuant to this decree, the government and NCCIR must articulate and adopt a step-by-step plan for 5G implementation, submitting relevant information to the Cabinet of Ministers for confirmation before setting up a frequency allocation auction for the operators.

In March 2020, in Kyiv, Ukraine held the third of a series of consultations to discuss cybersecurity policy, national cybercapacity building, international cybersecurity policy issues and security issues for future 5G networks.[35]

3.9.4 Spectrum assignment for 5G and market development

Ukraine has been successful in harmonizing the 1 800 MHz, 2 100 MHz and 2 600 MHz bands by introducing technology-neutral principles for operators in the Ukrainian market.[36] In January 2018, the Ukrainian regulator provided operators with additional spectrum in the 2 600MHz

band, and with spectrum in the 1 800MHz band the following July, issuing 15-year licences.[37] In November 2019, NCCIR issued Decision No. 529 confirming that it will allocate countrywide 5G-suitable wireless spectrum in the 3 400 MHz-3 600 MHz range on a competitive or tender basis in accordance with the 'Law on Radio-Frequency Resource of Ukraine 2000' of 2000[38] and other regulations.[39]

Given that 4G auctions were conducted in 2018, some private stakeholders recently expressed their unwillingness to invest in new technologies for the moment. Even though some 5G-related commercial progress has occurred,[40] part of the telecommunication sector in Ukraine is currently focused on the development of 4G and the expansion of Internet services in rural areas.[41]

In January 2020, Kyivstar, Lifecell and Vodafone Ukraine submitted a joint statement on redistribution of the 900 MHz band and separate applications for licence renewal to NCCIR.[42] Previously, the 900 MHz band was fragmented, and a large proportion of it was concentrated with one of the telecommunication operators, preventing the provision of next-generation 4G services across Ukraine.[43] Currently, these MNOs are deploying 900 MHz LTE services to expand their existing LTE-1800/2600 networks in rural areas, after their LTE-900 licences became valid at the start of July 2020.[44] As a result, in March 2020 NCCIR provided a technology-neutral licence to Kyivstar, Lifecell and Vodafone Ukraine, allowing them to begin offering 4G LTE-900 services starting on 1 July 2020.[45] Under the terms of the licences, the operators must extend LTE-900 services to all areas of the country with a population of over 2 000 people over the next two years.[46]

As at August 2020, no announcement had been made regarding the tendering process for 5G spectrum assignment in Ukraine. Government representatives also stated that it is necessary to provide a regulatory apparatus for technology neutrality for mobile communications, and that release of the first (790–862 MHz) and second (694–790 MHz) digital dividends was one of its priorities for 2020.[47]

3.9.5 Electromagnetic field levels and implementation dynamics

To foster the development of current 4G networks and advance the potential of 5G-enabled services and applications, the Cabinet of Ministers of Ukraine instructed the Ministry of Health to raise the maximum permissible level of electromagnetic radiation for high (30–300 MHz), ultra-high (300-3000 MHz) and very high (30–300 GHz) frequency bands by a factor of 10 – from 10 μW/cm^2 to 100 μW/cm^{2}In 2017, a similar change had been made[48] in relation to the original legislation on EMF from 1996,[49] which had already increased the permissible level from 2.5 to 10 μW/cm^2.[50]

In response to public pressure concerning alleged health hazards from the introduction of 5G in Ukraine,[51] an order issued by the President of Ukraine in July 2020 requested NCCIR to propose a number of measures to resolve the issue and provide the public with the appropriate information on the impact of mobile technologies and networks. In August 2020, NCCIR announced its action plan[52] to fulfil the President's request. Some of the actions include, *inter alia*, the provision of protocols for the measurement of EMFs by operators; public consultations with suppliers of radio equipment; and creation of a new section devoted to the impact of mobile technologies (4G, 5G) on human health on the NCCIR website.[53]

Furthermore, NCCIR intends to involve the Ministry of Digital Transformation, the Ministry of Health, the Administration of the State Service for Special Communications and Information

Protection of Ukraine and other bodies in taking action on a number of EMF-related challenges and issues, such as:[54]

- The need to adopt national standards that are necessary to assess the impact of EMF from cellular base stations on humans.
- The introduction of a warning sign to signal the presence of a source of non-ionizing radiation and the relevant danger level for humans.
- The need for additional medical research on the effects on humans of non-ionizing radiation from 5G stations in the mmWave range or scientific recognition of such research conducted outside Ukraine, including their implementation in the legislation of Ukraine.
- The need to develop and approve the procedure for the relevant bodies in the Ukrainian Ministry of Health's system to measure compliance with EMF levels at the request of citizens.
- Carrying out regular measurements within the Ministry of Health's system to monitor EMF levels during the deployment of 5G networks.
- Placing social advertising or information on the impact of mobile radio technologies on human health within the context of 5G.

Private stakeholders in Ukraine are also engaging with questions pertaining to EMF. In August 2020, representatives from Huawei Ukraine[55] and ZTE[56] presented solutions on EMFs from 5G base stations and on 5G Ma-MIMO EMF[57] to NCCIR.

3.9.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In May 2019, Vodafone Ukraine announced it was ready to launch 5G tests.[58] In the same month, the operator Lifecell – part of the Turkcell Group – tested 5G mobile technology in the 28 GHz frequency range in the city of Kyiv in partnership with Ericsson.[59] Through Ma-MIMO, a peak download speed of 25.6 Gbit/s was reached in the ultra-high frequency range of 28 GHz.[60]

As part of the 2019 Swedish-Ukrainian Business Forum, Lifecell also showcased a demonstration of 5G network and applications, including remote robotics for surgery, immersive real-time conferencing and virtual reality (VR) multiplayer interactive games. Private stakeholders organizing the event outlined six main regulatory and economic factors that would make 5G roll-out a success in Ukraine: i) Transparency on the State's plans for 5G development; ii) Comprehensive frequency spectrum allocation and licensing strategy; iii) Consumer and market readiness that includes accessible devices; iv) Economic demand and developed infrastructure; v) Having mobile networks, hardware and software ready for operation; and vi) Developing the necessary partnerships and ecosystem (devices and app developers, for example) to take the offers to prospective customers.[61]

In April 2019, Ukraine's Ministry of Infrastructure launched a pilot project relating to IoT on roads in partnership with Vodafone, Nokia Solutions and Networks Ukraine to create a virtual network to tackle issues related to road safety and traffic-flow analysis. The project is divided into three phases: testing, scaling and full implementation.[62] The long-term goal is to launch a full-scale project which will provide coverage of all highways of international importance with modern technologies.[63]

Between December 2019 and May 2020, Ericsson and the operator Lifecell conducted 5G tests using the 3.5 GHz band in seven of the operator's points of sale in six Ukrainian cities: Kyiv, Dnipro, Kharkiv, Lviv, Odessa and Cherksay.[64]

In February 2020, the Ministry of Digital Transformation of Ukraine and Swedish company Ericsson signed a memorandum of cooperation (MoC) in the development of fixed and mobile 4G LTE-A and 5G networks.[65] The ministry noted that a joint working group is being organized to work on technical expertise in mobile and fixed internet development.[66] The working group will also provide advisory and information support to the ministry on the evolution of mobile communications, frequency strategy and licensing policies.[67]

In April 2020, Vodafone Ukraine completed testing of AirScale equipment from Nokia on its LTE network in Kyiv. The 5G-ready equipment was tested in the 1 800 MHz and 2 600 MHz bands, achieving connectivity speeds as fast as 525 Mbit/s.[68]

In July 2020, Vodafone Ukraine and Kyivstar signed a memorandum of intent (MoI) on network sharing for exchange of the 900 MHz spectrum in eight Ukrainian regions.[69] The agreement covers both passive and active infrastructure on operators' mobile networks and should result in an acceleration of LTE technology coverage of Ukraine, reaching the country's rural areas and highways.[70] The operators plan to start practical implementation of the MoI in November-December 2020 after approval of the project by government agencies.

Endnotes

1 See: https://joinup.ec.europa.eu/sites/default/files/inline-files/SC64_D05.01_Digital_Government_Factsheets_Ukraine_vFINAL2_0.pdf

2 See: https://eufordigital.eu/countries/ukraine/

3 See: https://www.kmu.gov.ua/news/uryad-pidpisav-memorandum-shcho-zabezpechit-pokrittya-4g-na-90-teritoriyi-ukrayini [in Ukrainian].

4 See: https://eufordigital.eu/broadband-access-is-key-to-digital-transformation-of-ukraine/

5 See: https://issuu.com/mineconomdev/docs/digital_agenda_ukraine-v2__1_ [in Ukrainian].

6 See: http://www.e-ukraine.org.ua/media/Lviv_Minich_2.pdf

7 See: https://mtu.gov.ua/en/news/29453.html

8 See: https://www.kmu.gov.ua/npas/pro-shvalennya-koncepciyi-rozvitku-cifrovoyi-ekonomiki-ta-suspilstva-ukrayini-na-20182020-roki-ta-zatverdzhennya-planu-zahodiv-shodo-yiyi-realizaciyi

9 See: https://zakon.rada.gov.ua/laws/show/67-2018-%D1%80#Text [in Ukrainian].

10 Ibid.

11 Ibid.

12 Exchange rate as of September 2020.

13 See: https://www.fibre-systems.com/news/rural-ukraine-benefit-new-fibre-network

14 See: https://thedigital.gov.ua/news/podililisya-planami-rozvitku-optichnogo-internetu [in Ukrainian].

15 See: https://thedigital.gov.ua/news/mintsifra-ta-svitoviy-bank-rozpochinayut-spivpratsyu-zi-svitovim-bankom [in Ukrainian].

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

17 Ibid.

18 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

19 See: https://www.reportlinker.com/p05355157/Ukraine-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses.html?utm_source=PRN

20 See: https://documents1.worldbank.org/curated/en/896591621848142525/pdf/A-National-Broadband-Development-Strategy-and-Implementation-Plan-Recommendations-to-the-Ministry-of-Digital-Transformation-Government-of-Ukraine.pdf

21 See: https://thedigital.gov.ua/news/17-tisyach-naselenikh-punktiv-ne-mayut-zhodnogo-optichnogo-provaydera-doslidzhennya-mintsifri [in Ukrainian].

[22] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

[23] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[24] See: https://www.reportlinker.com/p05355157/Ukraine-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses.html?utm_source=PRN

[25] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[26] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

[27] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[28] See: https://www.epravda.com.ua/publications/2018/03/15/634981/ [in Ukrainian].

[29] See: https://www.president.gov.ua/en/news/zhittya-dedali-bilshe-perehodit-v-onlajn-krayinu-treba-zyedn-61061

[30] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

[31] See: https://thedigital.gov.ua/news/shche-7-stantsiy-kiivskogo-metro-pidklyucheni-do-4g [in Ukrainian].

[32] See: https://www.president.gov.ua/documents/2422019-26881 [in Ukrainian].

[33] See: https://www.cms-lawnow.com/ealerts/2019/05/ukraine-to-launch-5g-in-2020

[34] See: https://www.commsupdate.com/articles/2019/11/14/nccir-issues-decisions-on-3-4ghz-3-6ghz-licensing-2020-5g-plan/

[35] See: https://mfa.gov.ua/news/v-mzs-ukrayini-vidbuvsya-tretij-raund-mizhvidomchih-ukrayinsko-amerikanskih-konsultacij-u-sferi-zabezpechennya-kiberbezpeki [in Ukrainian].

[36] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Publications/0719_ITU%20Outcome%20Report%20Ukraine_finalweb.pdf

[37] See: https://www.businesswire.com/news/home/20190617005826/en/Ukraine-Mobile-Infrastructure-Broadband-Operators-Statistics-Analyses

[38] See: https://cis-legislation.com/document.fwx?rgn=11669

[39] See: https://nkrzi.gov.ua/index.php?r=site/index&pg=422&id=8842&language=uk [in Ukrainian].

[40] See: https://www.kinstellar.com/locations/news-deals-insights/detail/kyiv-ukraine/982/5g-spectrum-auctions-in-kinstellar-jurisdictions

[41] See: https://ucap.io/shkoda-vid-5g-shho-varto-znaty-pro-tehnologiyu-shho-zminyt-globalnyj-rynok/ [in Ukrainian].

[42] See: https://eufordigital.eu/implementation-of-lte-900-high-speed-mobile-internet-on-track-with-joint-statement-by-largest-operators-in-ukraine/

[43] See: https://en.brdo.com.ua/news/the-implementation-of-lte-900-high-speed-internet-is-at-the-track-thanks-to-a-joint-statement-of-the-largest-operators-of-ukraine/

[44] See: https://www.commsupdate.com/articles/2020/08/07/lifecell-joins-kyivstar-vodafone-in-4g-sharing-pact-intertelecom-4g-ambitions-stalled/

[45] See: https://www.commsupdate.com/articles/2020/03/20/kyivstar-lifecell-vodafone-ukraine-receive-lte-900-licences-intertelecom-gets-extension-to-pay-licence-fee/

[46] See: https://www.kmu.gov.ua/en/news/uryad-pidpisav-memorandum-shcho-zabezpechit-pokrittya-4g-na-90-teritoriyi-ukrayini

[47] See: https://ubr.ua/ukraine-and-world/technology/zamhlavy-mintsifry-rasskazal-o-planakh-vseobshchej-internetizatsii-ukrainy-do-2022-hoda-3888361 [in Ukrainian].

[48] See: https://zakon.rada.gov.ua/laws/show/z0488-96#Text [in Ukrainian].

[49] Ibid.

[50] See: https://112.international/society/ukraine-to-increase-permitted-level-of-electromagnetic-radiation-ten-times-what-does-this-mean-53426.html

[51] See: https://petition.president.gov.ua/petition/92038 [in Ukrainian].

[52] See: https://nkrzi.gov.ua/index.php?r=site/index&pg=444&id=9258&language=uk [in Ukrainian].

[53] See: https://nkrzi.gov.ua/images/upload/608/9258/Dodatok_304_04082020.doc [in Ukrainian].

[54] See: https://nkrzi.gov.ua/index.php?r=site/index&pg=99&id=1956&language=uk [in Ukrainian].

[55] See: https://www.youtube.com/watch?v=zozJol6QcHQ [in Ukrainian].

[56] See: https://www.youtube.com/watch?v=98C-Aa8K6ul [in Ukrainian].

[57] See: https://nkrzi.gov.ua/index.php?r=site/index&pg=460&language=uk [in Ukrainian].

[58] See: https://www.kyivpost.com/technology/vodafone-ukraine-confirms-plans-to-launch-5g-communication-tests-in-h2-2019.html

[59] See: https://www.telecompaper.com/news/lifecell-ericsson-test-5g-in-kiev--1294300

[60] See: https://internetua.com/v-shesti-gorodah-ukrainy-protestiruuat-5g [in Ukrainian].

[61] See: https://www.lifecell.ua/uploads/filelibrary/public/press_releases/EN_Press_release_5G%20Demo_Test_%20Ericsson_%20lifecell.pdf

[62] See: https://aiconference.com.ua/en/news/svyaz-5g-na-dorogah-i-umnie-viveski-dlya-gorodov-o-glavnih-sobitiyah-v-sfere-iskusstvennogo-intellekta-97933

[63] See: https://www.unian.ua/economics/telecom/10522014-v-ukrajini-testuvatimut-5g-dlya-rozumnih-dorig.html [in Ukrainian].

[64] See: http://arab.com.ua/en/in-six-cities-of-ukraine-will-test-5g-connection

[65] See: https://lb.ua/economics/2020/02/26/451014_mintsifri_ericsson_podpisali.html [in Ukrainian].

[66] See: https://thedigital.gov.ua/news/mintsifra-ta-ericsson-spivpratsyuvatimut-zadlya-rozvitku-merezh-novogo-pokolinnya-4g-lte-advanced-ta-5g [in Ukrainian].

[67] Ibid.

[68] See: https://itc.ua/news/vodafone-ukraina-protestiroval-oborudovanie-nokia-airscale-v-4g-seti-kieva-na-chastotah-1800-i-2600-mgcz-dostignuv-skorosti-mobilnogo-interneta-525-mbit-sek/ [in Ukrainian].

[69] See: https://www.developingtelecoms.com/telecom-technology/wireless-networks/9684-ukrainian-operators-begin-joint-lte-900-expansions.html

[70] See: https://www.insidetelecom.com/kyivstar-and-vodafone-ukraine-partnership-offering-4g-networks-to-rural-areas/

3.10 State of Israel

3.10.1 ICT background and current status of broadband

Israel has one of the highest gross domestic expenditures on high-technology research and development, and is often referred to as a 'start-up' nation characterized by its vibrant ICT sector.[1] Through many policies and initiatives since the 1990s, the Israeli Government laid the foundations for private industry to support innovation and made heavy investments in building strong human capital.[2] Israel also has a robust telecom market with a significant number of operators,[3] providing high household broadband penetration and covering almost the entire territory with 3G and 4G networks.[4] By 2017, Israel's ICT sector represented about 7.2 per cent of its GDP and 20 per cent of its exports of goods and services.[5] Despite the steady growth in the ICT sector, the fall in profits and revenue suffered by the country's largest operators over the past years remains one of the most pressing challenges as the private sector prepares to invest in new telecommunication infrastructure.[6] ICT development in Israel is guided by the National Digital Programme (2017–2022), which outlines the following three primary goals and areas of focus:[7]

Reducing socio-economic gaps:

- Bring the geographic and social periphery closer by improving digital literacy among weakened populations, providing access to quality public goods and services by digital means, and creating jobs and developing business in the geographic and social periphery.
- Reduce the cost of living by advancing the digitalization processes in the housing and real-estate areas, developing the financial area in the digital age, promoting the transition to digital products that produce economic savings, and foster informed consumption by digital means.
- Promote legal literacy by increasing access to information about rights through digital means and streamlining rights realization processes through digital means.

Accelerating economic growth:

- Promote digital industries and businesses by developing digital-based industries, turning business into digital business, increasing digital presence and encouraging the use of e-commerce platforms.
- Develop the employment market in the digital age by adapting digital skills in the education system, academia and the labour force to the modern employment market, increasing the use of online occupational training, expanding employment options in the digital age by removing distance barriers, and qualifying professional workers in digital and ICT fields.
- Support infrastructure development by developing physical infrastructures and promoting an enabling digital activity ecosystem.

Creating a smart and friendly government:

- Enhance the accessibility of State and local government by improving government services to citizens and reducing bureaucracy, digitalizing local government, advancing 'smart cities', promoting open government, and increasing ease of doing business.
- Promote innovative and effective government by increasing digitalization in internal government work, promoting information-based policy and cross-governmental sharing, developing the digital competencies of human capital in government, and expanding innovation and entrepreneurship in government.
- Improve public goods by focusing on the improvement of education, health, social welfare and other additional goods by digital means.

As the Israeli Government seeks to bridge the digital divide between urban and rural areas, the Ministry of Communications (MoC) notes that a wide geographical competition approach is the best way to improve network coverage by domestic operators, including the quality of the service offered, price performance, overall penetration, as well as further commercial competition with other private stakeholders.[8]

While other nations in the Europe region are operating fibre-optic networks, Israel relies on infrastructure rolled out before 2010, which has implications in terms of data-traffic capacity, as more users engage with ICTs and as users require increasingly high data rates. Buffeted by the COVID-19 pandemic, telecommunication operators in the country are hard-pressed to invest significant resources in infrastructure upgrades. Accordingly, the government has raised concerns over the need to upgrade the domestic telecommunication infrastructure to cater for the broadband needs of the Israeli population. The MoC is currently working to approve operators to make fibre available across Israel's territory, especially in remote areas.[9]

3.10.2 Broadband and mobile telecommunication data

ITU data show that 86.79 per cent of individuals in Israel used the Internet in 2019.[10] In 2010, the corresponding ITU figure for the country was 67.5 per cent, and 20.9 per cent in 2000. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 29.1[11] with an average fixed-network access speed of 99.7 Mbit/s.[12]

According to ITU data for 2019, the estimated proportion of households with Internet access at home stood at 75.9 per cent.[13] In terms of technology, DSL represents the largest market share of broadband subscriptions, while the fibre network is being deployed under the auspices of the Israel Broadband Company (IBC).[14] As at June 2019, FTTP/FTTH/FTTB subscribers in Israel represented 2 per cent of all broadband network connections.[15] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019, while Israel's came to 0.8 per cent for an unlimited Internet data allowance.[16]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was 126.8,[17] while the number of mobile-broadband subscriptions per 100 inhabitants stood at 115.[18] After a merger between Cellcom and Golan Telecom in 2020 approved by the Israeli regulators, there are now five MNOs – Cellcom, Partner, Pelephone, Partner HOT Mobile and Marathon 018 – that currently hold licences for use of the radio-frequency spectrum.[19] Given the highly competitive nature of the Israeli mobile market, with five MNOs (formerly six), the average revenue per user has dropped in 2018 for all major operators.[20] Falling revenues are largely attributed to increasing tariff competition between firms, and consumers switching providers at almost unprecedented levels.[21] The country's mobile-data basket cost represented 0.3 per cent of GNI per capita in 2019 for a monthly allowance of 30 GB, as against the Europe region average of 0.8 per cent for the same year.[22] This puts the 3G and 4G services among the cheapest in the Europe region, and with coverage of nearly the entire territory:[23] 94 per cent of the population covered by 4G/LTE services and 99 per cent covered by 3G.[24]

3.10.3 Current progress on 5G: Consultations and national strategies

The Government of Israel started consultations on 5G as early as 2018, focusing initially on expanding the deployment of cellular communication infrastructure in order to commence robust deployment of 5G.[25]

In July 2019, the government issued a tender for the development of 5G networks, with expected launch and development to occur in the time-frame 2020-2023.[26] The 5G tender was conducted in three main stages and considered the following frequencies: 700 MHz, 2 600 MHz and 3 500-3 800 MHz.[27] The 2 600 MHz frequency range is meant to initially provide services for 4G and ultimately 5G once the transfer is complete, whereas the 3 500 MHz range is assigned entirely for 5G usage.[28] Accordingly, the 5G tender outlined the following frequency inventory for each frequency band:[29]

- 700 MHz – Bandwidth of 30 x 2 MHz in FDD mode.
- 2 600 MHz – Bandwidth of 60 x 2 MHz in FDD mode.
- 3 500–3 800 MHz – Bandwidth of 300 MHz in TDD mode.

As the MoC articulated in the 2019 5G tender in Israel, the expected outcomes encompassed the following:[30]

- The frequencies offered in the tender will enable a response to the growing demand for broadband communications by expanding capacity.
- For the first time, the frequency tender will be accompanied by an incentive system that includes grants and a reduction of ILS 500 million (EUR 125 million)[31] in fees.
- Tender payments will be deferred to September 2022 in order to enable the operators to direct their financial resources to investment in upgrading the networks.
- In the tender, the owners of existing networks will be able to compete by submitting joint proposals in a manner that will lead to effective allocation of frequencies for the benefit of the public.
- Besides, the tender will include an open segment of 100 MHz for new players that will generate technological competition in the infrastructure and services of the 5G networks.

Operators will be expected to pay a total of ILS 80 million (EUR 20 million)[32] per year for the use of the new frequencies – in addition to the ILS 320 million (EUR 79.8 million) they currently disburse for 4G and 3G services. Winners may receive a 28 per cent reduction for the first four years, subject to government approval. They will be required to complete the deployment within five years and begin providing 5G services within 18 months of the start of deployment. The total cost of the deployment is estimated at ILS 2 billion (EUR 448.6 million).

In August 2020, the MoC initiated a series of conferences entitled 'Connected Authorities – Connect Israel' with the goal of assisting local and district authorities in connecting to advanced communication infrastructure. The ministry has announced that additional conferences will be held for the heads of local councils and mayors, in a similar format, to facilitate a more effective dialogue and consultations in the ministry's areas of operation in regard to 5G and other technologies.[33]

In partnership with the Ministry of Economy's Innovation Authority, the MoC is launching a new programme that will allow Israeli start-ups and industry to submit applications for R&D programmes at various sites (such as campuses, public spaces, hospitals, etc.) using 5G technologies, in two formats: i) Carried out on the frequencies allocated to the communication companies; and ii) Carried out on designated experimental frequencies to be allocated by the MoC for the purpose of the trials.[34]

In September 2020, India, Israel and the United States began a collaboration for the development of 5G with the goal of establishing a transparent, open, reliable and secure 5G communication network.[35]

When launching the 5G tender, the MoC also expressed strong interest in promoting the use of 5G for a potential smart-city programme for Israel, although not many details have been publicly announced as at September 2020.[36]

3.10.4 Spectrum assignment for 5G and market development

In August 2020, the MoC concluded the multispectrum auction to enable operators to roll out 5G, and the winning bidders were Pelephone, Cellcom-Golan-Marathon and Partner-HOT mobile. All three secured identical spectrum allocations, specifically a 10 MHz block in the 700 MHz band, a 20 MHz block in the 2 600 MHz band and 100 MHz in the 3.5 GHz (3 500 MHz – 3 800 MHz) band.[37] The 700 MHz band allocations will be valid for 15 years, while both the 2 600 MHz and 3.5 GHz allocations are valid for 10 years, with all concessions being renewable at the end of those periods.

Cellcom, Israel's largest mobile-phone operator, which has acquired rival Golan Telecom, stated it will pay ILS 115 million (EUR 28.7 million)[38] in licence fees. Partner Communications, the second-largest mobile operator, stated it will pay, together with HOT mobile, ILS 62.3 million (EUR 15.5 million) for its frequencies. Partner operates a joint radio network with HOT, a subsidiary of telecom and cable group Altice Europe.[39] Bezeq's subsidiary Pelephone will pay over ILS 88 million (EUR 21.9 million)[40] for its spectrum allocations. The aforementioned operators will not be required to make payment for their new spectrum until September 2022.[41]

Based on the ministry's estimation, conclusion of the frequency tender and commencement of the deployment of 5G infrastructure by the licence-holders will occur during the second half of 2020.[42]

In terms of market development, the local press has reported that there are currently some 25 Israeli companies working on 5G-related technologies, ranging from transnational firms as large as Intel to small early-stage start-ups such as TetaVi Ltd. and Binah AI Ltd. In areas ranging from healthcare to autonomous traffic management and from entertainment to drones, Israeli firms are gearing up for 5G by researching product potential and integrating with other verticals.[43]

3.10.5 Electromagnetic field levels and implementation dynamics

The 2006 Non-Ionizing Radiation (NIR) Law includes requirements related to the installation and operation of energy-emitting sources, as well as requirements for monitoring sources of NIR and publicizing the results. The Law stipulates that, in order to install a source of radiation, to operate a source of radiation or to provide radiation measurement services, it is necessary to receive prior authorization from the Ministry of Environmental Protection**.** Permits are granted for a limited period and must comply with certain conditions. In the context of 5G, the Ministry of Environmental Protection determines the maximum power output of broadcast centres so that radiation exposure levels are at least 10 times less than the radiation exposure thresholds defined by WHO as being harmless to the general population**.**[44]

The validity of the permit, depending on the different types of radiation sources, is stipulated in the regulations:[45]

- **Installation permit**: In order to obtain a permit to install a radiation-emitting source, certain conditions detailed in the Law must be met. Among them: evaluation of maximum levels of exposure anticipated from the sources of radiation, based on the technical

specifications, operation of the radiation sources for a limited period, and performance of trial measurements over a period defined by the Law.

- **Operations permit**: This is the second stage: Subject to the validity of the measurements performed during the period allocated by the above installation permit, a permit must be obtained to operate the radiation sources for a defined number of years. This permit is subject to the conditions stipulated by the Law.
- **Radiation services permit**: Not everyone is entitled to measure radiation. In order to perform this activity, one must obtain a radiation measurement services permit according to the Law. This permit, too, is subject to certain conditions, such as professional training and possession of the appropriate equipment and means to provide the service.

In coordination with the Ministry of Science and Technology, the Ministry of Environmental Protection established the Israeli National Information Centre for Non-Ionizing Radiation (TNUDA) in 2013. The centre is guided by the precautionary principle and therefore promotes educated use of technologies involving non-ionizing radiation while maintaining a balance between rapid technological advances and protection of public health.

Since September 2014, the TNUDA website serves as the main information channel for various target audiences in Israel (the general public, governmental offices, scientists and industry). In the light of the growing interest abroad and to respond to the wish to enable wider access to the information distributed by the centre, the English version of the website was launched in 2016.[46] To date, more than 200 articles have been published, covering a wide range of topics such as health, physics, legislation and policy. In addition, other items such as FAQs, selected publications and glossary are available to readers.[47]

Within the context of 5G development in Israel, the MoC has analysed the recommendations on the relationship between the network and EMF levels, and has announced that it will act, if necessary, to ensure the roll-out of 5G networks in the country while maintaining standards of public health. In parallel to publishing the tender and subsequent technological development, the Ministry of Health recommended further monitoring by the Ministry of Environmental Protection, which is expected to assess exposure levels, including an examination of the various levels of exposure to multiple sources of radiation (cellular sites of different sizes) at different stages throughout 5G development. The Ministry of Environmental Protection also recommends the following for the development of 5G:[48]

- Encouraging the sharing of cellular networks.
- Encouraging broader deployment within buildings, which reduces exposure to radiation.
- Deployment of additional broadcasting centres in areas where there is insufficient deployment.
- Proceeding in such a manner that most of the data volume is transmitted through wired networks that do not radiate.

The ministry is especially expected to take into account exposure levels at 'hot spots' and the combination of output data and antenna orientation (aggregating the application of beam deflection technology) while adhering to the principle of preventive precaution. The recommendation also included the establishment of an interministerial committee to review the existing standards in 5G implementation and come up with new actions or revisions if necessary.[49]

3.10.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In July 2020, Partner announced the establishment of its 5G network, known as the 'Partner 5G project', which positions the operator as the first private stakeholder to launch 5G in Israel. The operator announced that it is conducting 5G-related capability tests and has managed to attain a transmission speed of more than 1 GB. Partner also stated that it is currently upgrading the core of its existing cellular network with a view to paving the way for new technological capabilities, thus expanding the existing capacities of advanced voice calling services such as VoLTE (voice calls on 4G), Wi-Fi calling and others.[50]

In August 2020, the operator Pelephone Communications Ltd. announced the launch of its 5G network, called 'Pelephone Plus', which is set to start operations as soon as the Israeli regulator finalizes the frequency allocation. Pelephone has acquired a network of 250 5G sites from Ericsson, which has earned it an ILS 80 million (EUR 19.9 million)[51] grant from the MoC.[52]

In September 2020, three MNOs (Pelephone, Partner and Hot Mobile) launched their 5G networks and started to provide commercial services, after the ministry granted them the licences and the spectrum allocation was finalized.[53]

Endnotes

[1] See: https://www.privacyshield.gov/article?id=Israel-Information-Communication-Technology-ICT

[2] See: http://documents1.worldbank.org/curated/en/526981530526619514/pdf/Best-Practices-and-Lessons-Learned-in-ICT-Sector-Innovation-A-Case-Study-of-Israel.pdf

[3] See: https://www.brodynt.com/business-internet-connectivity-in-israel/

[4] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

[5] See: https://www.brookings.edu/wp-content/uploads/2018/12/FP_20181221_israel_developing_world1.pdf

[6] See: https://www.reuters.com/article/bezeq-results/israels-bezeq-telecom-q3-profit-revenue-fall-idUSL8N1NZ545

[7] See: https://www.gov.il/BlobFolder/news/digital_israel_national_plan/en/The%20National%20Digital%20Program%20of%20the%20Government%20of%20Israel.pdf

[8] See: https://www.oecd.org/sti/broadband/33871370.pdf

[9] See: https://www.reuters.com/article/us-israel-bezeq-internet/israels-bezeq-to-double-internet-speed-eyes-fibre-network-launch-idUSKCN24D0FV

[10] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

[11] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

[12] See: https://en.globes.co.il/en/article-israel-lags-oecd-peers-in-fiber-optic-infrastructure-1001335931

[13] See: See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

[14] See: https://www.brodynt.com/business-internet-connectivity-in-israel/

[15] See: https://en.globes.co.il/en/article-israel-lags-oecd-peers-in-fiber-optic-infrastructure-1001335931

[16] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[17] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[18] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[19] See: https://www.spectrummonitoring.com/frequencies.php/frequencies.php?market=ISR

[20] See: https://www.globenewswire.com/news-release/2019/06/24/1872897/0/en/Israel-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses-2019-Broadband-Penetration-Recently-Reached-100.html

[21] See: https://www.jpost.com/israel-news/israel-launches-race-to-build-5g-mobile-networks-595637

[22] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[23] See: https://www.brodynt.com/business-internet-connectivity-in-israel/

[24] ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i 271G" and "i271GA").

[25] See: https://www.gov.il/BlobFolder/news/27122018/en/Expanding%20the%20deployment%20of%20cellular%20communications%20infrastructure.pdf [in Hebrew].

[26] See: https://www.gov.il/BlobFolder/news/11072019_01/he/Tender%20for%20Generation%205,%2014.07.19.pdf [in Hebrew].

[27] See: https://uk.reuters.com/article/uk-israel-telecoms-5g/israel-holds-5g-mobile-network-tender-aims-for-2020-launch-idUKKCN1U90CK?il=0

[28] See: https://www.calcalistech.com/ctech/articles/0,7340,L-3843219,00.html

[29] See: https://www.gov.il/BlobFolder/news/14072019_01/he/5th%20Gen%20Tender%20-%20English.pdf

[30] See: https://www.gov.il/he/departments/news/14072019_01 [in Hebrew].

[31] Exchange rate as at September 2020.

[32] Exchange rate as at September 2020.

[33] See: https://www.gov.il/en/departments/news/19082020_1

[34] See: https://www.gov.il/en/departments/news/230812020_2

[35] See: https://www.thehindu.com/business/india-us-and-israel-collaborating-in-5g-tech-official/article32548545.ece

[36] See: https://www.gov.il/en/departments/general/08032020

[37] See: https://www.gov.il/BlobFolder/news/12082020_2/en/Letter%20passed%20to%20companies%20participating%20in%20the%20tender.pdf

[38] Exchange rate as at September 2020.

[39] See: https://telecom.economictimes.indiatimes.com/news/israeli-regulator-awards-licences-for-5g-networks/77536914

[40] Exchange rate as at September 2020.

[41] See: https://www.commsupdate.com/articles/2020/08/14/israel-concludes-5g-spectrum-auction-moc-approves-cellcoms-purchase-of-golan-telecom/

[42] See: https://www.gov.il/en/Departments/faq/01042020

[43] See: https://www.calcalistech.com/ctech/articles/0,7340,L-3833773,00.html

[44] See: https://www.gov.il/en/departments/news/01042020_2

[45] See: https://www.tnuda.org.il/en/policy-and-legislation/non-ionizing-radiation-law-israel

[46] See: https://www.tnuda.org.il/en

[47] See: https://www.who.int/peh-emf/project/mapnatreps/israel-2017.pdf?ua=1

[48] See: https://www.gov.il/en/departments/general/09072019_01

[49] See: https://www.gov.il/en/departments/faq/01042020

[50] See: https://www.israelhayom.co.il/article/780765 [in Hebrew].

[51] Exchange rate as at September 2020.

[52] See: https://www.telecompaper.com/news/pelephone-launches-5g-network-in-israel--1349225

[53] See: https://www.gov.il/en/departments/news/29092020_5

3.11 Iceland

3.11.1 ICT background and current status of broadband

Iceland is one of the world's most advanced and mature markets when it comes to infrastructure, diffusion and use of ICTs. The government first recognized the potential of ICTs as early as 1996 in the 'Icelandic Government's Vision of the Information Society'.[1] Moreover, the development of ICT-related policy documents such as 'Iceland the e-Nation' (2008–2012),[2] the 'Telecom Policy Statement' (2011-2014)[3] and the 'Electronic Communications Plan' (2011–2022)[4] played an important role in paving the way for a country with a solid and advanced fibre-optic network infrastructure as well as a strong focus on e-governance.[5] Largely thanks to its low corporate tax incentives, its highly skilled IT labour force[6] and its geographical position, Iceland has also become a connecting global hub for the operation of large international data centres[7] and an important location for international submarine cable systems.[8]

With a small domestic telecom sector, Iceland is known for having a competitive and highly progressive ICT market. Iceland has also to a very large extent harmonized[9] its electronic communications environment with the laws and regulatory framework of the European Union.[10] However, there are still areas that are not covered by private operators and that lack broadband services, which gained rapid popularity in Iceland the early 2000s owing to the early use of IPTV technologies. More recently, Iceland has also encountered a decrease in investment in the telecommunication sector, which fell 5.5 per cent in 2019 in comparison to the previous year.[11]

The Electronic Communications Plan (2011–2022)[12] contains ambitious objectives on quality, access, distribution and security of electronic communication services. The main objectives concerning access to electronic communication services are:

- 90 per cent of homes and places of work will have the option of a 30 Mbit/s fixed connection by 2014, and 100 per cent by 2022.
- 70 per cent of homes and places of work will have the option of a 100 Mbit/s fixed connection by 2014, and 99 per cent by 2022.
- 98 per cent of homes and places of work will have the option of high-speed mobile networks by 2014, and 99.9 per cent by 2022.
- 80 per cent of the country and the coastal waters will have the option of a high-speed mobile network by 2018.

Moreover, the government's approach has been to focus on strengthening the country's fibre-optic backbone network and also on supporting fibre-optic cable-laying in rural areas – where distances are such that other technologies cannot provide 100 Mbit/s on a fixed network. The communications plan also placed a clear emphasis on mobile-broadband services (4G/LTE), support to private stakeholders, network sharing, preservation and maintenance of the ever-growing infrastructures, and strong collaboration between telecom operators and municipalities as well as the federal government and other stakeholders.[13]

To achieve the above-mentioned targets, the government also approved a 'Four-year electronic communications plan for the years 2011–2014',[14] which sets objectives for:

- Accessible and easy communication.
- Cost-effective and efficient communication.
- Secure communications.
- Environmentally-friendly telecommunications.

Since 2016, government-led efforts have been in place to lay fibre-optic cables in Iceland's rural areas. For example, Iceland's Rural Fibre Project (*Ísland ljóstengt*)[15] is a short-term government initiative to bring ≥100 Mbit/s wired Internet to 99.9 per cent of households and businesses nationwide by year-end 2020, thereby accelerating achievement of the objectives of the Electronic Communications Plan (2011–2022) released in 2010. This project is overseen by the government-led Telecommunications Fund and originally included roughly 5 500 households and businesses,[16] and has a strong emphasis on cost efficiency, synergies with other infrastructure projects and cooperation with operators as much as possible.[17]

3.11.2 Broadband and mobile telecommunication data

ITU data show that 99 per cent of individuals in Iceland used the Internet in 2018.[18] In 2010, the corresponding ITU figure for the country was 93.4 per cent, and in 2000, 44.5 per cent. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 40.8.[19] In terms of type of connection, xDSL subscriptions peaked in 2008, at 98 per cent of connections, and have been in constant decline since 2013 as they are being replaced by fibre, which accounted for 62.8 per cent of all Internet subscriptions in Iceland in 2019.[20] Due to the high penetration of FTTH access throughout the country, average Internet speeds in Iceland are faster in comparison with most countries in Europe, with only 0.3 per cent of connections registering an average speed below 10 Mbit/s.[21] As at 2019, about 75 per cent of premises have FTTH[22] access, with all of the City of Reykjavik and town areas connected through Gagnaveita Reykjavíkur's (GR) fully fibre network.[23] Some 54.8 per cent of Internet subscribers enjoyed speeds of more than 500 Mbit/s in 2019, while only 4.4 per cent had an average speed lower than 30 Mbit/s. FTTP access has also been steadily growing, offering services to business, government and other organizations.[24] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019, while Iceland's corresponded to 1.6 per cent for a 50 GB cap per month in 2017.[25]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was 122.[26] Moreover, the number of active mobile-broadband subscriptions per 100 inhabitants reached 128.6 in the same year.[27] There are three major MNOs that dominate the market in Iceland: Síminn (formerly Landssíminn), Nova, and Vodafone (Formerly Og Vodafone, Íslandssími). The country's mobile-data basket cost corresponded to 0.5 per cent of GNI per capita in 2017 for a monthly allowance of 5 GB, as against the Europe region average of 0.8 per cent in 2019.[28] Over the past years, significant investment has been made in extending 4G infrastructure, and the major operators now provide 4G services to 98.9 per cent of the population in the country,[29] above the Europe region average of 97.6 per cent, although 2G and 3G are still being used by a small percentage of the population.[30] Domestic mobile data traffic for 2019 stood at 0.05 exabytes, more than a 20 per cent increase on a yearly basis.[31]

3.11.3 Current progress on 5G: Consultations and national strategies

In May 2018, Iceland signed a declaration of intent for cooperation on 5G with other Nordic countries within the framework of the Nordic Council of Ministers.[32] In addition to accelerating the development of 5G, this declaration outlines the collective vision for the Nordic region to become the first interconnected 5G region in the world and identifies areas in which Nordic cooperation needs to be strengthened. The document also acknowledges that the deployment of 5G will require substantial investments as well an appropriate regulatory framework both nationally as well as in forging a common Nordic 5G space.[33] This agreement is also aligned

with other Nordic areas of cooperation dealing with the adoption of IoT and other emerging technologies, such as the Nordic Smart City Network,[34] which helps governments create best practices for smart-city projects and urban development.[35]

To achieve this goal, in June 2018 Iceland agreed to cooperate closely with other Nordic countries to set up a common action plan for early adoption of 5G technology across the Nordic region. The action plan will:[36, 37]

- Encourage the development of new testing facilities, including testbeds.
- Ensure the technical coordination of 5G frequency bands within the region.
- Remove obstacles to the expansion of 5G network, in particular the deployment of base stations and antennas.
- Encourage and monitor the development of 5G, specifically for certain sectors such as transport, mission-critical communications, advanced automation in the manufacturing industry, and the energy sector.

Developments will be monitored and followed up by the Nordic Council of Ministers, facilitating implementation in cooperation with the Nordic governments, national telecommunication and digital regulatory bodies and stakeholders from the ICT and telecommunication industries.[38]

The 5G Action Plan 2018–2020[39] was released in late October 2018, establishing 23 deliverables grouped under the following policy goals:

- Encourage the development of new testing facilities, including testbeds.
- Ensure the technical coordination of 5G frequency bands within the region.
- Remove obstacles to expansion of the 5G network, in particular the deployment of base stations and antennas.
- Encourage and monitor the development of 5G, specifically for certain sectors including transport, critical communications, manufacturing, energy and the environment, health and welfare, and foster stakeholder dialogue on 5G application.

Nordic telecom companies supporting the region include Ericsson, Nokia, Iceland Telecom, TDC Group, Telenor Group, Tele2 Group, Telia Company and Vodafone Iceland. Representatives of these operators issued a statement welcoming the new deal between the countries and expressed their visions for appropriate spectrum-assignment rules and the removal of obstacles around the deployment of 5G infrastructure.[40]

Aside from the recent 5G spectrum allocation, cooperation with other Nordic countries and work on 5G-related EMF concerns, Iceland does not have a national strategy document on 5G as things stand in October 2020.[41]

3.11.4 Spectrum assignment for 5G and market development

The current generations of mobile network transmitters in Iceland (GSM, 3G and 4G) use frequencies between 700 MHz and 2.6 GHz.[42] In April 2020, Iceland's Post and Telecom Administration (PTA) allocated 5G frequency licences in the 3.6 GHz frequency band to Síminn,[43] Nova[44] and Syn (Vodafone Iceland),[45] which are MNOs that are already operating 4G networks. The spectrum in the 3.6 GHz band is allocated as follows:[46]

- Síminn: Block B3600 (3 500 MHz – 3 600 MHz).
- Nova: Block C3600 (3 600 MHz – 3 700 MHz.)
- Vodafone Iceland (Syn): Block D3600 (3 700 MHz – 3 800 MHz).

In the frequency authorization for these MNOs, it is stated that the 3.6 GHz frequency bands shall be used for high-speed mobile network based on technology neutrality. The service shall be in accordance with the standards and definitions set out in the data from ETSI, 3GPP and current conditions from CEPT (e.g. ECC Decision (11)06).[47] Due to the uncertainties concerning the various ways in which 5G can develop in the country and worldwide and its impact on communication law, the licences are valid only until the end of 2021. Future amendments in the licensing terms around the legislation as well as spectrum assignment may occur.

Through the licences, PTA indicates that frequencies at 3.6 GHz, as well as other and higher-frequency (e.g. 24.25–27.5 GHz) bands, are yet to be allocated and likely to be the mainstay for 5G in Iceland. Accordingly, the regulator expects that 5G will be implemented in different stages, the first being intended to support normal technological upgrades and the capacity of existing high-speed mobile networks in the companies' operations. Allocation of higher 5G frequencies will also include the development of IoT and other secure high-speed mobile network services, as well as cloud services, data centres and other technologies such as AI.

Radio frequencies are expected to be used efficiently and PTA has defined certain requirements for network development for each MNO, with the intention of improving service dissemination. Each licence receives a general and a special requirement detailing a proportion of the population to be covered (25 per cent each) alongside a list of 30 mobile sites across the country where 5G network shall be built with the average speed target of 200 Mbit/s to be reached by 31 December 2021. In particular, Síminn is required to provide 5G services with a minimum downlink speed of 200 Mbit/s to 90 per cent of the population in Blonduos, Thorlakshofn and Egilsstadir; Nova has the same requirement for Hellu, Sandgerdi and Vestmannaeyjum; and Vodafone Iceland has it for Hvolsvelli, Siglufirdi and Grindavik.[48]

Renewal of the frequency authorizations for the MNOs will depend on whether they have used the frequencies effectively in accordance with the relevant PTA criteria. When the 5G frequency licences are renewed, it can be expected that the data transfer speed will be increased, and more urban areas will be added to the group of those that will have access to 5G services in the future.[49]

3.11.5 Electromagnetic field levels and implementation dynamics

In 2002, under a new government Act on Radiation Protection, non-ionizing radiation was added to the remit of the Icelandic Radiation Safety Authority (IRSA).[50] For work-related situations, protection measures dealing with the effects of non-ionizing radiation are subject to an Act on Working Environment and Health and Safety in Workplaces and fall under the auspices of the Icelandic Administration of Occupational Safety and Health (AOSH).[51] Both of the above-mentioned authorities refer to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines and no national deviations from these are expected.

IRSA and PTA have established a collaborative project in parallel with the introduction of 5G. The project involves monitoring the development of 5G technology in Iceland as well as various measurements. IRSA is closely monitoring the development of 5G issues around the world, including through active participation in cooperation between the Nordic radiation protection institutions and international cooperation with WHO. In order to keep the Icelandic public informed of recent developments on health risks due to EMF, IRSA monitors information from reliable sources such as WHO, ICNIRP, the International Agency for Research on Cancer (IARC) and the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and

publishes it on its website. More specifically, several recent informative notes on 5G and EMF have been published supporting the ICNIRP guidelines (both the 1988 and most recent versions),[52] highlighting the limit values for EMF intensity in the frequency range 100 kHz – 300 GHz.

In the spectrum allocation approved by PTA in April 2020, Article 9 lays down the conditions with respect to radiation and environment for MNOs using the 3.6 GHz band. The document stipulates that the MNO shall ensure that the electromagnetic radiation from its equipment is within the limits specified in the ICNIRP guidelines for EMF or in accordance with the criteria contained in Icelandic rules and laws. Moreover, the MNO shall ensure that the installation and use of its equipment is in accordance with the relevant ITU recommendation (Recommendation ITU-T K.52).[53]

If it is found that electromagnetic radiation from electronic communication installations exceeds the limit values specified in ICNRIP recommendations, rules or relevant Icelandic standards, the frequency licence-holder shall rectify this without delay, or shall otherwise discontinue use of the electronic communication infrastructure in question. If the combined electromagnetic radiation from electronic communication installations located close to each other goes beyond the limit, without any individual equipment exceeding the limit, the frequency licence-holder shall replace the equipment while ensuring that the public does not have access to the area, or shall stop using it.[54]

3.11.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In February 2019, after receiving authorization from PTA, Nova announced it was starting 5G tests by launching the first 5G transmitter in Iceland, which was manufactured by Huawei. Through an MoU signed in the same month, the two parties also announced their intention to extend their cooperation on 5G technology in order to establish the best telecommunication network in Iceland in terms of radio coverage, stability and bandwidth ensuring reliable quality of service and enhanced experience.[55]

Within the framework of the MoU, Huawei has installed 5G base stations and routers at Nova's facilities and will be supplying 200 sites with 5G Ma-MIMO technology. The agreement states that Huawei will be responsible for planning, design, roll-out and optimization to ensure the overall network quality and user experience. It will supply approximately 2 000 units of 5G CPE.[56] Nova was also the first operator to deploy 3G, in 2006, 4G, in 2013, and 4.5G, in 2017.[57] In 2018 and 2019, Nova invested around ISK 1 billion (EUR 6.2 million)[58] per year in the development of its network.[59] On 5 May 2020, Nova commercially launched the first 5G network in Iceland and is to date providing 5G service in Reykjavik, Hella, Sandgerdi and Vestmannaeyjar.

In May 2019, Síminn (Iceland Telecom), which has the largest market share of data subscriptions in Iceland, and Ericsson signed an agreement for modernization of the operator's radio access and core networks by deploying Ericsson Cloud Packet Core portfolio upgrades to support the transition from 4G to 5G in Iceland. Enabled by Ericsson 5G New Radio and Ericsson Spectrum Sharing, the two companies plan to conduct 5G trials.

Furthermore, the agreement also aims to accelerate growth of the IoT ecosystem across Iceland's commercial sectors through NB-IoT and Category M1 (Cat-M1).[60] Accordingly, the Síminn-Ericsson agreement includes geo-redundant Ericsson Network Functions Virtualization Infrastructure operated on Ericsson's Blade Server Platform with Ericsson Virtual User Data

Consolidation, and Ericsson Fast VoLTE. Ericsson Fast VoLTE enables HD voice services with simultaneous LTE-speed surfing, which is likely to pave the way for more advanced communication services.[61]

In September 2020, Vodafone Iceland activated its first 5G transmitter with the intention of building a 5G network in the capital area over the next two years.[62]

Endnotes

1 See: https://www.stjornarradid.is/efst-a-baugi/frettir/stok-frett/1996/10/01/Vision-of-the-Information-Society/

2 See: https://www.government.is/media/forsaetisraduneyti-media/media/utgefidefni/Iceland_the_eNation.pdf

3 See: https://www.broadbandcommission.org/Documents/ITU_BroadbandPlans_2019.pdf

4 Ibid.

5 See: https://www.researchgate.net/publication/256666996_Case_studies_on_e-participation_policy_Sweden_Estonia_and_Iceland

6 See: https://www.iceland.is/trade-invest/ict#:~:text=Strong%20infrastructure%20for%20ICT&text=Icelanders%20have%20a%20solution%2Dfocused,in%20Europe%20and%20%234%20Worldwide

7 See: https://askjaenergy.com/2013/06/18/iceland-as-a-leading-data-centre-hub/

8 See: https://www.submarinecablemap.com/#/country/iceland

9 See: https://www.pfs.is/library/Skrar/English/About-PTA/PTA_Annual_Report_2012_En_HIGHRES.pdf

10 See: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/pdf/key_documents/2012/package/is_rapport_2012_en.pdf

11 See: https://www.pfs.is/library/Skrar/Tolfraedi/Tolfraediskyrslur-PFS/T%c3%b6lfr%c3%a6%c3%b0isk%c3%bdrsla_%20PFS_2017_2019_me%c3%b0%20fors%c3%ad%c3%b0umynd.pdf

12 See: https://www.althingi.is/altext/141/s/0593.html

13 See: https://www.pfs.is/library/Skrar/English/About-PTA/PTA_Annual_Report_2012_En_HIGHRES.pdf

14 See: https://www.althingi.is/altext/141/s/0592.html

15 See: https://www.stjornarradid.is/verkefni/samgongur-og-fjarskipti/island-ljostengt/ [in Icelandic].

16 See: https://joinup.ec.europa.eu/collection/egovernment/news/rural-fibre-100-mbs

17 See: https://www.government.is/topics/transport-and-telecommunications/icelands-rural-fibre-project/#:~:text=The%20Iceland's%20Rural%20Fibre%20Project,nationwide%20by%20year%2Dend%202020

18 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

19 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

[20] See: https://www.pfs.is/library/Skrar/Tolfraedi/Tolfraediskyrslur-PFS/T%c3%b6lfr%c3%a6%c3%b0isk%c3%bdrsla_%20PFS_2017_2019_me%c3%b0%20fors%c3%ad%c3%b0umynd.pdf

[21] See: https://www.pfs.is/library/Skrar/Tolfraedi/Tolfraediskyrslur-PFS/T%C3%B6lfr%C3%A6%C3%B0isk%C3%BDrsla_%202018_me%C3%B0Fors%C3%AD%C3%B0u.pdf

[22] See: https://genexis.eu/news/iceland-number-one-country-worldwide-in-homes-connected-to-fiber/

[23] See: https://www.ljosleidarinn.is/gagnaveita-reykjavikur

[24] See: http://www.reykjavikfibrenetwork.is/smart-communities

[25] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[26] See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Mobile_cellular_2000-2018_Dec2019.xls

[27] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[28] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[29] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[30] See: https://www.pfs.is/library/Skrar/Tolfraedi/Tolfraediskyrslur-PFS/T%c3%b6lfr%c3%a6%c3%b0isk%c3%bdrsla_%20PFS_2017_2019_me%c3%b0%20fors%c3%ad%c3%b0umynd.pdf

[31] ITU World Telecommunication/ICT Indicators Database online (2020[31]: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[32] See: https://ec.europa.eu/digital-single-market/en/news/nordic-countries-sign-letter-intent-be-forefront-5g-development

[33] See: https://www.government.se/press-releases/2018/05/new-nordic-cooperation-on-5g/

[34] See: https://nscn.eu/

[35] See: https://aithority.com/news/nordic-enterprises-see-5g-networking-as-boost-for-internet-of-things/

[36] See: https://www.government.se/49b8be/globalassets/government/dokument/statsradsberedningen/letter-of-intent--development-of-5g-in-the-nordic-region-.pdf

[37] See: https://techblog.comsoc.org/2018/06/06/5-nordic-countries-agree-to-accelerate-5g/

[38] See: https://www.government.se/49b8be/globalassets/government/dokument/statsradsberedningen/letter-of-intent--development-of-5g-in-the-nordic-region-.pdf

[39] See: http://norden.diva-portal.org/smash/get/diva2:1259977/FULLTEXT01.pdf

[40] See: https://www.siliconrepublic.com/comms/nordic-5g-deal-partnership

[41] See: https://www.pfs.is/fjarskipti/5g-a-islandi/ [in Icelandic].

[42] See: https://gr.is/fraedsluefni_um_5g/ [in Icelandic].

[43] See: https://www.pfs.is/library/Skrar/Skraningar-og-leyfi/Tidniheimildir/T%c3%ad%c3%b0niheimild%20S%c3%admans%20%c3%a1%2036%20GHz.pdf [in Icelandic].

[44] See: https://www.pfs.is/library/Skrar/Skraningar-og-leyfi/Tidniheimildir/T%c3%ad%c3%b0niheimild%20Nova%20%c3%a1%2036%20GHz.pdf [in Icelandic].

[45] See: https://www.pfs.is/library/Skrar/Skraningar-og-leyfi/Tidniheimildir/T%c3%ad%c3%b0niheimild%20S%c3%bdn%20%c3%a1%2036%20GHz.pdf [in Icelandic]

[46] See: https://www.commsupdate.com/articles/2020/05/01/pta-awards-5g-spectrum-in-3-6ghz-band-until-december-2021/

[47] See: https://docdb.cept.org/download/34f57e2a-1c04/ECCDEC1106.PDF

[48] See: https://www.commsupdate.com/articles/2020/05/01/pta-awards-5g-spectrum-in-3-6ghz-band-until-december-2021/

[49] See: https://www.pfs.is/?PageId=3a034dad-e97b-11e2-b5a5-005056864800&newsid=4b565d0a-8ae5-11ea-945d-005056bc2afe

[50] See: https://gr.is/

[51] See: https://www.vinnueftirlit.is/english/

[52] See: https://gr.is/5g-og-heilsa-spurt-og-svarad-a-vef-who/ [in Icelandic].

[53] See: https://www.pfs.is/library/Skrar/Skraningar-og-leyfi/Tidniheimildir/T%c3%ad%c3%b0niheimild%20S%c3%admans%20%c3%a1%2036%20GHz.pdf

[54] Ibid.

[55] See: https://www.telecomlead.com/mwc/huawei-signs-5g-agreements-with-viva-bahrain-and-nova-iceland-89363

[56] See: https://www.huawei.com/en/news/2019/2/huawei-icelandic-operator-nova-agreement-5g-testing

[57] See: https://www.nova.is/dansgolfid/5g-i-loftid-hja-nova [in Icelandic].

[58] Exchange rate as at September 2020.

[59] See: https://www.ruv.is/frett/5g-comes-to-iceland

[60] See: https://operatorwatch.3g4g.co.uk/2020/02/

[61] See: https://www.ericsson.com/en/news/2019/5/5g-and-massive-iot-in-iceland

[62] See: https://vodafone.is/5g/?childTab=0&question=question-2 [in Icelandic].

3.12 Principality of Liechtenstein

3.12.1 ICT background and current status of broadband

The Principality of Liechtenstein has a well-developed telecommunication infrastructure with high penetration rates above the regional average for both fixed and mobile services. Concentrating on investment by State-owned companies, Liechtenstein has been expanding its fibre-optic network since the mid-1990s. According to the Office for Communications, by the end of 2022 all premises will be connected by optical fibre, and the legacy infrastructure, i.e. copper and coax, will be switched off. The various policy and regulatory initiatives undertaken by the government and the regulator over the past years have fostered competition and supported infrastructure investment, which influenced the country's early development and stimulated the high growth rates recorded in the mobile-broadband market.[1] As at September 2020, no official strategy has been laid down by the government for 5G roll-out in Liechtenstein, although frequencies are being allocated to operators.

As a member of the European Economic Area (EEA), Liechtenstein applies the EU telecommunication *acquis*. The latest revision to the Communications Act was in 2020, and revision is under way to transpose the latest EU telecommunication directives (the 'Code') in the area of electronic communications. With the aim of promoting investment in a small market while fostering competition, two key policies have been implemented: the obligation to share mobile towers imposed on all MNOs, and vertical separation of the fixed-line incumbent.[2] The latter was a decision of the Government of Liechtenstein that came into effect in 2007, thus separating the fixed incumbent's network infrastructure operations and retail businesses.[3] Liechtenstein's telecommunication market benefits from a competitive environment in the fixed and mobile segments based on non-discriminatory access for all telecommunication service providers to the network infrastructure. More recently, many of the government's digital strategies have focused on legislation, governance, infrastructure and business,[4] thereby playing a crucial role in expanding broadband access and connectivity speed throughout the country.[5]

As part of the government programme for 2017–2021, Liechtenstein's 'Digital Agenda' is a core field of action for the new legislature concerning ICTs in the country. The main objective of the Digital Agenda is to optimize the process efficiency of the national administration, with a focus on electronic means of communication, thus strengthening digital service and the expansion of digital infrastructures – which also includes the development of 5G networks.[6]

The Digital Agenda is guided by the following overarching principles:[7]

- Liechtenstein shall actively use the opportunities of digitalization and address the associated challenges.
- It shall seek opportunities and deal with challenges of digitalization in cooperation in regard to society, the economy, science, education and administration.
- It shall work toward securing the population's trust in digital services in a way that is driven by reliable information, transparency, security and a strong and clear legal foundation.
- Companies based in Liechtenstein shall offer digitalization the chance to penetrate existing markets and further establish new segments as well as new niche areas for growth. In so doing, they will help foster existing skills and create new ones able to generate added value.
- Liechtenstein shall seize the opportunity for better, cheaper and innovative products, as well as technologies, service performances and business models.

- It shall boost its investment attractiveness as a location that is enhanced by digitalization. As such, the country shall create novel kinds of workspaces and job-related opportunities domestically.
- It shall promote simplified access to knowledge in all relevant sectors for the population.

The areas which these principles are designed to cover, as well as the goals and measures articulated in the Digital Agenda, are structured in the following topics of relevance: State and administration; Education; Economy; Blockchain and fintech; Infrastructure; Transportation; Health; Family affairs; and Culture. The strategy also states that its main goal shall influence ICT development beyond legislation, and its core concepts shall be seen as an overarching and cross-institutional resource for all kinds of stakeholders in the country.

In addition to this government-led agenda, the 'Digital Roadmap for Liechtenstein'[8] was launched at the end of 2017 in coordination between the government and other stakeholders in order to support business development in the country, which included over 50 companies and organizations and networks of relevance in business, science and politics. Complementarily to the Digital Agenda (2017-2021), the Digital Roadmap for Liechtenstein focuses primarily on eight key areas, especially from the point of view of the economy, to enable Liechtenstein to attain a high degree of digitalization by 2025:[9]

- Education: The focus is placed on educating and creating awareness in the population, encouraging businesses to train workers as well as fostering cooperation between educational institutions and business.
- Workforce: Shortage of skilled workers is a central topic of the digital roadmap. Flexible residence permits and a smart job platform for foreign specialists are among the measures to attract foreign talent.
- Digital infrastructure: This includes expanding the fibre-optic network and introducing the new generation of 5G mobile communications which are to be of high quality and as inexpensive as possible. The economy should expand its range of broadband and smart services accordingly
- Cybersecurity: Raising awareness about security risks on the Internet is an important part of the roadmap and should be incorporated in the national strategy.
- Research and innovation: Continuing the work of platforms for research and innovation to support knowledge and technology transfer is of primary importance. This includes the 'Innovation Day', the annual 'Digital Summit Liechtenstein' congress for decision-makers from home and abroad, as well as regular workshop events at companies. The establishment of a DigiLab focused on SMEs is also planned, as well as programmes for start-up funding and the expansion of endowed professorships at educational institutions
- Healthcare: E-health offers new and modern solutions for insured persons as well as service providers. The provision of an electronic health service can create significantly more security and efficiency in data handling, reduce unnecessary duplication and increase the quality of care.
- Mobility and energy: According to the strategy paper, all actors should give high priority to the areas of mobility and energy in order to develop innovative mobility concepts.
- E-government: E-government focuses on politics, administration and the legal framework. The population and companies should be able to access and use the services of the State administration digitally.

Moreover, extra attention is paid to emerging technologies such as AI, robotics, IoT, big data, cloud computing, and so forth. The digital roadmap is now to be implemented step-by-step in dialogue with politicians and the population, and be continuously developed.[10] In other words, Liechtenstein is now equipped with a strategy instrument from the perspective both of the economy and of the State.[11]

3.12.2 Broadband and mobile telecommunication data

ITU data show that 98.1 per cent of individuals in Liechtenstein used the Internet in 2017.[12] In 2010, the corresponding ITU figure for the country was 80 per cent, and in 2000, 36.5 per cent. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 45.4.[13] Since 2014, xDSL has been declining while coaxial cable Internet access has been increasing steadily, especially after 2017 with a rapid increase in glass fibre access for private customers.[14] By the end of 2019, fibre-optic network represented a quarter of all Internet connections in Liechtenstein (about 4 000 subscriptions).[15] As part of a EUR 48.3 million expansion plan, the regulator's vision is that operators will provide fibre-optic connectivity to the entire country by 2023,[16] which is part of the country's vision for deploying infrastructure to ensure further data traffic capacity development towards a 'gigabit society'.[17] The ITU Measuring Digital Development – ICT Price Trends 2019 report does not provide indicators for the fixed-broadband basket cost because GNI per capita data for Liechtenstein are not available; however, an unlimited monthly data allowance costs some USD 42.82[18] (EUR 36.25)[19] in 2020, down from USD 61.36 (EUR 51.94) in 2019.[20]

In 2019, the number of mobile-cellular subscriptions per 100 inhabitants was 127.1,[21] while active mobile-broadband subscriptions per 100 inhabitants stood at 132.4.[22] There are three major MNOs that dominate the market in Liechtenstein: Telecom Liechtenstein (FL1), Swisscom (Switzerland) and Salt (Liechtenstein) (formerly Orange Liechtenstein). Since the introduction of roam-like-at-home tariffs in the EEA from mid-2017, mobile subscriptions with Liechtenstein +423 numbers again increased significantly in 2019, reaching a share of 31 per cent at the end of the reporting year. The total number rose by 2 per cent, to 48 000 subscriptions.[23] Despite that, a significant number of mobile subscriptions are from Swiss mobile-phone providers with the number +417, which means that these mobile-phone subscriptions are subject to Swiss legislation.[24] Although the basket cost for mobile data remains unavailable on account of the lack of data on GNI per capita for Liechtenstein, a monthly package with a 20 GB Internet data allowance was reported to cost around USD 24.54 (EUR 20.77)[25] in 2019.[26] Overall, according to ITU calculations, 98 per cent of the population enjoys 4G/LTE services while 99 per cent of the population is covered by 3G.[27]

3.12.3 Current progress on 5G: Consultations and national strategies

The government regards the introduction of 5G as an important building block for the country's digital future, and as the logical continuation of previous strategies and government-led plans in the field of electronic communications. Therefore, no dedicated national strategy on 5G is necessary. The government states that it is largely by means of a modern and optical communication infrastructure that the country will be able to make its territory a highly attractive location for telecom investments and consequently improve the economy in the future.[28]

The initial strategy for Liechtenstein was to award 5G frequencies to operators at the end of 2019. However, the Ministry of Economy indicated that the Office for Communications had decided to wait for the frequency allocation to take place in neighbouring countries. In parallel to the proceedings in Austria, the Office prepared the allocation of 5G frequencies in Liechtenstein,[29] taking into consideration the possibility of coordinating the available frequencies closely with Switzerland and Austria[30] and ensuring optimal frequency allocation and efficient frequency use in the country.[31]

The MNOs in Liechtenstein can rely on a comprehensive fibre-optic network for connecting all the radio cells required for 5G.[32] Additionally, the Office for Communications also states that it is currently not possible to estimate how many new antenna locations in total will be required; although it can be assumed that, in a first phase of the 5G roll-out in Liechtenstein, the existing transmitter network which consists of 23 so-called 'macro locations' will be taken as a basis for building the network.[33]

In accordance with the current telecommunication rules in the country, the technical design of networks, which depends on the frequency band and the respective geographic coverage area, falls under the responsibility of MNOs. Depending on the technical concept adopted for expansion of the network, MNOs in Liechtenstein will have to handle increased bandwidths, which will require antennas with higher transmission capacities. Different network concepts also consider the use of microcells in metropolitan areas of the country.

3.12.4 Spectrum assignment for 5G and market development

In 2020, Liechtenstein started the process of assigning 5G frequencies in the 700 MHz, 1 400 MHz and 3.5 GHz bands. The regulator has already announced that it will not have recourse to an auction, but will use an administrative procedure,[34] under which the MNOs propose the optimal distribution of the available frequencies.

According to the Liechtenstein frequency allocation plan, the following additional frequency ranges will be available for the provision of public, nationwide technology-neutral mobile communication services to be operated by the major MNOs in the country:[35]

- 703–733 MHz/758 – 788 MHz (2 x 30 MHz) bands.
- 738–753 MHz (15 MHz) band.
- 1 427–1 517 MHz (90 MHz) band.
- 3 410–3 800 MHz (390 MHz) band.

The Office for Communications assumes that the award procedure can be completed in 2021. It will report on the result after the award procedure has been completed.

3.12.5 Electromagnetic field levels and implementation dynamics

To ensure protection of the population from electromagnetic radiation, the government issued the Environmental Protection Act (USG) in 2008[36] and the Ordinance on Protection from Non-Ionizing Radiation (NISV) in 2008.[37] This act and ordinance limit the non-ionizing radiation emanating from fixed systems (e.g. high-voltage lines, mobile radio or radio transmitters).

In December 2009, the population of Liechtenstein voted in a referendum to maintain the same limit values as prescribed in Switzerland. These are currently the most stringent exposure limits in Europe. The Swiss threshold level is set at 4–6 volts per metre (V/m) for the electric field strength.[38] In other words, the limits for EMF values in Liechtenstein are today 10 times stricter than those proposed by WHO.[39] In February 2019, members of parliament raised the question whether a relaxation of radiation protection is also expected in order to facilitate 5G deployment and uptake, insofar as 23 antenna masts are currently in place and current limits would require the installation of additional masts.[40]

Nevertheless, it is still unclear whether the legal regulations regarding non-ionizing radiation will have to be adapted for the introduction of 5G. Based on the amendment to the Environmental

Protection Act of 30 June 2020,[41] the responsible body – the Office for the Environment – stated that Liechtenstein is actively monitoring developments related to 5G and EMF in Switzerland, and explained further that it will respond to any adaptation of the legal framework to examine whether there would be any need for action for Liechtenstein.[42]

3.12.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In 2018, Telecom Liechtenstein (FL1) and Swisscom made announcements expressing their intention to expand their networks to encompass 5G services, but without providing a timeline or specific targeted goals to the public.[43]

In August 2019, A1 Telekom Austria Group announced the sale of its 24.9 per cent stake in FL1 to the State of Liechtenstein. The transaction increases the State's shareholding in the telecom operator from 75.1 per cent to 100 per cent. The companies had agreed to a strategic partnership in 2014 for a duration of five years, and A1 exercised its termination option in 2019. Further cooperation, especially at a technical-operational level, but without capital interlocking, was agreed between FL1 and the A1 Telekom Austria Group, which may have implications for 5G development in Liechtenstein.[44]

However, despite the structural changes in the telecom sector and other 5G developments by Swisscom in Switzerland, as at October 2020 there have been no major 5G-related commercial announcements in Liechtenstein.

Endnotes

1 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

2 Ibid.

3 Ibid.

4 See: https://joinup.ec.europa.eu/sites/default/files/inline-files/Digital_Government_Factsheets_Liechtenstein_2019.pdf

5 See: https://www.ico.li/liechtenstein-has-the-fastest-internet-in-the-world/

6 See: https://www.regierung.li/media/attachments/Regierungsprogramm_2017%E2%80%932021_www.pdf?t=636895549583835664 [in German].

7 See: https://www.regierung.li/media/attachments/ikr-DigitaleAgendaFL-A4-Einzelseiten-200dpi.pdf?t=636924885232021692 [in German].

8 See: https://digital-liechtenstein.li/ [in German].

9 See: https://digital-liechtenstein.li/application/files/7515/5680/8200/PM_digital_roadmap.pdf [in German].

10 See: https://digital-liechtenstein.li/beitraege/digitale-roadmap-die-regierung-ueberreicht [in German].

11 See: https://www.volksblatt.li/nachrichten/Liechtenstein/Wirtschaft/vb/230270/digitale-roadmap-an-erbprinz-und-regierung-uberreicht [in German].

12 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

13 See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

14 See: https://www.vaterland.li/liechtenstein/vermischtes/glasfaser-als-basis-fuer-5g;art171,400951 [in German].

15 See: https://www.llv.li/inhalt/118050/amtsstellen/marktstatistik [in German].

16 See: https://www.llv.li/inhalt/118043/amtsstellen/glasfaserausbau-ftth [in German].

17 See: https://www.llv.li/inhalt/118044/amtsstellen/warum-ist-der-glasfaserausbau-so-wichtig [in German].

18 See: https://www.supra.net/glasfaser.html [18] https://www.li-life.li/DE/Internet/Internet/tblid/187/Default.asp and https://www.hoi.li/internet/ (exchange rate at 12 October 2020: 1.09782, retrieved from https://www1.oanda.com/lang/de/currency/converter/) [sites in German].

19 Exchange rate as at September 2020.

20 See: https://www.itu.int/en/mediacentre/Documents/Documents/ITU-Measuring_Digital_Development_ICT_Price_Trends_2019.pdf

[21] See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[22] See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[23] See: https://www.llv.li/inhalt/118050/amtsstellen/marktstatistik [in German].

[24] See: https://www.llv.li/inhalt/12117/amtsstellen/mobilfunk [in German].

[25] Exchange rate as at September 2020.

[26] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[27] See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

[28] See: https://www.llv.li/files/srk/bua_051_2020_interpellation-einfuhrung-5g-mobilfunkstandards-in-liechtenstein.pdf [in German].

[29] See: https://www.liewo.li/liechtenstein/wirtschaft/5g-kommt-erst-ende-2020;art173,411124 [in German].

[30] See: https://www.vaterland.li/liechtenstein/wirtschaft/5g-liechtenstein-wartet-ab;art173,371703 [in German].

[31] See: https://www.landtag.li/kleineanfragenprint.aspx?id=15518 [in German].

[32] See: https://www.llv.li/inhalt/118044/amtsstellen/warum-ist-der-glasfaserausbau-so-wichtig [in German].

[33] See: https://www.landtag.li/kleineanfragenprint.aspx?id=15518 [in German].

[34] See: https://www.vaterland.li/liechtenstein/wirtschaft/5g-liechtenstein-wartet-ab;art173,371703 [in German]

[35] See: https://www.llv.li/files/ak/pdf-llv-ak-frequenzzuweisungsplan.pdf

[36] See: https://www.gesetze.li/chrono/2008199000 [in German]

[37] See: http://www.fao.org/faolex/results/details/es/c/LEX-FAOC130736/

[38] See: http://www.emfrf.com/liechtenstein-reduces-rf-exposure-limits/

[39] See: https://www.llv.li/files/srk/bua_051_2020_interpellation-einfuhrung-5g-mobilfunkstandards-in-liechtenstein.pdf [in German].

[40] See: https://www.landtag.li/kleineanfragenprint.aspx?id=15518 [in German].

[41] See: https://www.volksblatt.li/nachrichten/Liechtenstein/Politik/vb/253977/regierung-will-gesetzesgrundlage-fur-5g-schaffen [in German].

[42] See: https://www.landtag.li/kleineanfragenprint.aspx?id=13556 [in German].

[43] See: https://ligital.li/2018/03/swisscom-kuendigt-5g-auf-ende-jahr-an/ [in German].

[44] See: https://www.lightreading.com/5g/eurobites-ericsson-bags-deutsche-telekom-5g-ran-deal/d/d-id/762558

3.13 Principality of Monaco

3.13.1 ICT background and current status of broadband

The Principality of Monaco has a strong ICT sector characterized by the majority of its population being connected to the Internet. The government continues to prioritize the roll-out of fixed and wireless NGA networks and the deployment of Monaco Telecom's own mobile network to support ICT development in the country.[1]

Unlike in most countries in the Europe region, there is no independent telecommunication regulator in Monaco, but the Department of Platforms and Digital Resources, which is part of the government's General Secretariat, is charged with regulating the telecommunication market in the country.

Monaco does not have a national broadband strategy, but in April 2019 the government implemented the 'Extended Monaco: Smart Principality' programme as the Monegasque model for the digital world. Led by a cross-disciplinary authority, the Digital Transition Office, the programme's overarching vision combines the positive benefits afforded by digital technology and links them to matters of public policy and sustainable economic development until 2022. In other words, the programme sets out to take advantage of the enormous potential offered by digital technology and ensure that it directly benefits the Monegasque population.[2]

It is the government's view that by liberating Monaco from its territorial constraints, digital technology is an opportunity to embark on a new development cycle and to play a more prominent role alongside other global cities.[3] The areas of interest covered by 'Extended Monaco' include smart city, e-health, e-education, infrastructures, fintech, and initiatives related to e-government.[4] The 'Extended Monaco' programme is based on three main pillars: i) Enhancing quality of life; ii) Inaugurating a new cycle of economic prosperity; and iii) Boosting the value of the civil service.

In terms of digital-driven economic growth, the programme focuses on the following strategies and actions:[5]

1) Provide companies in the Principality with a framework that is conducive to capturing all the potential of digital technology:

- by equipping itself with large digital infrastructures such as 5G and fibre throughout its entire territory;
- by guaranteeing security and sovereignty;
- by adapting Monaco's legislative framework to facilitate the development of digital technology;
- by adapting legislation – three laws, in particular, were enacted in 2019, enshrining the blockchain, digital identity and digitalization concepts;
- by adopting a strategic State approach, with for example the Monaco Government initiating and driving digital technology-based economic growth initiatives or attracting digital and industrial partners.

2) Boost and perpetuate the Principality's current economic model:

- by contributing to the Principality's events strategy, for example by increasing the impact of key events such as the Grand Prix or the Yacht Show;

- by encouraging companies that enjoy a monopoly (SBM, SMEG, Monaco Telecom, CAM, etc.) to develop new services via digital technology.

3) Create new, highly targeted growth drivers for the digital sector in the Principality:

- by focusing on the technologies of the future in tandem with leading sectors in Monaco (real estate, wealth management, luxury, yachting, sport, business tourism) through the creation of financing structures or the setting up of dedicated start-ups via Monaco Tech, Monaco's business incubator;
- by attracting innovative and ethical companies through new funding methods such as Initial Coin Offerings.

Additionally, in the context of the COVID-19 global pandemic, the Ministry of State recently announced that the government is working on a digital resilience strategy. To succeed in such a strategy, the Principality will need to build new infrastructure, create and provide access to a local and international digital ecosystem and develop services that ensure continuity for public policies. The action plan will have three main strands: i) Developing digital infrastructure, including telecom networks and the cloud; ii) Optimizing digital technology for use by private users and businesses (smartphone equipment rate, availability of electronic signatures and stamps, e-commerce platforms, etc.); and iii) Improving the State's digital maturity (education, health, government, cybersecurity, etc.).[6]

3.13.2 Broadband and mobile telecommunication data

ITU data show that 97.1 per cent of individuals in Monaco used the Internet in 2017.[7]In 2010, the corresponding ITU figure for the country was 75 per cent, and in 2000, 36.5 per cent. In 2019, 77.8 per cent of main residencies in the country had some form of Internet access.[8] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 52.6.[9]

By virtue of an agreement with the Principality of Monaco, Monaco Telecom (a member of Eurecom in France) holds the monopoly on landline telephone services, fixed-Internet access and TV services. In the past, the telephone network used to be fully owned by the State, which now owns 45 per cent.[10] Monaco Telecom is aiming to equip 100 per cent of eligible buildings with fibre-optic cables by the year 2023.[11] In March 2019, the local press reported that Monaco Telecom had executed a six-month long optical fibre-network roll-out in the Fleur district of Monaco. The three-part project has been handled by Monaco Telecom, the Monegasque Water Company and the Urban Planning Department for Sanitation. By 2025, the government aims to provide full FTTH coverage.[12] In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants stood at 86.7.[13] Even though mobile-phone penetration has been high since the early 2000s, steady growth has been observed, particularly after 2008.[14] Moreover, the number of active mobile-broadband subscriptions was 86.4 per 100 inhabitants in 2019.[15] Monaco Telecom is the one national MNO that dominates the mobile sector, although French MNOs such as Orange, Bouygues Telecom, SFR and Free are also widely available in the country. In 2019, mobile-broadband Internet traffic within Monaco totalled 0.001 exabytes according to ITU.[16]

Over the past year, Monaco Telecom has invested heavily in revamping its networks, pioneering the deployment of countrywide infrastructures and services, such as mobile coverage in LTE+ technology as fast as 1 Gbit/s, a fixed-Internet data speed of 1 Gbit/s, and high-security data transfer across the operator's networks.[17] Nowadays, 3G and 4G/LTE are widely available in the country, with 100 per cent coverage.[18] Although the cost of the mobile data basket remains

unavailable on account of the lack of data on GNI per capita for Monaco, a monthly package with a 20 GB Internet data allowance cost USD 47.23 (EUR 39.86)[19] in 2019.[20] Given Monaco Telecom's small area of operation and the intense level of competition it faces from French operators, the operator is allowed to practise around 30 per cent higher prices than French operators according to government regulations.[21]

3.13.3 Current progress on 5G: Consultations and national strategies

In 2019, Monaco became the first State in Europe to have full and operational commercial 5G network coverage in its national territory,[22] over an area of an approximately 2 square kilometres, with 27 antennas deployed as at October 2020.[23]

While the country does not have a 5G strategy, 5G connectivity is the first pillar of the 'Extended Monaco' programme, alongside cloud services and fibre-optic development. Launched in April 2019, 'Extended Monaco' designates the deployment of infrastructure and public-policy initiatives across all relevant sectors such as, *inter alia*, health, education and smart city, as priorities until at least 2022.[24]

Through this programme, the government recognizes the need to build a cross-cutting architectural infrastructure foundation that will support digital transformation in the country, focusing on the quick development of an ecosystem that meets leading international standards, and will foster integration with other relevant vertical markets that ultimately will bring further economic development in Monaco.

In February 2020, the government published a user guide to 5G, answering the most frequently asked questions on the 5G roll-out and providing information on how these networks are set to benefit the population as well as both private and public stakeholders.[25]

3.13.4 Spectrum assignment for 5G and market development

As at October 2020, no public information or document on spectrum assignment for 5G is available in Monaco. However, it has been reported that 5G is being deployed on frequencies similar to those used for 4G and Wi-Fi.[26]

3.13.5 Electromagnetic field levels and implementation dynamics

In Monaco, the Smart Nation Department, which is operated under the General Secretariat of the Ministry of State, is responsible for ensuring that emissions from the Principality's radio networks comply with the regulatory thresholds. The department takes regular measurements across the Principality, focusing particularly on schools, healthcare institutions and retirement homes.[27]

Having regard to Law No. 928 of 8 December 1972, Ordinance No. 3.020 of 26 November 2010, pertaining to limits for the public's exposure to EMF, sets a global limit of 6 V/m on average for all radio frequencies, and a second, lower limit of 4 V/m for public mobile-phone networks (2G, 3G, 4G and 5G).[28] These are more restrictive EMF limits than the international standard published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the European Union's recommendation (28 to 87 V/m).[29]

In the 100 kHz and 6 GHz frequency bands, this limit value is 4.5 times below the lowest limit recommended by WHO, which is 28 V/m. Furthermore, an additional restriction of 4 V/m[30] was introduced for emissions from mobile-phone base stations (set at 6 V/m for places inside buildings).[31]

The measurements carried out by the Directorate for the Development of Digital Uses (DDUN) are available to the public in the form of an interactive map,[32] thus providing information on all the radio transmission sites constituting the public communication networks in the Principality, encompassing both broadcasting and mobile telephony.[33] This interactive site uses the latest EMF measurements carried out by DDUN), which are regularly updated, and which underline compliance with the Principality's exposure limits.[34]

3.13.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In September 2018, Monaco Telecom tested 5G services in conjunction with Huawei as part of an equipment-supply deal, extending previous collaboration agreements between these two private stakeholders. In this context, the operator showcased a 5G-connected unmanned aerial vehicle (UAV) broadcasting live high-resolution 360-degree panoramic images through a virtual reality headset.[35] Monaco Telecom also announced that the first 5G antennas have been installed in the Port Hercule area and that extended network coverage was under way.[36]

In February 2019, Monaco Telecom and Huawei signed an MoU to accelerate the deployment of smart-city-related projects in the Principality in the context of Monaco's '5G Smart Nation' project.[37] This strategic agreement sets out collaboration on projects in the fields of IoT, big data and cloud services.[38] The MoU also stipulated that Monaco Telecom will be able to rely on Huawei's 5G and NB-IoT networks already deployed in Monaco as well as on the test cloud platform based in Düsseldorf, Germany.[39] Utilizing Huawei's networks, Monaco Telecom switched on 5G in July 2019.[40]

In September 2019, the Belgian operator BICS announced the establishment of a live 5G data roaming service between Monaco Telecom and an Italian telecommunication company using BICS's 5G global IPX network.[41]

In addition to the 5G trials and pre-commercial announcements by the country's only MNO, local press has reported in October 2020 that companies such as Vizua 3D entertainment, an augmented reality start-up based in the MonacoTech Incubator, as well as public entities such as Monaco's firefighters working on reconnaissance drones with high-definition cameras, have plans to deploy 5G services shortly.[42]

Other projects related to smart cities undertaken by local start-ups were also reported within the context of a self-driving eco-bus and remote-control installations for better energy efficiency.[43]

Endnotes

1 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

2 See: https://monaconow.com/extended-monaco-the-principality-in-the-digital-world/

3 See: https://extendedmonaco.com/wp-content/uploads/2019/10/1014_DVCO_1904152_PDF_Telechargeable_GB_SR.pdf

4 Ibid.

5 Ibid.

6 See: https://extendedmonaco.com/en/project/la-resilience-numerique-une-necessite-dans-le-monde-dapres/

7 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

8 See: https://www.monacostatistics.mc/content/download/479752/5477820/file/Key%20figures%202019.pdf

9 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

10 See: https://www.brodynt.com/business-internet-connectivity-in-monaco/

11 See: https://monacolife.net/major-disruptions-amid-fiber-optic-extension/

12 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

13 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

14 See: https://www.monacostatistics.mc/content/download/446317/5060895/file/Rapport%20Recensement%202016.pdf [in French].

15 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

17 See: https://www.monaco-telecom.mc/en/enterprise/key-figures.html

18 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

19 Exchange rate as at September 2020.

20 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

21 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

[22] See: https://extendedmonaco.com/en/project/principality-of-monaco-is-worlds-first-country-to-have-full-operational-5g-coverage/

[23] Ibid.

[24] See: https://extendedmonaco.com/en/extended-monaco-programme-unveiled/

[25] https://en.gouv.mc/Portail-du-Gouvernement/Policy-Practice/A-Modern-State/News/User-Guide-to-5G

[26] See: https://en.gouv.mc/content/download/475991/5426699/file/05_depliant_sante_5G_GB_BAT.pdf

[27] Ibid.

[28] Ibid.

[29] See: https://www.meb.mc/en/news/5g-providing-a-foundation-for-the-smart-principality

[30] See: https://electromagnetichealth.org/electromagnetic-health-blog/monaco/

[31] See: https://www.gouv.mc/Portail-du-Gouvernement/Action-Gouvernementale/L-Environnement/Monaco-cite-durable/Carte-des-Mesures-Electromagnetiques

[32] See: https://cartoradio.mc/search/Afficher%20les%20sites,%20les%20mesures%20ou%20le%20cadastre=CartoRadio_Mesures_Exposition_Vue_2881+Mesure+mesure/@3178895.98451,2056411.50855,3

[33] See: https://cartoradio.mc/

[34] See: https://monacodailynews.com/2020/02/17/website-indicates-monacos-electromagnetic-fields/

[35] See: https://www.huawei.com/en/news/2018/9/huawei-monaco-telecom-5g

[36] See: https://spectrum.ieee.org/static/the-race-to-5g-technology

[37] See: https://www.commsupdate.com/articles/2019/06/03/monaco-telecom-to-proceed-with-5g-launch-this-summer-using-huawei-technology/

[38] See: https://www.monaco-telecom.mc/en/press/news/5g-smart-nation-uk.html

[39] See: https://www.huawei.com/en/news/2019/2/monaco-telecom-huawei-out-mou-5g-nation

[40] See: https://www.commsupdate.com/articles/2019/07/10/monaco-rolls-out-huawei-built-5g-network/

[41] See: https://bics.com/news/bics-enables-the-launch-of-monaco-telecoms-first-5g-roaming-service-in-europe/

[42] See: https://www.webtimemedias.com/article/5g-un-apres-premier-bilan-mitige-pour-monaco-telecom [in French].

[43] See: https://monacolife.net/fully-5g-connected/

3.14 Norway

3.14.1 ICT background and current status of broadband

Norway possesses one of the most advanced telecommunication markets in Europe. The country boasts penetration rates for fixed and mobile services well above the regional average, in addition to having a mature digital media sector. As a member of the European Economic Area (EEA), Norway has adhered to EU electronic communication directives, which has paved the way for further economic expansion of ICT in the country by private stakeholders. Since the inception of the *e*Norway action plan in 2000, ICT has been an integral part of government policies in the transition towards an information society, laying the foundation for subsequent ICT-related government programmes.[1]

In 2016, the Norwegian Ministry of Local Government and Modernization published the 'Digital Agenda for Norway' [2] in the form of a white paper, although initiatives on broadband have existed in Norway since 2005.[3] In the 2016 Digital Agenda, the government announced its intention to enable Norway to exploit the opportunities opened up by ICTs.[4] Furthermore, the white paper is driven by two key objectives: to ensure a user-centric and efficient public administration, and to achieve value creation and inclusion. The five key priorities articulated in the agenda include the following: i) A user-centric focus; ii) ICT should constitute a significant input factor for innovation and productivity; iii) Strengthened digital competence and inclusion; iv) Effective digitalization of the public sector; and v) Sound data protection and information security.[5]

In other words, the Digital Agenda for Norway describes how better access to digital literacy in the public and private sectors, regulation better adapted to a digital society and a public sector as a demanding customer will serve as policy instruments to achieve Norway's goals for the information society.

In particular reference to mobile and broadband for growth and inclusion, the Norwegian Government has set the following goals for future electronic communication policy:[6]

- 90 per cent of all households shall have access to at least 100 Mbit/s by 2020, based on a commercial roll-out in the market.
- The long-term goal is that all households shall have access to high-speed broadband.
- Mobile coverage where people live, work and travel.
- Good electronic communication networks shall be a competitive advantage for business and industry nationwide.
- The electronic communication authority shall map demand for and access to infrastructure that can be used by data centres.
- It shall be easy to deploy broadband networks.
- The regulations for laying broadband cables along municipal and county roads shall be as uniform as possible.
- Electronic communication service providers shall have fast access to available frequency resources to meet their needs.

Norway's ICT policy also reinforces the importance of a robust broadband infrastructure and widespread digital literacy among the population. The three main priority areas of that policy are to:[7]

- Ensure an information society for all, including by facilitating the supply and distribution of high-speed broadband, increasing digital literacy in the population and ensuring a universal design of ICTs.
- Contribute to innovation and value creation in business, by facilitating the development and use of services based on digital content, promoting a digital culture industry, making public data available for further use and promoting smart, energy-efficient ICT solutions in transport, energy and construction. The digitalization of business processes and the development of innovative solutions for the healthcare sector also add significant value.
- Digitalize public services, by coordinating ICT projects that have an impact across the public sector, promoting the development of self-service solutions, adapting regulations to promote digital solutions and ensuring that common ICT solutions are established and made available to the rest of management.

While Norway enjoys strong and affordable 4G coverage and its 3G networks are set to be phased out by 2025, significant investments and developments have occurred in the fibre sector, as there are more emerging key players in the country. As at October 2020, at least nine new submarine fibre projects are in progress, which are expected to be finalized by 2022,[8] representing an extension of more than 13 000 km.[9] This fits into the more than EUR 316.7 million expected to be invested in new submarine cable systems in the Nordic region by 2023. As a result, it is likely that the country will find itself equipped with a wider set of economic options for different routes going in and out of the country,[10] thus reducing Norway's reliance on existing networks coming out of other Nordic countries.[11]

In face of the COVID-19 pandemic, many Norwegian municipalities have successfully adapted to digital teaching. As is the case in other countries in the region, however, not all municipalities have enjoyed equal access to infrastructure, equipment and resources. To mitigate the upcoming phases of the pandemic, the Norwegian Government submitted its proposal for a revised national budget for 2020 on 12 May 2020. It includes a proposal to increase the budget for digital teaching by EUR 12.95 million.[12]

3.14.2 Broadband and mobile telecommunication data

ITU data show that 98 per cent of individuals in Norway used the Internet in 2019,[13] with practically all citizens connected to broadband.[14] In 2010, the corresponding ITU figure for the country was 93.4 per cent, and 52 per cent in 2000.[15] According to ITU data, the estimated proportion of households with Internet access at home in 2019 is 98 per cent.[16]

In 2018, the number of fixed-broadband subscriptions per 100 inhabitants stood at 41.3.[17] In 2015, the country's Internet services relied on nationwide DSL coverage and more than 100 local fibre providers. However, since 2016, DSL technology has been steadily decreasing while fibre coverage is growing. The operator indicated that it aims to convert all customers on its copper network to fibre by 2023.[18] In response to demand and in view of the stated goal of the Norwegian Communications Authority (Nkom) to expand broadband infrastructure in Norway, fibre has become a common technology for Internet access and is available in almost every city in the country,[19] offering a variety of services including access to the delivery of pay-TV.[20]

In 2018, Norwegian residential fibre connections passed the 1 million mark for the first time.[21] In October 2020, Nkom published its annual broadband survey, reporting that 74 per cent of

households had access to fibre broadband as of June 2020. Nkom highlighted the development of fibre-based technology in less populated areas in Norway, noting particularly that 55 per cent of residential households in rural regions now have access to fibre-enabled broadband, up from the figure of 45 per cent reported at mid-2019. Largely due to the revamped fibre-network coverage, the regulator also reported that 98 per cent of Norway's households had access to speeds of at least 30 Mbit/s, and that the number enjoying connectivity of above 100 Mbit/s is steadily growing.[22] Moreover, the regulator recently selected Telia Carrier to build a secure diverse fibre route to facilitate greater geographical distribution of traffic between Norway and continental Europe, which is set to be ready for service by the end of 2021.[23] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019, while Norway's corresponded to 0.7 per cent for an unlimited data allowance in 2019, ranking Norway among the top ten countries in Europe.[24]

According to ITU data, the number of active mobile-cellular subscriptions per 100 inhabitants in 2018 was of 107.2,[25] while mobile-broadband subscriptions per 100 inhabitants for the same year came to 99.2.[26] There are three major MNOs that dominate the market in Norway: Telenor, Telia (formerly NetCom before being rebranded in 2016) and Ice Norway. Over the past years, significant investment has been made in extending 4G infrastructure by private stakeholders.[27] In terms of 4G coverage, Telenor and Telia provide outstanding network coverage throughout the country, which makes Norway one of the countries with the highest rates of 3G and LTE/4G coverage, with both networks covering 99.9 per cent of the population.[28] In 2018, mobile-broadband Internet traffic within Norway totalled 0.298 exabytes.[29]

Furthermore, Norwegian operators have been particularly efficient in encouraging the adoption of VoLTE, enabling subsequent re-farming of the 3G spectrum to 4G. For example, Telenor announced that it has plans to shut down the 3G network entirely by the end of 2020[30] in order to provide better service on its 4G network.[31] The country's mobile-data basket cost corresponded to 0.4 per cent of GNI per capita in 2019 for a monthly allowance of 5 GB, as against the Europe region average of 0.8 per cent in the same year.[32]

3.14.3 Current progress on 5G: Consultations and national strategies

Nkom began plans to clear the 700 MHz 5G frequencies in 2017, making Norway one of the first countries headed towards 5G development.[33] As listed in the State budget, this move entailed an approximate cost of EUR 13.9 million for Norway,[34] paving the way for the first 5G commercial activities in the country in March 2017.[35]

Around the same time, the early stages of the Nordic 5G Action Plan were also put in place as a result of discussion among the Nordic-Baltic States on how their governments could better support and facilitate rapid development of 5G in the region. In this early agreement, Norway and co-signatories decided to:[36]

- Expedite the availability of more spectrum necessary for testing, research and the commercial roll-out of 5G networks.
- Cooperate with industry in pilots on 5G services through public-private partnerships, e.g. through universities or public enterprises.
- Support innovation and development of products and services making use of 5G networks.
- Encourage participation from universities and public research programmes in the development of new uses of 5G services.
- Promote early deployment in major urban areas and along major transport paths.

Although the country does not have a national strategy specifically targeting 5G, Norway articulates some of its objectives on 5G network development through the 'National Strategy for Artificial Intelligence', which was prepared by the Ministry of Local Government and Modernization in February 2019 for both the private and public sectors.[37]

In the AI strategy, 5G is regarded by the Norwegian Government as a vital enabling infrastructural technology for AI and a priority investment area.[38] Development of IoT as well as 5G-enabled products in the Norwegian mobile market is considered as an essential component for the development of AI. In other words, the strategy highlights that 5G infrastructure is set to play a crucial role in implementing full-scale introduction and use of IoT and other AI-enabled services across a variety of sectors such as transport, healthcare and smart cities. While 5G deployment is largely in the hands of private-sector operators such as Telia – which plans to develop 5G network by the end of 2023[39] – the Norwegian Government indicates that it plans to facilitate the rapid roll-out of 5G in the country.

Additionally, Nordic Council cooperation in the field of 5G – comprising Denmark, Finland, Iceland, Norway and Sweden as well as the Faroe Islands, Greenland and Aland[40] – is another component of Norway's 5G strategy. In 2018, the Nordic ministers signed a letter of intent (LoI) for the Nordic region to be first and most integrated 5G-region in the world.[41] The LoI acknowledges that the deployment of 5G will require substantial investments and an appropriate regulatory framework both in national contexts and towards a common Nordic 5G space.[42] This agreement is also aligned with other Nordic cooperation on the adoption of IoT and other emerging technologies, such as the Nordic Smart City Network,[43] which helps governments create best practices for smart-city projects and urban development.[44]

To achieve this goal, Norway agreed to cooperate closely with other Nordic countries to set up a common action plan for early adoption of 5G technology across the Nordic region. The action plan will:[45]

- Encourage the development of new testing facilities, including testbeds.
- Ensure the technical coordination of 5G frequency bands within the region.
- Remove obstacles to the expansion of 5G network, in particular the deployment of base stations and antennas.
- Encourage and monitor the development of 5G, specifically for certain sectors such as transport, mission-critical communications and advanced automation in the manufacturing industry, as well as the energy sector.

Norway is also instrumental in the EU project 5G VINNI, where Telenor, Ericsson Norway and Huawei Norway, among others, are pushing 5G technology development.[46]

3.14.4 Spectrum assignment for 5G and market development

In April 2019, Nkom cited the following frequency bands as relevant for allocation to mobile communications and 5G in the coming years: 738–758 MHz (700 MHz SDL); 1 427–1 518 MHz (1 500 MHz SDL); 2 300–2 400 MHz (2.3 GHz); 2 500–2 690 MHz (2.6 GHz); 3 400–3 800 MHz (3.6 GHz); and 24 250–27 500 MHz (26 GHz).[47]

Between June and August 2019, Nkom completed a consultation[48] on frequency resources for mobile communications and 5G.[49] The first 5G auction in Norway took place in June 2019, with the allocation of the 700 MHz band. Telia, Telenor and Ice won spectrum in this auction.

Then, in May 2020, the 28 GHz (n257) and the 38 GHz (n260) bands were auctioned to these operators. Auction for the 2.6-3.6 GHz band is set to occur sometime in 2021.[50]

The process ended with the following assignments:[51]

- Telenor was assigned 2 × 10 MHz of spectrum in the 700 MHz band subject to a coverage obligation on main highways, for a total auction price of EUR 16.6 million.
- Telia was assigned 2 × 10 MHz of spectrum in the 700 MHz band subject to a coverage obligation on designated railway sections, for a total auction price of EUR 20.2 million.
- Ice was assigned 2 × 10 MHz of spectrum in the 700 MHz band and 2 × 15 MHz in the 2.1 GHz band, for a total auction price of EUR 31.2 million.

In September 2019, Nkom established a frequency compass, which is a roadmap for frequency bands for mobile communications and 5G. The regulator states that its plans for allocations and harmonization are in line with international guidelines. Norway is part of the frequency harmonization within the EU, through the EEA agreement, in respect of which the country engages as an observer in certain cooperation groups such as the Radio Spectrum Committee and Radio Spectrum Policy Group.

Nkom has suggested there are grounds for allocating 300 MHz in the 3.6 GHz band under national permits, with 100 MHz to be issued under regional/local licences, although an alternative distribution method being examined is that all 3.6 GHz spectrum would be offered on a nationwide basis, with 2.3 GHz frequencies to be issued on a regional/local basis.[52] Following a consultation on this approach, the regulator started assessing the feedback and inputs in order to continue the preparations for further allocations going forward.[53]

With negotiations on standardization and technical prerequisites beginning 2020, observations on these frequency ranges have been conducted by Nkom:[54]

- 700 MHz: Available to mobile operators today, and being considered. Frequencies with long range, but lower data capacity. 700 MHz SDL is the former broadcast band that is now harmonized for mobile communications.
- 3.6–3.8 GHz: Most important pioneer band for 5G in Europe. In Norway, these frequencies will be auctioned off in 2021, but the mobile operators have test permits today, and test areas are being built where these will be used. The frequencies have a shorter range and high data capacity and are currently used for fixed-mobile broadband and 5G testing.
- 26 GHz: Used today for radio link and testing of 5G. The use will probably be to create smaller, delimited areas with good coverage in Norway. Short range and very high data capacity.

Existing licences in the 2.3 GHz, 2.6 GHz and 3.6 GHz bands expire on 31 December 2022. In the 700 MHz SDL, 1 500 MHz SDL and 26 GHz bands, the current licences and use are extended until a possible allocation has been decided.[55]

Finally, the regulator is deliberating on setting a spectrum cap for frequencies across all three bands, with consideration also being given to whether a 100 MHz cap should apply in the 3.6 GHz band specifically. In addition to this, the regulator also plans to set a starting price of approximately EUR 2.2 million per block and a frequency limit of 80 MHz.[56]

3.14.5 Electromagnetic field levels and implementation dynamics

Norway follows the EMF limits recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).[57] Since 2013, Nkom has performed outdoor measurements of

EMF in Norway and today continues to monitor EMF-related subjects in regard to the recent advances in telecommunications. In 2016, the government implemented the Norwegian Occupational Safety Regulation, which was enacted within the framework of Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from EMF.[58]

Nkom regularly monitors EMF exposure in Norway and maps out the exposure from various transmitters to guarantee that they are not exceeding the limit values.[59] To facilitate access to EMF information in the country, a radiation calculator is also available on the operator's website, which citizens can use to calculate the exposure level at a given geographic point within the country's territory.[60] More recently, Nkom also published a brochure concerning antenna systems for staff working on the installation of communication equipment who may be exposed to radiation.[61]

As of October 2020, Nkom and the Directorate for Radiation Protection and Nuclear Safety (*Direktoratet for strålevern og atomsikkerhet* – DSA)[62] have produced several information brochures on radiation,[63] the latest coming out in May 2020.[64] Moreover, Nkom dedicated an entire page on its website detailing information on EMF regulations within the 9 kHz-400 GHz frequency range to educate the general public on ongoing debates and the regulator's decisions to be respected by private operators.[65]

Concerning potential health hazards from the use of the highest 5G frequency (26 GHz), DSA points out on its website that similar frequencies have been in use for decades for radars and radio links as well as in countries such as the United States.[66]

Nkom has also conducted surveys in private homes and several schools, kindergartens and other public buildings in the largest cities (Oslo, Kristiansand, Bergen and Trondheim) to gather more information on EMF in the country.[67] Other actions on EMF-related issues have been headed by the Norwegian Institute of Public Health, commissioned by the Ministry of Health as well as the Care Services and the Ministry of Transport and Communication, to educate the Norwegian public on the effects of wireless networks on health.[68]

3.14.6 5G Commercial launches: Announcements, trial cities and digital cross-border corridors

In May 2017, Telenor Group and Huawei jointly announced the first 5G-based E-band multi-user MIMO demonstration in Norway, reaching a maximum speed of 70 Gbit/s.[69] In November 2018, Telenor founded the first Norwegian 5G testbed in Kongsberg,[70] which later received industrial support and now has grown to become a viable 5G innovation hub.[71] Telenor has also been coordinating the 2018 pan-European 5G-VINNI project, an EU-funded initiative within the Horizon 2020 programme which has a budget of EUR 20 million.[72]

In February 2019, the local press reported that 5G tests using the non-standalone 5G variant had begun at the Odeon Oslo movie theatre, which is located within the coverage area of Telia Norway's pilot networks. This cinema is the newest and biggest in the city of Oslo, with 14 halls all equipped with the newest sound and image technology. The location is testing 5G for the delivery of digital movie files, as well as providing Internet access in the cinema's guest Wi-Fi zones in the building. This makes Odeon Oslo the world's first 5G-based movie theatre.[73]

In February 2019, Ice Norway announced that it was building a 5G-ready network in urban areas across Norway based on Nokia AirScale Radio Access technology, with approximately 1 000 5G-ready base stations already deployed. The deployment is part of a multi-year agreement between Ice Norway and Nokia which includes network planning, site acquisition, civil works, deployment and care.[74]

In March 2019, Telenor announced its plans to invest in Trondheim as the first major city in the country to receive 5G. This represents the operator's biggest 5G project. Taking into account the existing partnerships between the municipality, the Norwegian University of Science and Technology and the business community on smart city, 5G is presented as a promising network for residents and a strategic investment focus for the operator.[75]

In September 2019, Telenor launched Scandinavia's largest and 5G pilot in the municipality of Elverum in addition to other pilots in nine further locations in Norway.[76] Through this project, Telenor became the first operator in Norway to integrate 5G into its mobile network, enabling more than 50 pilot customers in the municipality to be connected to the 5G network. Telenor also announced that Ericsson would be contributing to both 5G network equipment[77] and deployment.[78]

In October 2019, Telenor Group and Cisco signed an agreement whereby Cisco declared it would upgrade Telenor Norway's existing mobile core network to deliver 5G in Norway. Since 2010, Cisco has provided core technology to Telenor Norway's 3G and 4G networks. In 2018, the companies upgraded Telenor Norway's core network to provide Scandinavia's first nationwide network for IoT.[79]

Following the same strategy as for 4G deployment in the past, in October 2019 Telenor launched 5G pilots in Longyearbyen, the economic and administrative capital of the Archipelago of Svalbard, thus becoming the world's northernmost 5G pilot. The operator chose the region because Svalbard is a testbed for new technologies. It also illustrates the potentialities and challenges presented by 5G-enabled smart-city projects as an example for mainland Norway. The operator also reported on the development of 5G-powered drones in the Svalbard region for monitoring global-warming effects[80] as well as the use of emergency networks and 360-degree cameras.[81]

In December 2019, after more than a decade of collaboration on 4G, Telenor ceased its collaboration with Huawei and chose Ericsson as the key technology provider for 5G. In the context of the newly-formed partnership, the operator announced that it had carried out extensive security evaluation and considered factors such as technical quality, innovation and modernization of the network. According to Telenor, the use of Huawei network components in Norway will be phased out over a four- to fi-year modernization period.[82] Nevertheless, the press also reported that Huawei would still continue collaboration with Telenor both to maintain the 4G network and also to upgrade to 5G coverage in selected areas of Norway.[83] The Norwegian Government has confirmed that it will not ban Huawei from its network.[84]

Furthermore, in December 2019, the press reported that Ericsson, Telia and the Norwegian University of Science and Technology (NTNU) partnered in the 5G testing of an autonomous ferry, named milliAmpère. Ericsson 5G technology enabled Telia to securely support the large amount of data needed to operate the driverless transport ferry. The milliAmpère vessel was equipped with sensors that recorded its surroundings and controlled the steering system on board via 5G.[85]

In January 2020, Nokia Nuage Networks and Telia launched SD-WAN, the next-generation datacom services for the enterprise market. With SD-WAN, control and operation of the network are simplified as it is separated from underlying infrastructure and hardware and depends solely on the cloud. The companies announced that the new datacom services will utilize their 5G network. [86]

In March 2020, Telenor launched its commercial 5G network in nine different cities and villages across Norway, making it the first mobile operator in the country to offer 5G connection. According to the operator, it was intended that the official opening of Norway's first commercial 5G network would take place in the country's tech capital of Trondheim. However, due to the current situation with COVID-19, Telenor has decided to cancel the event and instead host the opening as a virtual videoconference. [87] The enhanced mobile-broadband services are being delivered in the 3.6 GHz band.[88] Telenor plans to launch 5G services in the capital Oslo and in Bergen, Stavanger and Sandnes by the end of 2020.[89]

In May 2020, Telia Norway launched its commercial 5G network relying on Ericsson's NR radio access network (RAN).[90] Both companies started working on 5G-related development in 2019. The network launch celebrated the coverage of Lillestrøm and parts of Groruddalen in the greater Oslo region as the first areas to benefit from enhanced mobile-broadband services.[91] Pursuant to the agreement, the collaboration also involves the deployment of Ericsson Spectrum Sharing (ESS) software,[92] which enables Telia Norway to share its spectrum between 4G and 5G network.[93] The operator announced that it aims to provide coverage to at least half of the Norwegian population by 2021 and offer nationwide 5G coverage in 2023.[94]

In September 2020, Ice Norway launched a major 5G pilot encompassing seven main sites in the northern region of Tromsø. The operator received a 3.7-3.8 GHz band test licence from the regulator, and it already has a large amount of 5G-ready Nokia base stations, in addition to lab tests reaching speeds of up to 1 Gbit/s. Press reports have indicated that the operator will invite just a few dozen customers to try out the network during the remainder of 2020.[95] The operator said it does not know exactly how long the trial will last but it is likely to run for several months. Customers wishing to participate must have 5G devices that support 3 600 MHz and Ice Norway will probably offer the pilot for routers as well as smartphones.[96] The operator also said that an initial public 5G offering in urban and rural areas is expected during early 2021, using 700 MHz / 2 100 MHz.[97]

Telenor anticipated that during 2021 it will upgrade close to 2 000 5G base stations, while a total of 8 500 base stations are set to be upgraded within the next four to five years.[98]

Endnotes

1 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

2 See: https://www.regjeringen.no/contentassets/07b212c03fee4d0a94234b101c5b8ef0/en-gb/pdfs/digital_agenda_for_norway_in_brief.pdf

3 See: https://en.wikipedia.org/wiki/National_broadband_plan

4 See: https://www.regjeringen.no/en/aktuelt/digital-agenda-for-norway-digitisation-vital-for-welfare-and-jobs/id2484184/

5 See: https://www.regjeringen.no/contentassets/07b212c03fee4d0a94234b101c5b8ef0/en-gb/pdfs/digital_agenda_for_norway_in_brief.pdf

6 See: https://www.regjeringen.no/en/dokumenter/digital-agenda-for-norway-in-brief/id2499897/sec8

7 See: https://joinup.ec.europa.eu/sites/default/files/inline-files/Digital_Government_Factsheets_Norway_2019.pdf

8 Projects under development include: England Cable NO-UK.com; Skagen Fibre East and West; North Sea Connect; Celtic Norse; N0r5ke Viking; Havtor; and others.

9 See: https://greenmountain.no/2020/05/06/fiber-projects-in-norway/

10 Ibid.

11 See: https://www.computerweekly.com/news/252474496/State-backs-Norways-fiber-cable-capacity-building

12 See: https://www.regjeringen.no/en/statsbudsjett/2020/rnb2020/id2715690/

13 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

14 See: https://www.ssb.no/en/statbank/table/11000/tableViewLayout1/

15 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

17 See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Fixed_broadband_2000-2018_Dec2019.xls

18 See: https://www.thefastmode.com/technology-solutions/14123-telenor-norway-aims-to-convert-all-copper-customers-to-fiber-by-2023

19 See: https://www.tutela.com/hubfs/Assets/Nordics%20State%20of%20Mobile%20Networks%20Report%20-%20January%202019.pdf and https://en.wikipedia.org/wiki/Internet_in_Norway#:~:text=Fiber%20is%20also%20almost%20in,place%20with%20support%20for%20it

[20] See: https://www.broadbandtvnews.com/2019/05/14/fibre-takes-command-in-norway/

[21] See: https://www.telecompaper.com/news/norwegian-residential-fibre-connections-exceed-1-mln-for-first-time-in-2018--1292512

[22] See: https://www.commsupdate.com/articles/2020/10/07/nkom-says-74-of-households-now-have-access-to-fibre-as-it-publishes-annual-broadband-survey/

[23] See: https://www.capacitymedia.com/articles/3825948/telia-picks-bulk-for-new-fibre-route-from-norway

[24] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[25] See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Mobile_cellular_2000-2018_Dec2019.xls

[26] See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[27] See: https://www.lifeinnorway.net/the-worlds-fastest-mobile-internet/

[28] See: https://www.tutela.com/hubfs/Assets/Nordics%20State%20of%20Mobile%20Networks%20Report%20-%20January%202019.pdf.

[29] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[30] See: https://tefficient.com/who-has-the-best-network-in-the-nordics-winter-2018-update/

[31] See: https://www.thefastmode.com/investments-and-expansions/13923-telenor-norway-to-start-shuting-down-3g-network-in-2019-to-maintain-2g-for-now#:~:text=Telenor%20Norway%20announced%20that%20it,will%20be%20completed%20in%202020.&text=Following%20the%20closure%20of%20the,connect%20to%20the%202G%20network

[32] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[33] See: https://www.commsupdate.com/articles/2019/11/04/norwegian-regulator-clears-use-of-700mhz-5g-frequencies-from-1-november/

[34] See: https://e24.no/teknologi/i/e8G129/regjeringen-vil-bruke-150-mill-for-aa-sikre-nye-mobilfrekvenser-og-tidligere-5g-start

[35] See: https://www.telenor.com/the-first-steps-towards-5g-in-norway/

[36] See: https://www.regjeringen.no/en/aktuelt/nordisk-baltisk-samarbeid-for-neste-generasjon-mobilnett-5g/id2540561/

[37] See: https://www.regjeringen.no/contentassets/1febbbb2c4fd4b7d92c67ddd353b6ae8/en-gb/pdfs/ki-strategi_en.pdf

[38] See: https://www.regjeringen.no/contentassets/1febbbb2c4fd4b7d92c67ddd353b6ae8/en-gb/pdfs/ki-strategi_en.pdf

[39] See: https://presse.telia.no/pressreleases/telia-norge-skal-bygge-ut-et-nasjonalt-5g-nett-i-loepet-av-2023-2928999

[40] See: https://um.dk/en/foreign-policy/nordic-baltic-cooperation/#:~:text=The%20Nordic%20Council%20of%20Minister's,Nordic%20activities%20lead%20to%20synergies

[41] See: https://www.norden.org/en/declaration/letter-intent-development-5g-nordic-region

[42] See: https://www.government.se/press-releases/2018/05/new-nordic-cooperation-on-5g/

[43] See: https://nscn.eu/

[44] See: https://aithority.com/news/nordic-enterprises-see-5g-networking-as-boost-for-internet-of-things/

[45] See: https://www.government.se/49b8be/globalassets/government/dokument/statsradsberedningen/letter-of-intent--development-of-5g-in-the-nordic-region-.pdf

[46] See: https://www.5g-vinni.eu/

[47] See: https://www.nkom.no/frekvenser-og-elektronisk-utstyr/frekvenser-til-mobilkommunikasjon-og-5g/tildeling-av-frekvenser-til-mobilkommunikasjon-og-5g [in Norwegian].

[48] See: https://www.nkom.no/frekvenser-og-elektronisk-utstyr/frekvenser-til-mobilkommunikasjon-og-5g/tildeling-av-frekvenser-til-mobilkommunikasjon-og-5g/_/attachment/download/ed650cc2-d19e-4083-ba99-9fc968c4b4d2:1ade81420762f505c2728c61ced8c00f0d58bbf6/H%C3%B8ring%20om%20frekvenser%20til%20mobilkommunikasjon%20og%205G.pdf [in Norwegian].

[49] See: https://www.nkom.no/hoeringer/h%C3%B8ring-av-overordnede-rammer-for-5g-tildelingen [in Norwegian].

[50] See: https://www.everythingrf.com/community/5g-frequency-spectrum-in-norway

[51] See: https://www.dotecon.com/news/first-5g-auction-in-norway-completed/

[52] See: https://www.commsupdate.com/articles/2019/06/19/nkom-consulting-on-plans-for-allocating-5g-suitable-spectrum/

[53] Ibid.

[54] See: For more information please contact NKOM: https://www.nkom.no/

[55] See: https://www.nkom.no/frekvenser-og-elektronisk-utstyr/frekvenser-til-mobilkommunikasjon-og-5g/tildeling-av-frekvenser-til-mobilkommunikasjon-og-5g [in Norwegian].

[56] See: https://www.telecomreview.com/index.php/articles/wholesale-and-capacity/3976-norway-prepares-for-2021-spectrum-allocation-auction

[57] See: https://www.nkom.no/fysiske-nett-og-infrastruktur/elektromagnetisk-straling [in Norwegian].

[58] See: https://www.who.int/peh-emf/project/mapnatreps/norway-2017.pdf?ua=1

[59] See: https://www.fhi.no/globalassets/dokumenterfiler/rapporter/2012/low-level-radiofrequency-electromagnetic-fields--an-assessment-of-health-risks-and-evaluation-of-regulatory-practice.-niph-report-20123.pdf

[60] See: https://finnsenderen.no/#/straaling

[61] See: https://issuu.com/nasjonalkommunikasjonsmyndighet/docs/folder_for_installers_about_electromagnetic_radiat?fr=sY2U0NDE1Mjg1NjA

[62] See: https://dsa.no/mobil-og-tradlost/5g-og-radiosignaler

[63] See: https://www.nkom.no/fysiske-nett-og-infrastruktur/elektromagnetisk-straling/_/attachment/download/a6098108-11ed-4cae-a309-28821f0de5e1:1903da3f9b389f5967066209f936c4db91e378d6/Brosjyre%20om%20str%C3%A5ling,%20mai%202020.pdf [in Norwegian]

[64] Ibid.

[65] See: https://www.nkom.no/fysiske-nett-og-infrastruktur/elektromagnetisk-straling [in Norwegian].

[66] See: https://dsa.no/mobil-og-tradlost/5g-og-radiosignaler

[67] See: https://www.nkom.no/fysiske-nett-og-infrastruktur/elektromagnetisk-straling [in Norwegian].

[68] See: http://www.emfexplained.info/?ID=25794

[69] See: https://www.huawei.com/en/news/2017/3/Huawei-Telenor-First-5G-Demo-Norway

[70] See: https://www.computerweekly.com/news/252480126/Telenor-opens-Norways-first-5G-service

[71] See: https://norden.diva-portal.org/smash/get/diva2:1370095/FULLTEXT01.pdfe

[72] See: https://www.telenor.com/how-about-a-slice-of-5g-to-boost-your-business/

[73] See: https://www.zdnet.com/article/norway-weve-just-opened-worlds-first-5g-movie-theater/

[74] See: https://www.ice.no/om-ice/pressemeldinger/ice-norway-ready-for-5g-with-nokia/

[75] See: https://www.telenor.com/media/announcement/trondheim-to-become-norways-biggest-5g-city

[76] See: https://www.forbes.com/sites/forbes-personal-shopper/2020/10/05/marvel-pair-eyewear-superhero-themed-kids-glasses/#7ecbb2ec3c9b

[77] See: https://www.mynewsdesk.com/no/telenor/pressreleases/telenor-aapner-5g-nett-paa-fornebu-2919820 [in Norwegian].

[78] See: https://www.telenor.com/media/press-release/telenor-launches-scandinavias-largest-5g-pilot-in-norway

[79] See: https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=2028213

[80] See: http://norden.diva-portal.org/smash/get/diva2:1370095/FULLTEXT01.pdf

[81] See: https://www.telenor.com/media/announcement/telenor-to-pilot-5g-on-top-of-the-world#:~:text=(Longyearbyen%2C%2014%20October%202019),will%20launch%20on%2020%20October

[82] See: https://www.reuters.com/article/us-telenor-ericsson-huawei-tech-idUSKBN1YH0RM

[83] See: https://www.reuters.com/article/us-telenor-ericsson-huawei-tech/telenor-says-huawei-will-still-play-role-in-5g-rollout-idUSKBN1YJ0BW

[84] See: https://www.reuters.com/article/us-norway-huawei-tech-idUSKBN1WB15G

[85] See: https://www.smart-industry.net/driverless-transport-5g-takes-to-the-waves-with-automated-ferry-in-norway/

[86] See: https://www.nokia.com/telia-norway-launches-sd-wan-simplified-and-centralized-network-control-in-the-cloud/

[87] See: https://www.telenor.com/media/press-release/telenor-opens-first-commercial-5g-network-in-norway#:~:text=Telenor's%205G%20network%20was%20commercially,%2C%20Bergen%2C%20Stavanger%20and%20Sandnes

[88] See: https://www.ericsson.com/en/news/2020/3/5g-switch-in-norway

[89] See: https://5gobservatory.eu/5g-launch-by-telenor-norway-in-march-2020/

[90] See: https://www.teliacompany.com/en/news/news-articles/2020/telia-launches-5g-in-norway/

[91] See: https://www.ericsson.com/en/news/3/2020/telia-norway-launches-commercial-5g-powered-by-ericsson

[92] See: https://www.rcrwireless.com/20200513/carriers/telia-launches-5g-network-norway-ericsson

[93] See: https://finance.yahoo.com/news/ericsson-boosts-5g-network-norway-155903535.html

[94] See: https://www.telecomtv.com/content/5g/telia-norway-launches-commercial-5g-powered-by-ericsson-38634/

[95] See: https://www.telecompaper.com/news/ice-norway-starts-5g-pilot-in-tromso--1354357#:~:text=Norwegian%20mobile%20operator%20Ice%20has,Lillestrom%20and%20parts%20of%20Oslo

[96] See: http://www.gtigroup.org/news/ind/2020-09-27/15569.html

[97] See: https://www.nkom.no/arrangementer/digitalt-frekvensforum/_/attachment/download/50561aa8-7b34-4616-91a0-00c51700baeb:194bf07a1c5b2ec000f4541b9ea3a84d9355b14b/Frekvensforum%2016.09.2020%20-%20Geir%20Andresen%20-%20ICE.pdf

[98] See: https://www.telenor.com/media/press-release/telenor-opens-first-commercial-5g-network-in-norway#:~:text=Telenor's%205G%20network%20was%20commercially,%2C%20Bergen%2C%20Stavanger%20and%20Sandnes

3.15 Republic of San Marino

3.15.1 ICT background and current status of broadband

San Marino has made significant investments in strategic ICT infrastructure in the past few years. The cabling of the country's entire territory with fibre-optic networks by the major telecom providers is well under way. In regard to 5G, San Marino gained global attention when it became the 5G test pioneer location in Europe in 2018. The government is currently working with private stakeholders on the construction of a nationwide public infrastructure for the provision of next-generation mobile services for commercial users.[1]

In 2018, the Institute for Innovation of the Republic of San Marino ('San Marino Innovation'), a private-law company that is exclusively State-owned,[2] launched a series of projects and initiatives entitled 'Digital Agenda' guiding the country's digital development plan. According to Delegated Decree No. 23 of 7 March 2018, San Marino Innovation should:

- study, develop and deploy innovation strategies for the public administration;
- gather, foster and evaluate projects and ideas supporting development of the Sammarinese Digital Agenda;
- propose to State Congress the approval of the plan for digital development and file annually a report on the general status of digital development and implementation of the Sammarinese Digital Agenda.

The Sammarinese Digital Agenda is coordinated with the Digital Agenda for Europe[3] and is geared to fostering priority cooperation between business systems, innovators, public administration, research and San Marino services, through the involvement of all the actors involved.[4]

While the country does not have a broadband strategy, the Sammarinese Digital Agenda presents a series of actions and initiatives focused on structural interventions that are capable of fostering technological innovation while pursuing the objectives of sustainable socio-economic growth in the country.

In addition, the country is at the forefront of distributed ledger technology and has also recently adopted several decrees to facilitate ICT development in the areas of new technologies such as blockchain[5] and others.[6]

3.15.2 Broadband and mobile telecommunication data

ITU data show that 60.2 per cent of individuals in San Marino used the Internet in 2017, with significant growth in the period 2011–2017.[7] In 2009, the corresponding ITU figure for the country was 54.2 per cent, and 48.8 per cent in 2000.[8] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 32.7.[9] While the 2019 ITU Measuring Digital Development ICT Price Trends report does not provide the fixed-broadband basket cost indicator because GNI per capita data are not available for San Marino, an unlimited monthly data allowance cost around USD 19.65 (EUR 16.57)[10] in 2019.[11]

In 2019, the number of active mobile-cellular subscriptions was 114.4 per 100 inhabitants,[12] while the number of broadband subscriptions per 100 inhabitants stood at 131.4 in the same year.[13] Although the penetration of mobile phones has been high since the early 2000s, steady growth has been observed after 2008.[14] Despite the small size of its territory, there are three

major MNOs in San Marino: San Marino Telecom (SMT), Telefonia Mobile Sammarinese (TMS), and Telecom Italia (TIM) San Marino. Additionally, Italy's major operators such as Illiad, TIM, Vodafone and Wind Tre are also available in San Marino's territory.[15] Nowadays, 3G and LTE/4G are widely available in the country, with 99 per cent population coverage according to ITU data.[16]

3.15.3 Current progress on 5G: Consultations and national strategies

As early as 2017, the Government of San Marino started engaging with public-private cooperation agreements to replace 4G to 5G networks in the country, with the goal of becoming Europe's first nation to have full 5G coverage ahead of others in the region.[17] Despite these early 5G-related initiatives, the country does not have a national strategy on 5G. Since the country's territory only consists of 61 square kilometres and has more relaxed laws on airwaves, some operators claim that it is a far more suitable testing ground for 5G than surrounding Italy.[18]

However, the local press reported that the government's strategies on 5G are likely to focus on banking and tourism, two very active sectors in San Marino promising a significant economic return in the long run. Other areas of possible focus include industry 4.0, public security and smart city.[19]

3.15.4 Spectrum assignment for 5G and market development

There is no public information available from the Sammarinese regulator concerning 5G spectrum assignment plans in the country. However, the key spectrum to be auctioned is in the 3.5 GHz and 26 GHz bands.[20]

The local press has reported that TIM, for example, will run on 3.5 GHz spectrum while it tests 26 GHz transmission in Turin, Italy, with the hope of rolling out these frequencies in San Marino.[21]

3.15.5 Electromagnetic field levels and implementation dynamics

As at October 2020, no public information on EMF limits is available in San Marino.

3.15.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

In July 2017, TIM announced that San Marino was in the operator's sights to become Europe's first country with an operating mobile network. On that occasion, both TIM and the Government of San Marino signed an MoU, describing TIM's engagement in updating the mobile sites of its network in the country with 4.5G.

The MoU articulated the introduction of some of the features of 5G, such as evolved mast towers (MIMO 4x4), carrier aggregation, superior modulation and cloud architecture, as well as introducing 'small cells' using small, low-power masts with low environmental impact in the principal streets and piazzas of the historical centre of the San Marino, a UNESCO world heritage site.[22]

The technology plan in the MoU included doubling the number of existing mobile sites and installing several dozen 'small cells', linked by optical fibre and distributed throughout the whole of the territory of San Marino. Among the expected services originating from the 2017 MoU, it was established that TIM was set to supply to the San Marino Government with new-generation

services linked to smart city. The MoU also encompassed remote surveillance solutions in extensive areas of the territory, virtual reality to support tourism and, through the introduction of 5G technologies in the production processes used in its manufacturing industry, novel services to develop Industry 4.0 in the San Marino area.[23]

Given San Marino's small territorial dimensions, the early stages of 5G roll-out in the country included the deployment of performance tests of network equipment and applications to help refine the definition of 5G standards[24] and fix any issues before the roll-out in neighbouring Italy, one of TIM's most active markets, and in wider Europe.[25] It is within this context that TIM and LG also signed a collaboration agreement focused on the development of 5G in Italy. This partnership aims to enhance the innovation capacity of these private stakeholders in the development of 5G in the region.[26]

In May 2018, TIM conducted a live demonstration of 5G in the 26 GHz band in the country[27] ahead of full commercial launch.[28] The test allowed users to stream live video using a device featuring a Qualcomm Snapdragon X50 5G modem.[29]

In September 2018, the operator announced that it had turned on the first full 3GPP Rel15 standard 5G site in the region of Faetano, using the 3.5 GHz frequency band, in collaboration with Nokia.[30] As part of the TIM-Nokia agreement, the private stakeholders managed to cover nearly the entire territory, in addition to deploying eight macro sites operating antennas at 3.5 GHz and 26 GHz in the country, with all locations being equipped with Ma-MIMO technology as well as beamforming.[31]

In October 2018, the operator activated a 5G antenna in Serravalle Stadio, also using the 3GPP Rel15 standard in the 3.5 GHz frequency band. This is the site that services the whole San Marino Rally Village area, and will support the various applications developed by TIM and Nokia during the competition, showcasing 360° high-definition cameras, virtual-reality headsets, the potentialities and power of the 'TIM Streaming' broadcasting platform and 5G-enabled opportunities for 'virtual tourism'.[32]

In December 2018, TIM signed an agreement with Nokia to foster 5G development in San Marino.[33] As a result, TIM confirmed in late 2018 that it had switched on 5G in San Marino[34] through Nokia's New Radio (NR) interface, making San Marino the first country in the world to activate 5G for commercial tests.[35]

Endnotes

1 See: https://news.itu.int/how-san-marino-is-leveraging-emerging-technologies/

2 See: https://www.worldcommercereview.com/publications/article_pdf/1627

3 See: https://www.europarl.europa.eu/factsheets/en/sheet/64/digital-agenda-for-europe

4 See: https://www.sanmarinoinnovation.com/eng-agenda-digitale

5 See: https://www.sanmarinoinnovation.com/sanmarinoblockchain

6 See: http://www.worldcommercereview.com/publications/article_pdf/1627

7 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

8 Ibid.

9 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

10 Exchange rate as at September 2020.

11 See: https://www.itu.int/en/mediacentre/Documents/Documents/ITU-Measuring_Digital_Development_ICT_Price_Trends_2019.pdf

12 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

13 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

14 See: https://www.monacostatistics.mc/content/download/446317/5060895/file/Rapport%20Recensement%202016.pdf

15 See: https://en.wikipedia.org/wiki/Telecommunications_in_San_Marino

16 See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

17 See: https://www1.folha.uol.com.br/tec/2017/07/1901927-san-marino-sera-o-1-pais-europeu-a-implementar-rede-de-internet-5g.shtml [in Italian].

18 See: https://operatorwatch.3g4g.co.uk/2018/08/san-marino-launches-first-nationwide-5g.html

19 See: https://www.telesintese.com.br/san-marino-e-primeiro-pais-da-europa-com-5g-ativado/ [in Italian].

20 See: https://blog.telegeography.com/a-guide-to-5g-spectrum-auctions-in-western-europe-italy-greece-spain-portugal-san-marino

21 See: https:/www.rcrwireless.com/20180904/5g/tim-5g-san-marino

22 See: https://www.gruppotim.it/en/press-archive/market/2017/TIM-Repubblica-San-Marino-MoU-5G-ENG.html

[23] Ibid.

[24] See: https://www.fiercewireless.com/wireless/san-marino-claims-title-for-first-state-europe-to-get-5g

[25] See: https://eu.smartcitiescouncil.com/article/europes-first-5g-state-san-marino

[26] See: https://www.rcrwireless.com/20181218/5g/tim-nokia-complete-full-5g-coverage-san-marino

[27] See: https://telecoms.com/489917/tim-nokia-and-qualcomm-do-some-5g-stuff-in-san-marino/

[28] See: https://ecfsapi.fcc.gov/file/1040331077123/Analysys%20Mason%20-%20Global%20Race%20to%205G%20Update.pdf

[29] See: https://www.commsupdate.com/articles/2018/05/24/tim-conducts-live-5g-demo-in-san-marino/

[30] See: https://www.gruppotim.it/en/press-archive/market/2018/NS-TIM-Nokia-SanMarino-40918.html

[31] See: https://eu.smartcitiescouncil.com/article/europes-first-5g-state-san-marino

[32] See: https://www.thefastmode.com/technology-solutions/13511-tim-turns-on-2nd-5g-antenna-to-support-san-marino-s-rally-legend

[33] See: https://telecoms.com/494256/tim-flips-on-the-5g-switch-in-san-marino/

[34] See: https://www.gruppotim.it/content/dam/telecomitalia/en/archive/documents/media/press_notes/business/2018/Nota-Stampa-TIM-Nokia-SanMarino-ENG-17122018.pdf

[35] See: https://www.gruppotim.it/en/press-archive/market/2018/Nota-Stampa-TIM-Nokia-SanMarino-17122018.html

3.16 Switzerland

3.16.1 ICT background and current status of broadband

The Confederation of Switzerland is a leading country in ICT development and benefits from one of the most sophisticated ICT sectors in the world. The country possesses high-quality mobile-phone services as well as significant broadband penetration, with average speeds well above the European average. In terms of fixed broadband, the country has a universal DSL infrastructure and an extensive optical-fibre broadband network characterized by cross-platform competition.[1] Operators in Switzerland are among the biggest investors in telecommunication networks in Europe, and telecom services are affordable for Swiss customers.[2] More recently, fibre has progressed rapidly in the country and now at least one-third of Swiss households are directly connected by a fibre-optic connection (FTTH).[3] In terms of mobile, despite market liberalization in 1998 with the entry of numerous alternative operators, Switzerland has one of the least competitive markets in Europe.[4]

The first national strategy for the digitalization of Switzerland was published in 1998, and it has been revised several times. While Switzerland has aligned some of its policies with those of the European Union, its telecommunication polices are yet to be harmonized. In 2016, the country adopted the 'Digital Switzerland' strategy, which contained four key objectives: Innovation, growth and prosperity in the digital world; Equal opportunities and the participation of all; Transparency and security; and contribution to sustainable development.[5] Many other ICT policies have been implemented ever since, with a particular focus on e-government, e-health and digital transformation.[6]

In September 2020, the Swiss Federal Council adopted the 'Digital Switzerland' strategy for the period 2020–2022.[7] As a joint task of authorities at all levels of the State, the economy, science, civil society and politics, the strategy provides the guidelines for government action and indicates where and how authorities, academia, the private sector, civil society and politics must work together in order to shape the transformation process for the benefit of everyone in Switzerland.[8]

The strategy is structured in a way that aims to position the Swiss people at the forefront, while facilitating structural change. It pursues five key objectives: i) Enabling equal participation for all and strengthening solidarity; ii) Guaranteeing security, trust and transparency; iii) Continuing to strengthen people's digital empowerment and self-determination; iv) Ensuring value creation, growth and prosperity; and v) Reducing the environmental footprint and energy consumption.[9]

Based on the key objectives, the Digital Switzerland strategy focuses on the following fields of action and their respective vision/goals as well as measures and key documents related to them:[10]

- Education, research, and innovation.
- Infrastructure.
- Security.
- Environmental protection, natural resources and energy.
- Political participation and e-government.
- The economy.
- Data, digital content and artificial intelligence.
- Social affairs, healthcare and culture.

- International commitment.

The strategy contains information on how each broad field of action contributes to attaining the United Nations SDGs. Under each of the wider fields of action described in the strategy, there are a series of goals and a list of key documents related to each goal, as well as a number of indicators to measure their progress.

Accompanying the strategy and its goals is an action plan giving, for each project, a short description, the status of the measure and the responsible stakeholder, so that stakeholders can monitor the accomplishment of the broader objectives laid down in the document.[11] The Digital Switzerland office within the Federal Office of Communications (OFCOM) decides on the inclusion in the action plan of measures undertaken by participants outside the federal administration by arrangement with the latter's respective competent specialist agencies.[12]

In regard to broadband in underserved areas, private stakeholders are investing heavily in the deployment of telecommunication infrastructure[13] and, more recently, they have also engaged in joint venture strategies to maximize FTTH services as well as Wi-Fi technology[14] throughout Switzerland.[15]

3.16.2 Broadband and mobile telecommunication data

ITU data show that 93.2 per cent of individuals in Switzerland used the Internet in 2019.[16] In 2010, the corresponding ITU figure for the country was 83.9 per cent, and in 2000, 47.1 per cent. According to ITU data, the estimated proportion of households with Internet access at home in 2019 was 91.5 per cent.[17]

In 2019, the number of fixed-broadband subscriptions per 100 inhabitants stood at 45.2.[18] DSL/FTTx providers are still way ahead of optical-fibre network operators when it comes to Internet access, though DSL has been declining each year. At the end of 2019, just over 71 per cent of users were connected via a telecom operator (2 838 000 connections), while 29 per cent were connected via a cable operator (1 157 000 connections). When it comes to the customers who are supplied via an FTTH/B connection as well as via hybrid fibre and copper technologies (FTTC and FTTS), the alternative telecom providers play a critical role in Switzerland, with a combined market share of some 20.2 per cent of broadband connections in the country in 2019.[19] Most of the broadband Internet users in Switzerland enjoy a downlink transfer rate of between 30 and 100 Mbit/s[20] with an average of 61 Mbit/s in 2019, compared with 44 Mbit/s in 2018.[21]

Moreover, as a result of DSL and CATV subscribers migrating to fibre-optic technology (FTTH and FTTB), significant growth in the fibre sector has been observed, particularly since 2010.[22] By the end of 2019, about 21 per cent of all broadband subscribers in Switzerland (about 850 000 users) were using a fibre-optic connection.[23] In 2017, about 15 per cent of subscribers had a fibre-optic connection in Switzerland.[24] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019, while Switzerland's was only 1 per cent for an unlimited data package per month in the same year.[25]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was 127.2,[26] while active mobile-broadband subscriptions per 100 inhabitants stood at 99.[27] In addition to a small number of MVNOs, there are three major MNOs that dominate the market in Switzerland: Swisscom, Sunrise, and Salt (formerly Orange). Between 2010 and 2017, the number of mobile users who signed up for Internet data plans rose from 3.4 million to 8.4 million.[28] In 2019, there

were 5.3 million online shoppers, a significant increase in the number of users engaging with e-commerce.[29] The country's mobile-data basket cost corresponded to 0.7 per cent of GNI per capita in 2019 for a monthly allowance of 30 GB, as against the Europe region average of 0.8 per cent in 2019.[30] 3G as well as LTE/4G and 4G+ cover practically the entire population of Switzerland,[31] with official ITU data indicating 99 per cent for 4G/LTE and 100 per cent for 3G in 2019.[32] ITU data for the same year also show that mobile-broadband Internet traffic within Switzerland came to 0.85 exabytes.[33]

3.16.3 Current progress on 5G: Consultations and national strategies

The Swiss Government anticipates that 5G is set to exert a significant impact on the delivery of services related to, *inter alia*, broadband mobile radio network; mobility, transport and logistics; public security; production; energy; and health.

The country started discussing 5G frequency allocation as early as 2017, with the Federal Council reserving the frequency bands 700 MHz and 3.5 GHz for mobile communications. This strategy entailed making changes to the National Frequency Allocation Plan (NFAP),[34] which were approved by the Federal Council in November 2017. Moreover, the Federal Council agreed to lower the licence fees for mobile spectrum in the 3 GHz range from January 2018 onwards. The move aimed to take into account the less favourable propagation characteristics encountered in the higher frequency bands, and thus facilitate the development of 5G in Switzerland.[35]

In February 2018, the Swiss Parliament's Transport and Telecommunications Committee (TTC) called for a revision of the nation's regulations regarding non-ionizing radiation, claiming that the existing rules hinder necessary mobile network expansion, particularly with regard to 5G.[36]

Between January and February 2019, on behalf of Federal Communications Commission (ComCom), OFCOM conducted a frequency auction for 5G, auctioning an extensive bundle of mobile frequencies and thus creating the conditions for 5G development in Switzerland.[37] By incorporating bidding restrictions and consolations with private stakeholders, the frequency licences for 5G were acquired by the country's three MNOs for the following auction prices: Salt (EUR 88 million),[38] Sunrise (EUR 83.1 million) and Swisscom (EUR 182 million).

In January 2020, OFCOM posted a 5G fact sheet with an introductory overview of Switzerland's stance on 5G development. No comprehensive authorization by a central authority is necessary for the introduction of 5G in Switzerland. However, like all other radio technologies operating in the country, 5G deployment must meet the conditions associated with regulations for mobile radio antennas and appropriate frequency band usage, and the conditions laid down in the licences.[39]

OFCOM also maintains an interactive website containing information on the geographic distribution of 5G antenna locations so the public can follow the development of 5G in the country; the website is based on the data provided by operators. Information is available on 4G, 3G, 2G, radio, TV broadcasters and microwave links.[40]

As at October 2020, Switzerland had no national strategy for 5G development, but continued to be among the European pioneers in new-network deployment.

3.16.4 Spectrum assignment for 5G and market development

In Switzerland, mobile-telephony frequencies are licensed in a technology-neutral manner, which gives operators the freedom to choose the technology they use to provide mobile telecommunication services.[41] The 800 MHz, 900 MHz, 1 800 MHz, 2 100 MHz and 2 600 MHz bands were auctioned in 2012, while the 2019 auction encompassed a wide range of additional mobile radio frequencies (700 MHz, 1 400 MHz and 3 500 MHz) more relevant to 5G, and generated some EUR 353.9 million from the private operators.[42] Using the frequency bands below 6 GHz, as currently licensed in Switzerland, a maximum data rate of 3 Gbit/s is expected.[43]

The result of the 2019 spectrum auction is outlined below for each MNO:[44]

- Swisscom: 2 × 15 MHz (three 2 × 5 MHz blocks) in the 700 MHz band and 120 MHz of unpaired spectrum in the 3 500 MHz range, as well as 50 MHz of SDL frequencies in the 1 400 MHz band
- Salt: 2 × 10 MHz in the 700 MHz band, 80 MHz in the 3 500 MHz band and 10 MHz of SDL 1 400 MHz frequencies
- Sunrise: 2 × 5 MHz of paired spectrum and 1 × 10 MHz of SDL airwaves in the 700 MHz range, as well as 100 MHz of 3 500 MHz frequencies and 15 MHz of SDL spectrum in the 1 400 MHz band.

Five frequency blocks of 5 MHz in the 2 600 MHz band and the 700 MHz and 1 400 MHz ranges were not sold. The frequencies that have not been awarded will remain with the Confederation and be put out for tender again at a later date. Under the auction, the frequencies were assigned for 15 years, thereby giving the operators long-term planning security to develop their networks. Licences are granted with coverage obligations. By 2024, the licence-holders have to cover 50 per cent of the Swiss population with 700 MHz spectrum and 25 per cent with other frequencies.[45]

3.16.5 Electromagnetic field levels and implementation dynamics

Switzerland applies precautionary principles regarding permitted EMF from mobile communication installations. The relevant sources of EMF regulation in the country stem from the 'Ordinance on Protection from Non-Ionizing Radiation' (NISV/ORNI; SR/RS 814.710),[46] which is technology-neutral and applies equally to 3G, 4G or 5G. In the ordinance, the Federal Council set two types of limit values for mobile-phone radiation: 'emission limit values'[47] and 'installation limit values', the latter applying in particular to apartments, schools, kindergartens, hospitals, permanent workplaces and children's playgrounds.

The document was prepared in 1999 and enacted in February 2000[48] by the Federal Office for the Environment (FOEN) of Switzerland.[49] It was subsequently adapted in 2008 and 2013, when a component of technology neutrality was introduced. The NISV/ORNI codifies the exposure limits for EMF emission as recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), WHO and the European Union. It includes:

- Emission limit values (ELV): In the area of mobile radio frequencies, the limit is between 41 and 61 volts per metre (V/m).
- Installation limit values (ILV): These are around 10 times lower than the ELVs for mobile-phone radiation (4 to 6 V/m). They do not have to be adhered to everywhere, only in 'places of sensitive use'.

In November 2019, Switzerland's Department for the Environment, Transport, Energy, and Communication (DETEC) published a report entitled 'Mobile communications and radiation',[50] which is an output from a previous working group on the topic from the previous year.[51] This working group was made up of representatives from research and technology, the medical profession, the telecommunication industry, interest groups and municipal, cantonal and federal authorities. Overall, the report provides information on the existing mobile-phone networks and the necessary expansion steps to meet the demand for data transfer in the country. It also summarizes knowledge on current and forecasted future radiation exposure of the population, as well as the current understanding and gaps on the subject. In five steps, the report presents the measures through which the necessary expansion could be made possible, what costs would ensue, what additional infrastructure would be required and how the limit values for cell-phone antennas would have to be adjusted.[52]

Based on this report, the Federal Council decided on further actions concerning EMF and 5G, which focused on the following:[53]

- Implementation aid for adaptive antennas: The federal government is in the process of developing an implementation guide for dealing with the new adaptive antennas. All mobile-phone antennas must comply with the provisions of the NISV/ORNI. Adaptive antennas, which are a fundamental component of 5G, can focus the radiated power specifically on individual users. This means that a higher power is emitted in the direction of the user, but the radiation is much lower in all other directions. The exposure with adaptive antennas is therefore usage dependent.
- Implementation of accompanying measures: Accompanying measures according to the report of the 'Mobile Communications and Radiation' working group of November 2019 will be implemented with the involvement of relevant departments, interested stakeholders and the cantons within the scope of existing resources and maintaining the existing responsibilities.
- Sustainable cellular network: With the report in response to the Häberli-Koller postulate 19.4043 'For a sustainable mobile radio network', a better basis for decision-making for future mobile radio technologies is to be created to avoid further polarization of opinions.

In addition to the FOEN and the work done by the Federal Office of Public Health (FOPH), the cantonal environmental protection offices are responsible for compliance with the limits for non-ionizing radiation laid down in the ordinance. They examine operators' calculations on the radiation intensity of every antenna. An explanation of cantonal authorization for the construction of new antennas or the modification of existing antennas is available on the FOEN website.[54] In addition, a series of fact sheets for various appliances producing NIR is available on the FOPH website.[55]

While the EMF limits are much more stringent in Switzerland than in most European countries, recent attempts to change the legislation have occurred,[56] as referred to in § 3.16.3 above. For instance, a parliamentary motion[57] pushing for potential relaxation of the limit values for EMF exposure in the country was rejected by the Swiss Parliament amid safety concerns.[58] The basis for that decision is largely the precautionary principle enshrined in the Environmental Protection Act,[59] which states that emissions are to be limited to the extent that this is technically and operationally possible and economically viable.[60]

In addition to the 2019 civic pressure from opponents of 5G in Switzerland,[61] in February 2020 the local press reported that some Swiss regions had responded to locals' calls for '5G-free zones' by temporarily suspending the use of new mobile sites constructed for 5G and requesting the regulator to provide more scientific and technical information proving that 5G presents no

health hazard.[62] However, other news media reports later reported that in fact the FOEN had only submitted an information letter to the cantons, some of which had imposed moratoria on 5G planning permission.[63]

3.16.6 5G Commercial launches: Announcements, trial cities and digital cross-border corridors

One of the earliest commercial announcements related to 5G took place in June 2016, when Swisscom unveiled a partnership with Ericsson to launch the '5G for Switzerland' programme in collaboration with the *École Polytechnique Fédérale de Lausanne* (EPFL). '5G for Switzerland' is part of the Ericsson '5G for Europe' programme, announced in 2015.[64] Under collaboration in Switzerland, Swisscom, Ericsson and EPFL announced they planned to address challenges such as smart transportation, autonomous driving, automated traffic control systems, smart grid and IoT.[65]

In May 2017, Swisscom introduced network function virtualization (NFV) and launched 5G tests at its shops in Switzerland, allowing customers to experience an Internet speed of 800 Mbit/s.[66] In June 2017, Swisscom and Ericsson demonstrated applications based on 5G network slicing and NB-IoT.[67] In July 2017, the operator carried out field tests in Zurich of an Ericsson-built 5G system. The test used a single base station and two terminal devices and achieved peak download speeds of 10 Gbit/s.[68] On that occasion, the operator expressed interest in developing IoT-related services in Switzerland.

Within the Ericsson-Swisscom partnership, the operator announced in November 2017 that it was upgrading Swisscom's LTE networks to revamp data traffic speeds. It also announced that it had plans to rely on Ericsson to provide complete digital transformation of Swisscom's network, which includes the deployment of Ericsson's full-stack telecom cloud solution with network slicing technologies, and a 5G portfolio offering with Ma-MIMO.[69] Moreover, Swisscom's industrial partner, Ypsomed, has used 5G applications in the Industry 4sector.[70] In a pilot project, Ypsomed created a 5G test network and digitalized the entire process chain, from the delivery of raw materials and product manufacture through to provisioning and supply.[71]

In January 2018, Salt and Nokia demonstrated 5G 3.5GHz network performance at Salt's headquarters in the municipality of Renens under a temporary licence from OFCOM. The demonstration involved a 5G antenna with 8×8 MIMO technology supporting end-to-end applications, which included: 4.5 Gbit/s mobile data downloads; virtual reality applications showcasing ultrafast network latency (in the range of 1 millisecond) under 'real conditions'; and 360-degree live video transmitted from secondary locations, further highlighting the ultrafast latency and capacity of the 5G network configuration.[72]

In June 2018, Sunrise commissioned its first 5G cell tower in Switzerland and took the opportunity to announce that its plans to launch '5G for People' (or the so-called 'fibre-optics over the air') for 2019. In addition to boosting mobile data services, Sunrise intends to use 5G to offer residential broadband with data transfer rates of up 1 Gbit/s in areas where customers do not have access to fibre networks. In other words, the operator suggests that 5G could be used as a replacement for ADSL/VDSL connections, especially outside high-population areas, as these locations are typically lower-priority for fibre deployments and have greater potential to upgrade existing mobile networks without exceeding the current radiation limits.

In July 2018, Swisscom began 5G trials in Guttanennen, a remote mountain municipality of 200 km² in the Bernese Oberland with about 300 inhabitants, to test how the platform could improve connectivity in remote areas.[73] Based on this trial, the operator suggested that 5G technology could be used in combination with the fixed-network infrastructure, thereby improving the availability of ultrafast broadband.[74]

One of Switzerland's biggest milestones in 5G was announced in September 2018, when Ericsson and Swisscom claimed that they had accomplished Europe's first end-to-end, multivendor non-standalone (NSA) data call in the 3.5 GHz band in the Swiss city of Burgdorf. Data transmissions were carried out using Intel's Mobile Trial Platform (MTP) device and Swisscom's 5G-subscribed SIM card.[75] A few weeks later the Swiss operator indicated that it had expanded the number of 5G test locations to other areas of the country. Furthermore, it announced that it had connected to its test system, for the first time, a smartphone prototype equipped with a Qualcomm 5G mid-band modem[76] and a Wistron NeWeb Corporation (WNC) hotspot.[77]

Within the framework of its '5G for People' plan, Sunrise deployed the first end-to-end 5G network in November 2018, when it activated its 5G network at the Laax ski resort on the Crap Sogn Gion mountain, becoming the world's first standardized 5G network at a ski resort.[78] On this occasion, the operator indicated that its system was capable of providing download speeds of up to 300 Mbit/s and utilizes 8×8 MIMO technology and 3.5 GHz spectrum.

In January 2019, Salt signed a letter of intent (LoI) with Nokia to upgrade the operator's radio and mobile core network, thus improving its existing 3G and 4G platforms for more efficient launch of 5G services.[79] In February 2019, Sunrise announced plans for a limited 5G trial for around 100 selected residential and business customers using its 'Sunrise Internet Box 5G'.[80] The operator's initial expectation was to launch commercial 5G in the first half of 2020, though that has been delayed.

In April 2019, the operator confirmed that its new 5G network was turned on, with initial network coverage of 150 towns, villages and cities. In August 2019, Sunrise expanded its network coverage to 262 cities, towns and villages across the country, although it was not until September 2019 that the operator opened its services to the general public.[81] In November 2019, Sunrise announced that its 5G network was live in 309 towns, which represented almost double the coverage provided by the other competing provider. The company stated that its 5G services were able to provide a top speed of up to 2 Gbit/s to at least 80 per cent of the population. With Huawei's 'LampSites' solution, Sunrise is ensuring powerful 5G coverage inside buildings.[82] Instead of relying on the mmWave frequencies being used to support 5G in other markets, Sunrise confirmed that its 5G networks utilize spectrum in the 700 MHz and 2.4-2.5 GHz bands.[83]

In April 2019, Swisscom activated its 5G network in 102 locations in the first 54 towns, including Basel, Bern, Chur, Davos, Geneva, Lausanne and Zurich. Alongside the upgrade for mobile users, and amid the intense debates over EMF limits and health going on around the same time, Swisscom announced its plans to use the 5G network to provide broadband connections for customers outside of its fibre footprint.[84] Swisscom also announced plans to use dynamic spectrum sharing (DSS) to offer 5G coverage to the rest of the population.[85]

In October 2019, Sunrise partnered with Huawei to boost the maximum download speeds of 3.67 Gbit/s in a Zurich-based 5G trial. The trial used a 100 MHz block of C-band spectrum (3.3-4.2 GHz), alongside commercial network equipment fully conforming to 3GPP standards.[86]

In August 2020, after a pause of several months in commercial 5G announcements in Switzerland amid the COVID-19 pandemic, Sunrise deployed a Nokia's cloud-native converged charging software to drive 5G monetization. According to Ericsson, such a solution enables the operator to more rapidly package, price and promote a wide range of consumer and business services. As such, Nokia notes that Sunrise will be able to quickly create differentiated offers for even the most complex IoT use cases and services enabled by 5G network slicing.[87]

Although Switzerland has a dynamic commercial sector for 5G tests and deployment, 4G plays a significant role as early 5G networks still rely on 4G connections to operate because they use 5G NSA.[88]

Endnotes

1 See: https://www.budde.com.au/Research/Switzerland-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses

2 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

3 See: https://www.comcom.admin.ch/comcom/en/Homepage/documentation/activity-report.html

4 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

5 See: https://www.bakom.admin.ch/bakom/en/homepage/digital-switzerland-and-internet/strategie-digitale-schweiz.html

6 See: https://joinup.ec.europa.eu/sites/default/files/inline-files/Digital_Government_Factsheets_Switzerland_2019.pdf

7 See: https://www.digitaldialog.swiss/en

8 See: https://www.bakom.admin.ch/bakom/en/homepage/digital-switzerland-and-internet/strategie-digitale-schweiz.html

9 See: https://www.digitaldialog.swiss/en/key-objectives

10 See: https://www.digitaldialog.swiss/en/fields-of-action/

11 See: https://www.digitaldialog.swiss/en/actionplan

12 See: http://www.digitaldialog.swiss/en/

13 See: https://www.swisscom.ch/en/about/company/portrait/network/fibre-optics-network-expansion-map.html

14 See: https://www.salt.ch/media/press/files/2020/6/29/6c76f4de-240a-403c-b26b-18fd0169f196/451/20200629_PR_100k_Fiber_customers_EN.pdf

15 See: https://www.nasdaq.com/articles/switzerlands-sunrise-french-owned-salt-link-up-in-%243.1-bln-broadband-jv-2020-05-19

16 See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

17 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "xHH6_IDI").

18 See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

19 See: https://www.comcom.admin.ch/comcom/en/Homepage/documentation/facts-and-figures/broadband/market-share.html

20 See: https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/facts-and-figures/statistical-observatory/internet-service-provider.html

[21] See: https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/facts-and-figures/statistical-observatory/broadband.html

[22] See: https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/facts-and-figures/statistical-observatory/broadband/breitbandinfrastruktur.html

[23] See: https://www.comcom.admin.ch/comcom/en/Homepage/documentation/facts-and-figures/broadband/glasfaser.html

[24] See: https://www.comcom.admin.ch/dam/comcom/en/dokumente/Statistik/oecd-breitband-penetration-2019/December-2019/Percentage%20of%20fibre%20connections%20in%20total%20fixed%20broadband,%202017-2019.xlsx.download.xlsx/Percentage%20of%20fibre%20connections%20in%20total%20fixed%20broadband,%202017-2019.xlsx

[25] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[26] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911").

[27] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[28] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

[29] See: https://www.swissstats.bfs.admin.ch/collection/ch.admin.bfs.swissstat.en.issue20000252000/article/issue20000252000-20

[30] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[31] See: https://www.bakom.admin.ch/dam/bakom/en/dokumente/bakom/telekommunikation/Zahlen%20und%20Fakten/Sammlung%20statistischer%20Daten/Infrastruktur/Terrestrial%20mobile%20network%20infrastructures.xlsx.download.xlsx/Terrestrial%20mobile%20network%20infrastructures.xlsx

[32] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

[33] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i136mwi").

[34] See: https://www.bakom.admin.ch/bakom/en/homepage/frequencies-and-antennas/national-frequency-allocation-plan.html

[35] See: https://www.commsupdate.com/articles/2017/11/09/switzerland-lines-up-5g-spectrum-auction-for-h2-2018/

[36] See: https://www.commsupdate.com/articles/2018/02/01/kvf-calls-for-federal-council-to-clear-path-for-5g/

[37] See: https://www.bakom.admin.ch/bakom/en/homepage/frequencies-and-antennas/award-of-mobile-telephony-frequencies/starting-signal-for-new-award-of-mobile-radio-frequencies.html

[38] Exchange rate as at September 202.0

[39] See: https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/technology/mobile-communications-evolution-towards-5G/5g-faq.html#931839373

[40] See: https://map.geo.admin.ch/?topic=funksender&lang=en&bgLayer=ch.swisstopo.pixelkarte-farbe&layers=ch.bakom.mobil-antennenstandorte-5g,ch.bakom.radio-fernsehsender,ch.bakom.mobil-antennenstandorte-gsm,ch.bakom.mobil-antennenstandorte-umts,ch.bakom.mobil-antennenstandorte-lte&catalogNodes=403,408&layers_visibility=true,false,false,false,false&E=2634483.08&N=1162301.89&zoom=7

[41] See: https://www.bakom.admin.ch/dam/bakom/en/dokumente/faktenblatt_5g.pdf.download.pdf/factsheet_5G.pdf

[42] See: https://www.comcom.admin.ch/comcom/en/Homepage/documentation/media-information.msg-id-73916.html

[43] See: https://www.bakom.admin.ch/bakom/en/homepage/telecommunication/technology/mobile-communications-evolution-towards-5G/5g-faq.html#931839373

[44] See: https://www.newsd.admin.ch/newsd/message/attachments/55585.pdf

[45] See: https://5gobservatory.eu/5g-spectrum/national-5g-spectrum-assignment/#1563958389100-0edfce99-fd41

[46] See: https://www.admin.ch/opc/fr/classified-compilation/19996141/index.html [in German, French and Italian].

[47] Here the distinction between immission and emission limits is important, because also in Switzerland the immission limit is still at 100 µT.

[48] See: https://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Europe/Switzerland_files/table_sz.htm

[49] See: https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2017/EMF/Switzerland%20EMF-5G%20Case%20FINAL.pdf

[50] See: https://www.bafu.admin.ch/dam/bafu/de/dokumente/elektrosmog/fachinfo-daten/bericht-mobilfunk-und-strahlung.pdf.download.pdf/Bericht_MobilfunkStrahlung.pdf [in German].

[51] See: https://www.bafu.admin.ch/bafu/de/home/themen/elektrosmog/dossiers/bericht-arbeitsgruppe-mobilfunk-und-strahlung.html [in German, French and Italian].

[52] See: https://www.bafu.admin.ch/dam/bafu/en/dokumente/elektrosmog/fachinfo-daten/bericht-mobilfunk-und-strahlung.pdf.download.pdf/Report_MobileRadio-Radiation.pdf

[53] See: https://www.bafu.admin.ch/bafu/de/home/themen/elektrosmog/dossiers/bericht-arbeitsgruppe-mobilfunk-und-strahlung.html [in German, French and Italian].

[54] See: https://www.bafu.admin.ch/bafu/de/home/themen/elektrosmog/dossiers/bericht-arbeitsgruppe-mobilfunk-und-strahlung.html#1502548024 [in German, French and Italian].

[55] See: https://www.bag.admin.ch/bag/en/home/gesund-leben./umwelt-und-gesundheit/strahlung-radioaktivitaet-schall/elektromagnetische-felder-emf-uv-laser-licht/emf.html

[56] See: https://ehtrust.org/switzerland-policy-recommendations-cell-phones-wireless-radiation-health/

[57] See: https://www.who.int/peh-emf/project/mapnatreps/switzerland_2018.pdf?ua=1

[58] See: https://www.reuters.com/article/us-swiss-5g/swiss-maintain-5g-emission-standards-amid-safety-concerns-idUSKCN22420H

[59] See: https://www.admin.ch/opc/en/classified-compilation/19830267/index.html

[60] See: https://www.bafu.admin.ch/bafu/de/home/themen/elektrosmog/dossiers/bericht-arbeitsgruppe-mobilfunk-und-strahlung.html#78916420 [in German, French and Italian].

[61] See: https://www.swissinfo.ch/eng/radiation-fears_several-thousand-protest-against-5g-in-swiss-capital/45246224

[62] See: https://www.techradar.com/news/swiss-cantons-halt-use-of-new-5g-masts-due-to-health-concerns#:~:text=Networking-,Swiss%20cantons%20'halt'%20use%20of%20new%205G,masts%20due%20to%20health%20concerns&text=Some%20Swiss%20regions%20have%20suspended,to%20launch%20next%2Dgeneration%20networks[62]

[63] See: https://www.mobileworldlive.com/featured-content/top-three/switzerland-denies-halting-5g-rollouts

[64] See: https://www.ericsson.com/en/press-releases/2015/9/ericsson-launches-5g-for-europe-program-with-academic-research-and-industry-partners

[65] See: https://www.ericsson.com/en/news/2016/6/swisscom-and-ericsson-launch-5g-for-switzerland

[66] See: https://www.swisscom.ch/en/about/news/2017/06/20170628-mm-5g-speed.html

[67] Ibid.

[68] See: https://www.commsupdate.com/articles/2017/07/07/swisscom-tests-10gbps-5g-prototype/

[69] See: https://www.ericsson.com/en/press-releases/2017/11/swisscom-selects-ericsson-as-strategic-supplier-for-gigabit-lte-and-5g

[70] See: https://www.swisscom.ch/en/business/enterprise/themen/connectivity/5g-applications-ypsomed.html

[71] See: http://5gobservatory.eu/5g-trial/major-european-5g-trials-and-pilots/

[72] See: https://www.salt.ch/media/press/files/2018/1/25/fa5ff6bc-9c08-4713-b69c-a19d2e43c21c/309/Salt_5G%20-%20Salt%20and%20Nokia%20showcase%20mobile%20network%20of%20the%20future.pdf

[73] See: https://www.swisscom.ch/en/about/medien/aktuell/5g-test-guttannen.html

[74] Ibid.

[75] See: https://www.ericsson.com/en/press-releases/2018/9/ericsson-and-swisscom-get-5g-ready-for-business

[76] See: https://www.qualcomm.com/news/releases/2018/11/08/qualcomm-swisscom-wnc-and-ericsson-successfully-achieve-worlds-first-5g-nr

[77] See: https://www.swisscom.ch/en/about/news/2018/11/20181108-mm-5g-smartphone-prototyp.html

[78] See: https://www.sunrise.ch/en/medium-and-large-enterprises/home/sunrise-mit-5g-netz-in-laax.html

[79] See: https://www.sdxcentral.com/articles/news/switzerlands-salt-picks-nokia-for-5g/2019/01/

[80] See: https://www.lteto5g.com/sunrise-targets-5g-network-coverage-in-150-cities-and-villages-by-march-2019/

[81] See: https://www.commsupdate.com/articles/2019/09/19/sunrise-opens-5g-service-to-public-upc-to-offer-1gbps-nationwide/

[82] See: https://5gobservatory.eu/switzerlands-sunrise-expands-5g-coverage-to-80-of-population/

[83] Ibid.

[84] See: https://www.swisscom.ch/en/about/news/2019/04/17-erstes-5g-netz-live.html

[85] See: https://www.rcrwireless.com/20191203/5g/dss-5g-switzerland-australia?utm_campaign=20191203%20RCRenewsTues&utm_medium=email&utm_source=Eloqua

[86] See: https://www.commsupdate.com/articles/2019/10/10/sunrise-huawei-notch-3-67gbps-in-zurich-5g-trial/

[87] See: https://www.nokia.com/about-us/news/releases/2020/08/18/sunrise-deploys-nokias-converged-charging-software-to-drive-5g-monetization/

[88] See: https://www.opensignal.com/reports/2020/05/switzerland/mobile-network-experience

3.17 United kingdom of Great Britain and Northern Ireland

3.17.1 ICT background and current status of broadband

The United Kingdom of Great Britain and Northern Ireland is one of the world's largest ICT markets, with a highly advanced telecommunication sector, characterized by its early liberalization and strong commercial competition. With affordable prices, the country has high penetration rates for fixed and mobile services. For fixed broadband, the penetration is also very high, and well above the European average. In the Europe region and beyond, the United Kingdom (UK) continues to be a champion of privatization in the telecommunication sector and elsewhere, and its example greatly impacted the shaping of EU policies on telecommunications. While national policies continue to prioritize the roll-out of high-speed broadband throughout the UK and upgrades of networks, there are still rural areas that lack broadband.

Building on a longstanding strategic approach to digital development, in March 2017 the UK Government launched its 'UK Digital Strategy'. The strategy builds on the 'Culture' white paper[1] as well as the 'Building our Industrial Strategy' green paper,[2] and articulates the UK's framework for the digital economy with particular regard to growth, technology and innovation. The UK Digital Strategy sets out the government's goals for digital infrastructure, creating an advanced skills base, encouraging the use of digital tools and improving access to digital services, while addressing opportunities for businesses, research and development. Accordingly, the UK Digital Strategy's seven main strands are:

- Connectivity – Building a world-class digital infrastructure for the UK.[3]
- Digital skills and inclusion – Giving everyone access to the digital skills they need.[4]
- The digital sectors – Making the United Kingdom the best place to start and grow a digital business.[5]
- The wider economy – Helping every British business become a digital business.[6]
- A safe and secure cyberspace – Making the UK the safest place in the world to live and work online.[7]
- Digital government – Maintaining the UK government as a world leader in serving its citizens online.[8]
- Data – Unlocking the power of data in the UK economy and improving public confidence in its use.[9]

Based on the legislation as well as rules imposed by the regulator, every home and business in the UK has the legal right to request a decent, affordable broadband connection.[10] Moreover, some of the UK Government's targets set in the strategy are consistent with the European Commission's Digital Agenda for Europe (DAE).

Furthermore, it is worth mentioning that the UK Government has achieved its aim of providing 95 per cent coverage with 24 Mbit/s by the end of 2017.[11] The government has set a target to achieve nationwide gigabit connectivity as soon as possible, with an ambition to reach this goal by 2025.[12]

In addition to the expansion of fixed services, the UK Government launched the 'Shared Rural Network' (SRN) in March 2020. This project is a public-private investment partnership to transform mobile-broadband coverage in rural areas without duplicating infrastructure. Led

by UK's four MNOs – EE, Telefónica UK (O2), Three, and Vodafone – through a jointly owned company called Digital Mobile Spectrum, SRN determines the following:[13]

- Each MNO shall reach 88 per cent coverage of the UK by 2024.
- Each MNO shall reach 90 per cent coverage of the UK by 2026.
- Each MNO shall reach nation-specific coverage targets in England, Northern Ireland, Scotland and Wales by 2026.
- Collectively, the MNOs shall provide additional coverage to 280 000 premises and 16 000 km of roads by 2026.

To meet these targets, the UK Office of Communications (Ofcom) has developed legally enforceable coverage obligations that are attached to the MNOs' radio spectrum licences. Together, this means all four MNOs will deliver 95 per cent combined 4G coverage across the whole of the UK landmass[14] by the end of 2025.[15]

Other broadband-related government-led policies that are worth mentioning in the UK context include the Welsh Government's Superfast Cymru: a project to deliver superfast broadband access of at least 30 Mbit/s to nearly 700 000 premises;[16] the Scottish Government's commitment to extending superfast broadband access to 100 per cent of premises across Scotland by 2021;[17] the UK's ICT and digital services strategy for the period 2020-2025, which deals with the government's engagement with private stakeholders to achieve the United Nations SDGs and meet the government's net-zero commitments;[18] the Digital Northern Ireland 2020 (DNI) project;[19] and others.

Amid the socio-economic challenges that resulted from the COVID-19 pandemic, the local press has reported that the UK Government is currently working on a new digital strategy[20] with a focus on: i) Securing an adequacy agreement with the European Union; ii) Creating a highly-skilled digital workforce; iii) Building a world-class next-generation infrastructure; and iv) Ensuring a regulatory regime that is pro-competition and pro-innovation.[21]

3.17.2 Broadband and mobile telecommunication data

ITU data show that 92.5 per cent of individuals in the United Kingdom had access to the Internet in 2019.[22] In 2010, the corresponding ITU figure for the country was 85 per cent, and in 2000, 26.8 per cent. In 2018, the number of fixed-broadband subscriptions per 100 inhabitants was 39.6.[23] Data from the UK's Office for National Statistics show that fixed broadband has continued to be the most popular type of household Internet connection since first measured in 2015, with 98 per cent of households with Internet access having this type of connection in 2019.[24] While ADSL1 and ADSL2+ are available throughout the country, cable and FTTC as well as FTTP are becoming increasingly available and offered by several ISPs, with FTTP now representing the most common fibre connection in the UK.[25] Throughout the country, London and the South East were the UK regions with the highest Internet use in 2019, while Northern Ireland remained the lowest.[26] Despite that, Northern Ireland has the highest full-fibre coverage of any UK nation, with nearly a third of homes able to receive it. Wales was also positioned above the UK average, with 12 per cent coverage.[27] In terms of fibre connections throughout its territory, only around 10 per cent of UK homes received full-fibre broadband, offering download speeds of up to 1 Gbit/s as at September 2019.[28]

In its 2019 report, Ofcom, the regulatory authority in the UK, reported that data use on fixed lines increased to an average of 315 GB per connection per month, up from 240 GB in 2018.

In its 2020 summer update, Ofcom reported that 14 per cent of homes in the UK had full-fibre broadband connectivity, offering download speeds of up to 1 Gbit/s, showing an increase in fibre connectivity of at least 2.2 million additional homes in comparison to the previous year.[29] Furthermore, 57 per cent of UK homes were able to get ultrafast broadband (300 Mbit/s).

Whilst household Internet access has risen over the last decade, it has been levelling off in recent years.[30] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of GNI per capita in 2019, while the United Kingdom's corresponded to 1.3 per cent for an unlimited monthly data package in 2019.[31]

In 2018, the number of mobile-cellular subscriptions per 100 inhabitants was 118.37.[32] Moreover, the number of active-mobile broadband subscriptions per 100 inhabitants stood at 98.54 in the same year.[33] In addition to a few MVNOs, there are four major MNOs that dominate the market in the United Kingdom: Vodafone, 3 UK (H3G), Telefónica O2, and EE (acquired by BT).[34] Both 3G and 4G mobile networks were available to 99.7 per cent of the population in 2018.[35] In terms of geographic coverage, data from the regulator reveal that 67 per cent of the UK's land area is covered by 4G by the four major MNOs in the country, while 91 per cent of the country can get reliable 4G from at least one operator.[36] However, challenges concerning mobile-broadband coverage in rural areas remain a relevant issue insofar as only 63 per cent of rural areas received coverage from all four major operators, while 5 per cent of the UK's landmass gets no mobile voice and text reception at all.[37] The country's mobile-data basket cost corresponded to 0.6 per cent of GNI per capita in 2019 for a monthly allowance of 5 GB, as against the Europe region average of 0.8 per cent in the same year.[38]

2.17.3 Current progress on 5G: Consultations and national strategies

In October 2015, the Chancellor of the Exchequer announced the creation of a National Infrastructure Commission (NIC), charged with providing a clear picture of the future infrastructure that the UK needs to prioritize.[39] As early as 2016, NIC published a final report on 5G with a set of recommendations on metrics for network development. The report also included a call for Ofcom and the government to review the prevailing regulatory regime governing spectrum and obligations to ensure that it supports the sharing of telecom infrastructure for the 5G roll-out. NIC has called for local authorities and local enterprise partnerships (LEPs) to work with network providers to develop approaches that enable the deployment of tens of thousands of small cells in urban centres.[40]

Also, in 2016, the UK Government announced the creation of its National Productivity Investment Fund (NPIF), worth a total of EUR 25.3 billion, of which EUR 815.6 million funded by the government were allocated to 5G trials and full-fibre deployment across the UK by 2020-2021.

In January 2017, a report from the Future Communications Challenge Group (FCCG) identified three policy areas that could enhance the 5G deployment phase in the UK: i) Facilitating operators' ability to deploy network equipment; ii) Ensuring the industry has sufficient spectrum; and iii) Ensuring application of net neutrality rules is compatible with 5G use cases.[41]

In March 2017, the Department for Digital Culture, Media and Sport (DCMS) released a policy paper entitled 'Next-Generation Mobile Technologies: A 5G strategy for the UK'.[42] This strategy sets out the government's ambition that the UK should be a global leader in 5G so that the country can take early advantage of its potential and help to create a world-leading digital

economy that works for everyone. The strategy outlines the key themes and a set of specific measures to determine the UK's progress towards 5G, which are:[43]

- Building the economic case.
- Fit-for-purpose regulations.
- Local areas – governance and capability.
- Coverage and capacity – convergence and the road to 5G.
- Ensuring safe and secure deployment of 5G.
- Spectrum.
- Technology and standards.

In terms of investment, the strategy details the government's plan to initially invest around USD 19.5 million on a 'cutting-edge' facility equipped with appropriate technology to run trials in partnership with industry working at the forefront of 5G.[44] The strategy outlines DCMS's collaboration with Ofcom in identifying and tackling unnecessary barriers to infrastructure sharing, and will explore the potential for a clearer and more robust framework to allow companies to share infrastructure while preserving investment incentives.

Building upon a series of documents relating to 5G in the country, in July 2018 the UK Government announced its main target of providing the majority of the population with a 5G signal by 2027. The government's strategy for future digital infrastructure – full-fibre and 5G – is set out in DCMS's Future Telecoms Infrastructure Review (FTIR). FTIR focuses on supporting a 'market expansion model' for 5G in the UK.[45] It identifies four priority areas that government policy for 5G will focus on to support the market expansion model:[24]

- Make it easier and cheaper to deploy mobile infrastructure and support market expansion, including implementation of the wide-ranging Electronic Communications Code (ECC) on site access and consideration of further planning reforms.
- Support the growth of infrastructure models that promote competition and investment in network densification and extension.
- Fund beneficial use cases through the government's EUR 220.5 million 5G Testbeds and Trials programme that helps de-risk business models for 5G.
- Promote new, innovative 5G services from existing and new players, through the release of additional spectrum; here, consideration should be given to whether more flexible shared-spectrum models can maintain network competition between MNOs while also increasing access to spectrum to support new investment models, spurring innovation in industrial IoT, wireless automation and robotics, and improving rural coverage.

In November 2018, Ofcom launched a report entitled 'Enabling 5G in the UK', providing further information on the regulator's work to guarantee the early 5G roll-out in the country within the framework of the 2017 strategy and previous public consultations. The report provides an overview of the actions taken by Ofcom to enable the 5G development in the UK:[46]

- Making spectrum available for 5G and other wireless services.
- Working with government and policy-makers to ensure access to sites is not a barrier to 5G.
- Ensuring access to appropriate connectivity between 5G base stations and the core network (backhaul).
- Ensuring net-neutrality regulation is not a barrier to deployment.
- Acting as a facilitator, working with government, different industry sectors and other countries to further understand potential applications of 5G.

In November 2018, the UK Government published the 'National Infrastructure and Construction Pipeline' report, which givens an overview of public and private investments that are under way or expected to be put toward 5G and full-fibre (FTTP) between 2018/19 and 2020/21 (financial years). The document specifies that EUR 7.5 billion should be devoted to full-fibre and 5G upgrades by 2021.[47]

Following previous 5G-related investments by the government, DCMS announced a GBP 64 million (EUR 70 million)[48] funding package for 5G trials in February 2020. DCMS also announced that the funding package shall benefit residents of rural areas.[49] The package can be broken down into:[50]

- EUR 33.1 million for the Rural Connected Communities (RCC) competition for seven 5G research and development projects across the UK. This includes five in England, one in Wales and one in Scotland, with plans to expand into Northern Ireland. Test sites will be set up in Yorkshire, Gwent, Monmouthshire, Orkney, Wiltshire, Nottinghamshire, Dorset, Shropshire and Worcestershire.
- More than EUR 5.5 million of funding will be awarded to two industrial projects, led by Ford Motor Company and Zeetta Networks, to test the benefits of using 5G to boost productivity in the manufacturing sector.
- A new EUR 33.1 million for the open competition – '5G Create' – has been launched to develop new uses for 5G in a variety of industries, including creative sectors such as film, TV and video games. From enabling remote production to supporting the expansion of the increasingly popular world of e-sports, 5G has the potential to revolutionize the UK's booming creative industries. Six projects have already been selected across the UK with more to be announced soon.

Additionally, many other public consultations covering issues of spectrum allocation, rules on the auction for the 700 MHz and 26 GHz bands, as well as rural mobile coverage and EMF have been launched by the regulator between 2019 and 2020,[51] all of which have been taken into account for the auctions and 5G roll-out rules in the UK. [52]

2.17.4 Spectrum assignment for 5G and market development

In September 2017, Ofcom published a report outlining its preparations for the release of spectrum suitable for future mobile services.[53] The regulator also mentioned that it supports the Radio Spectrum Policy Group's (RSPG) identification of 26 GHz as a 'pioneer band' for 5G in Europe.[54]

In April 2018, Ofcom concluded the first auction of 5G spectrum by selling 150 MHz of 3.4 GHz spectrum previously used by the Ministry of Defence, with all four MNOs securing spectrum for 10 years.[55] The auction had two bidding stages – principal and assignment stages – using a format known as simultaneous multiple round ascending (SMRA), generating the following licensing results:[56]

- Airspan Spectrum Holdings Limited did not win spectrum in either band.
- EE Limited won 40 MHz of 3.4 GHz spectrum at a cost of EUR 335.2 million.
- Hutchison 3G UK Limited won 20 MHz of 3.4 GHz spectrum at a cost of EUR 167.6 million.
- Telefónica UK/O2 won all 40 MHz of the 2.3 GHz spectrum available, at a cost of EUR 228.1 million; and 40 MHz of 3.4 GHz spectrum at a cost of EUR 352.1 million.
- Vodafone UK won 50 MHz of 3.4 GHz spectrum at a cost of EUR 419 million.

As reflected above, Ofcom also auctioned 40 MHz of 2.3 GHz spectrum for immediate use to provide additional capacity for 4G networks, which can also be used for 5G in the future. When compared to the 4G spectrum auction that took place in 2013, the 2018 auction generated a financial amount that is equivalent to roughly three-quarters of the spectrum previously auctioned.[57]

On 9 March 2020, the UK Government announced that it had agreed a deal with the four mobile operators to deliver the 'Shared Rural Network', which will see operators collectively increase mobile-phone coverage throughout the UK to 95 per cent by the end of 2025, underpinned by legally binding coverage commitments. Compliance with these obligations will be assessed by Ofcom in 2024, by when each operator has committed to have reached 88 per cent geographic coverage of the UK, and in 2026, by when each operator has committed to have reached at least 90 per cent geographic coverage of the UK. Each operator has also agreed to meet coverage thresholds in each UK nation, again to be assessed in 2024 and 2026, alongside collectively providing coverage to new roads and premises. Progress towards these outcomes will be published in the regular Ofcom Connected Nations reports.

In July 2018, Ofcom opened up a consultation on 57–71 GHz frequencies. On this occasion, the regulator decided to change the authorization approach for fixed wireless systems in the 64-66 GHz band to licence-exempt and to implement common technical conditions across the 57-71 GHz band for short-range wideband data transmission systems and fixed wireless systems.[58] Furthermore, Ofcom has been working to free up the 168 MHz of spectrum between 7.9 GHz and 8.4 GHz, and 2.25 GHz of spectrum between 24.25 GHz and 26.5 GHz.[59] It plans to make the 1 492–1 517 MHz band available for future wireless-broadband services by December 2022. Moreover, Ofcom is also considering the 37–43.5 and 66–71 GHz bands, and potentially also the 32 GHz (31.8–33.4 GHz) band.[60]

In June 2019, Ofcom issued a public consultation on defragmentation of 3.4-3.8 GHz frequencies. As a result, the regulator plans to introduce spectrum sharing and open up spectrum (3 800–4 200/1 800/2 300 MHz) to private network operators and vertical industry players on a first-come-first-served basis. Spectrum sharing will also be introduced on the 26 GHz frequencies, but only for indoor services. In July 2019, Ofcom published a document entitled 'Draft UK Interface Requirement (IR) 2105', defining the technical conditions for 'Shared Access Indoor 26 GHz'.[61]

In November 2019, Ofcom issued a consultation on draft statutory instruments that would support its local spectrum-access and spectrum-sharing policies.

In March 2020, Ofcom announced the rules that will apply for its forthcoming auction of 5G-suitable spectrum. According to these rules, the spectrum would be made available for bids in the following lots:[62]

- Six lots of 2 x 5 MHz (60 MHz in total) in the 700 MHz band with a reserve price of EUR 110.8 million per lot.
- Four lots of 5 MHz (20 MHz in total) of 700 MHz downlink-only spectrum, with a reserve price of EUR 1.1 million per lot.
- 24 lots of 5 MHz (120 MHz in total) of 3.6–3.8 GHz spectrum, with a reserve price of EUR 22.2 million per lot.

Regarding the obligations, Ofcom confirmed that it does not plan any longer to include coverage obligations, and that the two spectrum lots that carried a proposed maximum will no

longer apply.[63] The regulator has also imposed a 37 per cent cap on overall spectrum holdings. As a result, EE will be allowed to obtain a maximum of 120 MHz, while Three and Vodafone will be able to secure up to 185 MHz and 190 MHz, respectively. In view of its current spectrum holdings, O2 will not be restricted by the cap.[64]

Private stakeholders have also requested Ofcom to move to a more flexible approach to licensing for 5G spectrum in order to allow spectrum that is not being used by the major MNOs to be used by other parties, for example in rural areas.[65]

In August 2020, as a result of the COVID-19 pandemic, Ofcom postponed its plans to auction the 700 MHz and 3.6-3.8 GHz bands to January 2021.[66]

2.17.5 Electromagnetic field levels and implementation dynamics

The UK Government mandates that that EMF emissions should comply with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines. More specifically, the UK's policy on EMF limits is set out in the Written Ministerial Statement of 2009, though it stems from the advice given by the National Radiological Protection Board (NRPB) in 2004.[67] This policy details national compliance with the 1998 ICNIRP exposure guidelines[68] in the terms of the 1999 EU Recommendation, and a precautionary policy called 'optimal phasing'.[69] All the practical details needed to apply the policy of compliance with exposure limits as well as the optical phasing are contained in a Code of Practice.[70] It is Public Health England (PHE), an executive agency of the Department of Health and Social Care, that is at the forefront of public health matters associated with radio-frequency EMFs in the UK.[71] All manufacturers, installers and operators of radio equipment should therefore already consider the recommendations by PHE and Ofcom when manufacturing, installing or operating equipment.[72]

While the UK's Mobile Telecommunications and Health Research Programme (MTHR) ended in 2012, the UK Government has been funding research on the effects on health of a range of EMF and mobile technologies mainly through the Department of Health and Social Care's National Institute for Health Research (NIHR) and PHE. Recent projects have considered airwave health monitoring, the study of mobile-phone use on health,[73] a study on mobile phones and adolescents and cognition at Imperial College London,[74] as well as other PHE research initiatives, including its Advisory Group on Non-Ionizing Radiation (AGNIR), which came to an end in 2017.[75]

Although Ofcom is not responsible for setting EMF safety levels in the UK, it has been testing the EMF levels near to mobile-phone base stations for many years. Ofcom's published measurements have consistently shown that EMF levels are well within the internationally agreed levels published in the ICNIRP Guidelines.[76] In February 2020, Ofcom published a consultation which proposes to include a specific condition in Wireless Telegraphy Act licences requiring licensees (including mobile operators and other radio users) to comply with the ICNIRP Guidelines.[77]

Concerning 5G development, PHE has been providing the public with information on reviews, guideless and policies, while acknowledging that fewer studies have been conducted at the mmWave frequencies that are planned for use by 5G than at lower frequencies. In recent measurements near 5G-enabled base stations, Ofcom has recorded measurements well within the levels for general public exposure from the ICNIRP Guidelines. In fact, the highest level measured was approximately 1.5 per cent of the levels identified in the ICNIRP Guidelines.[78]

In April 2020, within the context of growing civic pressure stemming from conspiracy theories linking 5G to the global COVID-19 pandemic, Ofcom released a brochure affirming that there is no scientific basis or credible evidence regarding a causal relationship between the two.[79] Currently, PHE information about EMF exposure is available on the unified UK Government website.[80] The material about base stations has been updated to mention recent technology developments, such as 5G, and the latest national and international health evidence reviews. PHE continues to deliver expert review reports on NIR topics as and when sufficient new evidence has accumulated.[81]

On 24 September 2020, PHE updated its guidance on mobile-phone base stations, and how exposure is measured. This information can be found on the gov.uk website. Following a consultation earlier in the year, Ofcom announced on 5 October 2020 that it intends to include a specific condition in the licences of mobile-phone companies and TV and radio broadcasters requiring licensees to comply with the limits on EMF exposure proposed by ICNIRP.[82]

Finally, Ofcom is making available a trial version of an EMF calculator[83] that will make it straightforward for many licence-holders and other spectrum users to demonstrate their compliance. Ofcom also recently opened a further consultation on EMF among private stakeholders.[84]

2.17.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

Since 2015, private stakeholders have been engaging with Ofcom on matters related to the commercialization of 5G, providing comments on high-frequency bands and other regulatory measures.[85] Additionally, in the same year, the University of Surrey announced that its 5G Innovation Centre (5GIC) had achieved data speeds of 1 Tbit/s over a distance of 100 metres in lab tests using university-built equipment.[86] Other tests and partnerships between operators and equipment providers also took place during the same year. For instance, EE, in partnership with Alcatel-Lucent, achieved download speeds of more than 5 Gbit/s using 'XG.FAST' over 35 metres of cable and 1.8 Gbit/s over 100 metres of copper lines.[87]

In August 2016, EE announced a research collaboration agreement on 5G with Nokia. The agreement details the companies' plans to work together on potential customer use cases for 5G technologies, the creation of 5G proof of concept (PoC) trials and development of the emerging technology standards and equipment. The local press reported that Nokia and BT were conducting trials at the operator's lab in Suffolk using Nokia's AirScale radio access.[88]

In February 2017, telecom infrastructure company Arqiva announced plans for 5G trials in the UK in partnership with Samsung. The 5G trials included testing 5G FWA technology in highly urbanized areas such as downtown London. The trials utilized Samsung's 5G network solution and CPE, and Arqiva's 28 GHz mmWave spectrum.[89] After four months, the companies announced that they had established a stable two-way mmWave link with downlink speeds of around 1 Gbit/s through CPE.[90]

In February 2017, Vodafone, Ericsson and Qualcomm Technologies announced a new collaboration focused on a 5G New Radio (NR) trial based on the 5G NR specifications. The trial utilized advanced 3GPP 5G NR technologies including Ma-MIMO antenna technology, adaptive self-contained TDD, beamforming techniques, scalable OFDM-based waveforms

to support wider bandwidths, advanced coding and modulation schemes, and a new flexible framework design.[91]

In March 2018, O2 UK announced the construction of 5G testbeds at the O2 arena in North Greenwich, the first venue to have launched a live 4G trial in London back in 2011. The operator informed the public that its 5G testbed will rely on a multi-access edge computing (MEC) solution and will be configured for the virtualization of core 5G network technologies.[92]

In April 2018, Vodafone, after securing a 50 MHz block of spectrum in the 3.4 GHz band in April, announced that it had become the UK's first MNO to complete a test of 5G spectrum across an existing live network (LTE/4G). The operator claimed it used 3.4 GHz frequencies on its network between Manchester and its headquarters in Newbury, Berkshire. To carry out the 5G spectrum test, it used a site at its Manchester contact centre which houses around 1 000 customer service employees, and its offices in Newbury, with the test utilizing Ma-MIMO technology combined with 3.4 GHz spectrum running over the operator's core 4G network.[93] In June 2018, Vodafone announced that the seven initial 5G trial cities would be Birmingham, Bristol, Cardiff, Glasgow, Liverpool, London and Manchester.[94] In October 2018, Vodafone UK announced, for the first time, that it was able to stream live 5G mobile data at a site in Salford, Manchester.[95]

In September 2018, DCMS unveiled the West Midlands as the first large-scale 5G testbed in the UK.

In October 2018, in preparation for a full commercial 5G launch, EE has switched on the UK's first 5G trial network in London's Canary Wharf.[96] In November 2018, EE announced new 5G trial sites across East London: Provost Street, City Road, Central Street, Old Street, Cheapside, St Paul's, Finsbury Circus Garden, Clerkenwell Street and Bartholomew Square.[97] The operator launched its commercial 5G network in May 2019. Moreover, EE claims to have extended the reach of its next-generation mobile-broadband connectivity to a total of 112 towns and cities across the country by October 2020. Meanwhile, EE claims that in the last twelve months it has more than doubled the amount of 5G sites in what it refers to as 'key cities', such as Belfast, Birmingham, Cardiff and Edinburgh.[98]

In November 2018, Three UK announced investments of more than EUR 2.2 billion[99] in network infrastructure in preparation for the launch of 5G.[100] To upgrade its network, the operator announced that it had acquired the country's 'leading 5G spectrum portfolio'; signed an agreement for the roll-out of new cell-site technology to prepare major urban areas for the roll-out of 5G devices; built a super high-capacity dark fibre network, which connects 20 new data centres; deployed a 5G-ready, fully integrated cloud-native core network in the new data centres, which at launch will have an initial capacity of 1.2 TBit/s; and rolled out carrier aggregation (CA) technology at 2 500 sites in the 'busiest' areas.[101] Beyond London, the company announced 16 additional cities, including the UK's three other capitals: Cardiff, Edinburgh and Belfast.[102]

In February 2019, Vodafone UK has announced the switch-on of a 5G hotspot at Manchester Airport using Ma-MIMO technology. Given that 5G handsets are not yet available for consumers, the operators used its Gigacube device—a portable router that is 5G-enabled. As such, the trial has seen consumers connect to 5G via the Gigacube and use a free 'Entertainment Pass' for streaming video service NOW TV to download and stream content.[103] In other 5G tests occurring at the same time, local press reported that Vodafone was using 5G smartphones form factor connected to Qualcomm Snapdragon X50 5G modems and antenna modules with integrated RF transceiver, RF front-end and antenna elements.[104]

In June 2019, O2 UK announced it had initiated 5G tests at the Millbrook Testing Ground for self-driving cars in Bedfordshire using 2.3 GHz and 3.4 GHz spectrum.[105] According to O2, the on-site network at Millbrook consists of 59 cell sites and 89 small cells, and is operated by British wireless solution provider Dense Air. Under a 12-month agreement with the AutoAir project, O2 will integrate the sites and small cells into its public infrastructure.[106]

In July 2019, Vodafone UK switched on its 5G network for both residential and business customers for about the same price, with initial coverage of seven cities – Birmingham, Bristol, Cardiff, Glasgow, Manchester, Liverpool and London. The operator also announced choices for 5G smartphones during the summer of 2019. Moreover, it announced the launch of a 5G router for use in the home and office in order to give customers without a fixed-line connection high-speed broadband access.[107] A few weeks later, the operator expanded 5G to Birkenhead, Bolton, Gatwick, Lancaster, Newbury, Plymouth, Stoke-on-Trent and Wolverhampton.[108]

In August 2019, Three UK announced the launch of '5G home broadband service' in London. In the second half of 2019, the operator revealed its 5G commercial launch across 25 towns and cities. It also announced the introduction of the world's first 5G-ready, fully integrated cloud core network in partnership with Nokia. Three UK says it has already successfully tested its new core network with 3 500 of its employees and has started to migrate 4G customer traffic onto the new core.[109]

In October 2019, O2 UK announced the launch of its 5G network with a range of new tariffs, including an unlimited data option, at the same price as its 4G equivalents. The commercial launch is based on a partnership with Ericsson and Nokia, following a competitive tender. O2 UK also noted that it expects the new 5G network to supplement its existing 4G connectivity, which remains 'the backbone of the network'.[110]

In January 2020, Vodafone UK announced that it had become the first operator in the country to successfully introduce 5G multi-operator radio access network (MORAN) technology.[111] The operator noted that the new platform enables providers to share the same mobile base station, helping to reduce energy usage and the number of masts needed. Moreover, Vodafone UK has confirmed that it started offering 5G roaming in five locations in the Republic of Ireland – Cork, Dublin, Limerick, Galway and Waterford. Previously, it had made 5G roaming available in Germany, Italy and Spain.[112]

In February 2020, Three UK outlined details for its mobile 5G launch plans. The operator contended that it was the only operator able to meet the ITU 2020 standard for full 5G services, by having at least 100 MHz of 5G-suitable spectrum. Three UK also confirmed that all new and existing customers will have access to 5G with no speed caps and at no extra cost on all postpaid, prepaid and SIM-only tariffs.[113]

In April 2020, BT signed an agreement with Ericsson for the deployment of its dual-mode 5G core (Evolved Packet Core and 5G Core), a fully container-based, cloud-native mobile packet core for 4G, 5G NSA and 5G SA services as a single fully integrated core. Ericsson highlighted that its 5G core should help BT create and deliver new services such as enhanced mobile broadband, network slicing, mobile edge computing, mission-critical vertical industry support and advanced enterprise services.[114]

In June 2020, O2 UK also selected Ericsson as the equipment provider for 5G RAN to other regions of the UK as part of its network modernization programme.[115]

In June 2020, EE's 5G service was reported to be live in 80 towns and cities across the country. The company is using NSA 5G NR deployment focused on using the combined power of 4G and 5G technologies. In a second phase from 2022, it will introduce the full 5G core network, enhanced device chipset capabilities, and increased availability of 5G-ready spectrum. A third phase, beginning in 2023, will introduce ultra-reliable low-latency communications (URLLC), network slicing and multi-gigabit-per-second speeds.[116]

In July 2020, Vodafone UK announced that it had launched a new 5G SA network at Coventry University, in partnership Ericsson, MediaTek, OPPO and Qualcomm. The operator contended that the new network will be used to show the true benefits of 5G, including ultra-low latency, guaranteed speed performance, and IoT.[117]

In September 2020, Three UK signed a deal with British pure-fibre provider CityFibre, extending their multimillion-euro 5G backhaul contract signed earlier in 2020. Under the amended contract, the fibre network provider will connect a further 1 300 mobile masts in 59 towns and cities across the UK.[118]

In September 2020, BT announced that Nokia has been selected as a 5G RAN vendor for its commercial operations in the UK. Nokia will supply its AirScale Single RAN (S-RAN) portfolio for both indoor and outdoor coverage, including 5G RAN, AirScale base stations and Nokia AirScale radio access products.[119] Furthermore, under the terms of the deal, Nokia will also optimize BT's 2G and 4G networks and work alongside the carrier on the development of the OpenRAN ecosystem. It will also utilize Nokia Software's ng-SDM and NetAct network management platform, supporting the network evolution to 5G.[120]

Still in September 2020, under this agreement, BT's Nokia-powered network, which is said to currently cover Greater London, the Midlands and rural locations, will reportedly be extended to cover multiple other towns and cities across the UK, named as: Aberdeen, Bournemouth, Brighton, Cambridge, Carlisle, Cheltenham-Gloucester, Chesterfield, Dundee, Exeter, Grimsby, Hull, Ipswich, Lincoln, Newbury, Northampton, Norwich, Peterborough, Plymouth, Southampton, Stoke-on-Trent, Swindon, Torbay and York.[121]

Endnotes

1 See: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510798/DCMS_The_Culture_White_Paper__3_.pdf

2 See: https://beisgovuk.citizenspace.com/strategy/industrial-strategy/supporting_documents/buildingourindustrialstrategygreenpaper.pdf

3 See: https://www.gov.uk/government/publications/uk-digital-strategy/1-connectivity-building-world-class-digital-infrastructure-for-the-uk

4 See: https://www.gov.uk/government/publications/uk-digital-strategy/2-digital-skills-and-inclusion-giving-everyone-access-to-the-digital-skills-they-need

5 See: https://www.gov.uk/government/publications/uk-digital-strategy/3-the-digital-sectors-making-the-uk-the-best-place-to-start-and-grow-a-digital-business

6 See: https://www.gov.uk/government/publications/uk-digital-strategy/4-the-wider-economy-helping-every-british-business-become-a-digital-business

7 See: https://www.gov.uk/government/publications/uk-digital-strategy/5-a-safe-and-secure-cyberspace-making-the-uk-the-safest-place-in-the-world-to-live-and-work-online

8 See: https://www.gov.uk/government/publications/uk-digital-strategy/6-digital-government-maintaining-the-uk-government-as-a-world-leader-in-serving-its-citizens-online

9 See: https://www.gov.uk/government/publications/uk-digital-strategy/7-data-unlocking-the-power-of-data-in-the-uk-economy-and-improving-public-confidence-in-its-use

10 See: https://www.ofcom.org.uk/phones-telecoms-and-internet/advice-for-consumers/broadband-uso-need-to-know

11 See: https://ec.europa.eu/digital-single-market/en/country-information-united-kingdom#:~:text=Main%20aims%20for%20broadband%20development,of%20the%20population%20by%202027

12 See: Conservative Party Manifesto, 2019.

13 See: https://www.gov.uk/government/news/shared-rural-network

14 See: https://www.techuk.org/resource/government-announces-new-digital-strategy.html

15 See: https://www.gov.uk/government/news/shared-rural-network

16 See: https://gov.wales/broadband-in-wales

17 See: https://www.gov.scot/publications/realising-scotlands-full-potential-digital-world-digital-strategy-scotland/

18 See: https://www.gov.uk/government/publications/greening-government-ict-and-digital-services-strategy-2020-2025

19 See: https://joinup.ec.europa.eu/sites/default/files/inline-files/Digital_Government_Factsheets_UK_2019.pdf

[20] See: https://tech.newstatesman.com/policy/uk-digital-strategy-2020

[21] See: https://www.techuk.org/insights/news/item/18040-government-announces-new-digital-strategy

[22] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H").

[23] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b").

[24] See: https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2019

[25] See: https://www.ofcom.org.uk/phones-telecoms-and-internet/advice-for-consumers/advice/broadband-speeds/broadband-basics

[25] https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2019

[26] See: https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2019

[27] See: https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2019/latest-uk-broadband-mobile-coverage-revealed

[28] Ibid.

[29] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-update-summer-2020/interactive-report

[30] See: https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2019

[31] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[32] See: https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Mobile_cellular_2000-2018_Dec2019.xls

[33] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw").

[34] See: https://www.spectrummonitoring.com/frequencies/#UK

[35] See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G" and "i271GA").

[36] See: https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-update-summer-2020

[37] Ibid.

[38] See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

[39] See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/597421/07.03.17_5G_strategy_-_for_publication.pdf

[40] See: https://www.gov.uk/government/news/government-must-take-action-now-to-secure-our-connected-future-so-we-are-ready-for-5g-and-essential-services-are-genuinely-available-where-they-are-n

[41] See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/582640/FCCG_Interim_Report.pdf

[42] See: https://www.gov.uk/government/publications/next-generation-mobile-technologies-a-5g-strategy-for-the-uk

[43] See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/597421/07.03.17_5G_strategy_-_for_publication.pdf

[44] See: https://www.commsbusiness.co.uk/features/uk-5g-strategy-update/

[45] See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

[46] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf

[47] See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759222/CCS207_CCS1118987248-001_National_Infrastructure_and_Construction_Pipeline_2018_Accessible.pdf

[48] Exchange rate as at September 2020.

[49] See: https://www.gov.uk/government/news/new-65-million-package-for-5g-trials

[50] Ibid.

[51] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0032/198770/ofcom-annual-report-and-accounts-2019-20.pdf

[52] See: https://5gobservatory.eu/public-initiatives/national-5g-plans-and-strategies/#1533566348807-66cd9716-c6d2

[53] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf

[54] See: https://www.telegeography.com/products/commsupdate/articles/2017/02/09/ofcom-updates-5g-spectrum-plans

[55] See: https://5gobservatory.eu/5g-spectrum/national-5g-spectrum-assignment/#1533313745961-d2a5cc14-241a

[56] See: https://www.ofcom.org.uk/about-ofcom/latest/features-and-news/results-auction-mobile-airwaves

[57] See: https://5g.co.uk/guides/5g-uk-auction/

[58] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0016/115630/Implementing-decisions-5771-GHz-band.pdf

[59] See: https://5g.co.uk/news/ofcom-additional-spectrum-5g/4922/

[60] See: https://5g.co.uk/guides/5g-uk-auction/

[61] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0031/158278/draft-ir-2105-shared-access-26-ghz-indoors.pdf

[62] See: https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2020/plans-for-spectrum-auction

[63] See: https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2020/mobile-airwaves-auction

[64] See: https://www.rcrwireless.com/20200804/5g/uk-regulator-award-additional-5g-spectrum-january-2021

[65] See: https://commonslibrary.parliament.uk/research-briefings/cbp-7883/

[66] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0012/200901/melanie-dawes-to-mnos.pdf

[67] See: http://www.emfs.info/wp-content/uploads/2014/07/DHletterandannex2004.pdf

[68] See: https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf

[69] See: http://www.emfs.info/policy/sage/1ia-govt/

[70] See: http://www.emfs.info/wp-content/uploads/2014/07/PowerlinesDemonstratingcomplianceVCoP2012resaved.pdf

[71] See: https://www.gov.uk/government/publications/5g-technologies-radio-waves-and-health

[72] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0013/190003/emf-condoc.pdf

[73] See: http://www.thecosmosproject.org/

[74] See: https://www.scampstudy.org/

[75] See: https://www.who.int/peh-emf/project/mapnatreps/uk_2019.pdf?ua=1

[76] See: https://www.ofcom.org.uk/spectrum/information/mobile-operational-enquiries/mobile-base-station-audits

[77] See: https://www.ofcom.org.uk/consultations-and-statements/category-1/limiting-exposure-to-emf

[78] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0013/190003/emf-condoc.pdf

[79] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0015/202065/5g-guide.pdf

[80] See: https://www.gov.uk/government/groups/advisory-group-on-non-ionising-radiation-agnir

[81] Ibid.

[82] See: https://www.ofcom.org.uk/consultations-and-statements/category-1/limiting-exposure-to-emf

[83] See: https://www.ofcom.org.uk/__data/assets/file/0022/204529/emf-calculator-v0.1.1.xlsx

[84] See: https://www.ofcom.org.uk/consultations-and-statements/category-1/limiting-exposure-to-emf

[85] See: https://www.commsupdate.com/articles/2015/01/19/ofcom-invites-comments-on-high-frequency-bands-for-5g/

[86] See: https://www.bbc.com/news/technology-31622297

[87] See: https://www.thefastmode.com/technology-solutions/6338-bt-pushes-broadband-speeds-to-5-6gbps-with-xg-f ast-over-copper-lines

[88] See: http://www.lteto5g.com/bt-nokia-ink-research-collaboration-agreement-5g-technologies/

[89] See: https://news.samsung.com/global/arqiva-and-samsung-kick-off-uks-first-5g-fixed-wireless-access-trial

[90] See: https://5g.co.uk/news/samsung-and-arqiva-5g-fwa-trial-live/4190/

[91] See: https://www.ericsson.com/en/news/2017/2/ericsson-qualcomm-and-vodafone-trial-5g-new-radio-for-unified-5g

[92] See: https://news.o2.co.uk/press-release/o2-launch-5g-test-bed-o2/

[93] See: https://newscentre.vodafone.co.uk/press-release/first-test-new-5g-spectrum-across-live-network/

[94] See: https://newscentre.vodafone.co.uk/press-release/5g-trial-seven-cities/

[95] See: https://www.landmobile.co.uk/news/vodafone-5g-trial-salford/

[96] See: https://www.mirror.co.uk/tech/ee-launches-first-5g-network-13368492

[97] See: https://newsroom.ee.co.uk/ee-switches-on-5g-trial-sites-in-east-london/

[98] See: https://www.commsupdate.com/articles/2020/10/14/ee-extends-5g-coverage-to-twelve-more-locations/

[99] See: https://www.mobileworldlive.com/featured-content/top-three/3uk-set-for-2b-5g-investment

[100] See: https://www.zdnet.com/article/three-uk-to-invest-over-2bn-in-new-5g-infrastructure/

[101] See: https://www.commsupdate.com/articles/2018/11/08/three-uk-claims-to-have-committed-gbp2bn-investment-in-5g/

[102] See: https://www.telegraph.co.uk/technology/2018/11/13/ee-roll-5g-16-cities-next-year-demand-led-strategy/

[103] See: https://5gobservatory.eu/5g-trials-at-manchester-airport-by-vodafone/

[104] Ibid.

[105] See: https://www.mobilenewscwp.co.uk/News/article/o2-activate-5g-network-june-millbrook-testing-ground

[106] See: https://www.commsupdate.com/articles/2019/04/15/o2-to-commence-5g-testing-in-june-2019/

[107] See: https://newscentre.vodafone.co.uk/press-release/5g-uk-live-date-announced-5g-roaming-this-summer/#:~:text=Vodafone%20will%20switch%20on%20its,and%20Spain%20over%20the%20summer

[108] See: https://www.commsupdate.com/articles/2019/07/18/vodafone-uk-extends-5g-network-coverage/

[109] See: https://www.computerworld.com/article/3428136/three-uk-launches-5g-ready-cloud-core-network-in-time-for-5g-rollout.html

[110] See: https://news.o2.co.uk/press-release/connecting-britain-o2-continues-5g-switch-on-across-the-uk-in-tyne-and-wear-surrey-and-lincoln/#:~:text=O2%20has%20announced%20that%20its,and%20customers%20in%20the%20UK

[111] See: https://www.thefastmode.com/services-and-innovations/16218-vodafone-uk-intros-5g-multi-operator-ran-expands-5g-roaming-to-ireland

[112] See: https://www.commsupdate.com/articles/2020/01/14/vodafone-uk-extends-5g-coverage-introduces-moran-technology/

[113] See: https://www.commsupdate.com/articles/2020/02/14/three-uk-confirms-mobile-5g-launch-plans/

[114] See: https://www.ericsson.com/en/press-releases/2020/4/bt-and-ericsson-join-up-to-deliver-cloud-native-dual-mode-5g-core

[115] See: https://www.rcrwireless.com/20200611/5g/ericsson-extends-5g-partnership-uk-02

[116] See: http://5gobservatory.eu/market-developments/5g-services/

[117] See: https://www.coventry.ac.uk/news/2020/coventry-university-5g/

[118] See: https://www.techradar.com/news/three-expands-5g-backhaul-deal-with-cityfibre

[119] See: https://www.rcrwireless.com/20200929/5g/nokia-secures-5g-ran-contract-from-uk-carrier-bt

[120] See: https://www.nokia.com/about-us/news/releases/2020/09/29/nokia-signs-5g-deal-to-become-bts-largest-infrastructure-partner/

[121] See: https://www.commsupdate.com/articles/2020/09/30/bt-selects-nokia-as-5g-ran-vendor/

3.18 Vatican City State

3.18.1 ICT background and current status of broadband

The Vatican City State is the smallest State in the world in terms of population as well as size of territory, extending over an area of fewer than 50 hectares enclaved in the heart of Rome in Italy.[1] The nation's interior telecommunication system is composed of two strongly integrated subsystems: fixed infrastructure and mobile infrastructure. It is important to note that the mobile communication system has been designed to be capable of using satellite connections so that it is possible to ensure telecommunication services wherever needed, tracking the pastoral travels of the Pope.[2]

With a small number of residents, Vatican's telephone system operates through an automatic digital exchange. In terms of ICTs, the country is known for controlling its own Internet top-level domain (TLD), which is registered as (.va), and broadband service is widely available.[3] The Vatican City State has been given an ITU radio prefix, HV, which is sometimes used by amateur radio operators, and has also been assigned maritime and aeronautical international call signs.

In the face of the new digital transformation, the country has increasingly relied on new ICT-enabled services for wider dissemination of messages from the Pope and other institutions in the State to the rest of the world. In November 2018, a Vatican digital expert urged priests around the world to get online and take advantage of the possibilities afforded by broadband.[4]

Furthermore, is also important to underline that the nation's 5G strategy is evolving and is subject to change.

3.18.2 Broadband and mobile telecommunication data

In terms of telephone services, the Governorate's Department of Telecommunication has been responsible for the Vatican Telephone Service since 2012, although it was first officially launched in 1930, and offered services to approximately 360 end users. Since 1960, its capacity has increased tremendously.[5]

In the 1990s, the Vatican expanded its internal telecom infrastructure, providing the city with a highly advanced state-of-the-art network. Currently (2020), the some 5 000 phone terminals in the Vatican City State are connected through an IMS exchange. Fibre-optic links provide phone and data connectivity to Italian communication operators and international data carriers, as well as to the extraterritorial zones.

3.18.3 Current progress on 5G: Consultations and national strategies

As at October 2020, no public information is available for the Vatican City State concerning 5G consultations and strategies.

3.18.4 Spectrum assignment for 5G and market development

As at October 2020, no public information is available concerning 5G spectrum assignment in the Vatican City State. However, the country coordinates its spectrum use with its neighbouring country in accordance with the ITU instruments.

In the near future, a 5G broadband application scenario could be envisaged to develop and improve broadcasting applications.

3.18.5 Electromagnetic field levels and implementation dynamics

Since 1992, pursuant to the resolution of the Special Delegate of the Pontifical Commission for the Vatican City State (Prot. Gen. 225620 of 16 December 1992), the nation has adopted precautionary values provided by the International Commission on Not-Ionizing Radiation Protection (ICNIRP) for the EMF exposure limits for the 0 Hz-300 GHz frequency range.[6] By Ministerial Decree 381/98 (which entered into force in January 1999), Italy adopted a limit of 20 V/m regardless of frequency; however, in the case of presence for continuous stays of not less than four hours, the Decree reduces these limits to 6 V/m for all electromagnetic waves.[7]

In response to the challenges raised by alleged EMF exposure violations of Italy's Ministerial Decree 381/98 by Vatican Radio antennas in the city of Rome,[8] the Vatican agreed to have part of its programmes broadcast by other stations in Italy or abroad (from within the Principality of Monaco), and the Italian Government agreed to pay for the costs of the transfer.[9] Since then, the national Italian EMF limits now in force were set by decree of the Prime Minister in August 2003, replacing a previous decree of 1992,[10] and present more restrictive quantitative limits than the standards provided by ICNIRP.[11]

3.18.6 5G commercial launches: Announcements, trial cities and digital cross-border corridors

As at October 2020, no 5G commercial launch had occurred in the Vatican City State. Nonetheless, developments are proceeding apace in the surrounding areas of the enclave, primarily driven by operators such as TIM (which activated its 5G network in parts of Rome and Turin in June 2019) and Vodafone (which switched on its network around the same time in Rome and Turin as well as Bologna, Naples and the metropolitan areas of Milan). In early 2019, both TIM and Vodafone signed a cost-share agreement on the roll-out of new 5G infrastructure throughout Italy.[12]

Endnotes

1 See: https://www.vaticanstate.va/it/ [in Italian].

2 See: https://ieeexplore.ieee.org/abstract/document/5678677

3 See: https://en.wikipedia.org/wiki/Vatican_City

4 See: https://br.reuters.com/article/idUSKCN1NB2E7

5 See: https://www.encyclopedia.com/places/spain-portugal-italy-greece-and-balkans/italian-political-geography/vatican-city

6 See: https://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Europe/Vatican_files/table_vt.htm

7 See: http://www.radiovaticana.va/archivio/010403_rv_em.html [in Italian].

8 See: https://spectrum.ieee.org/energy/the-smarter-grid/sins-of-transmission

9 See: https://repository.upenn.edu/cgi/viewcontent.cgi?article=1018&context=be_papers

10 See: https://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Europe/Italy_files/table_it.htm

11 See: https://www.5gitaly.eu/2018/wp-content/uploads/2019/01/5G-Italy-White-eBook-5G-planning-under-EMF-constraints.pdf

12 See: https://5gobservatory.eu/tim-launches-5g-services-in-parts-of-rome-and-turin-with-new-5g-plans/

4 Conclusions

Overall, it must be acknowledged that 4G technology now covers more than 91 per cent of non-EU countries in the Europe region. Compared to only five years ago, this is a significant improvement which has an impact on the lives of millions of people and testifies to the fact that the Europe region is reducing existing gaps within its boundaries.

Considering that the European Union is accelerating its 5G development, however, more needs to be done to reduce the investment cycle in 4G so as to speed up 5G deployment, especially in some non-EU countries. Moreover, a number of issues remain, including freeing the 700 MHz band (DD2) for mobile communications as well as creating an enabling environment for the commercialization of services relying on the 26 GHz band.

On top of these challenges, two further issues were highlighted in the proceedings of the ITU Regional Forum for Europe on 5G strategies, policies and implementation which took place on 22-23 October 2020. The first is radio-frequency electromagnetic fields (RF-EMF), which in some countries are a cause of concern among the general public leading to the spread of misinformation that risks hindering the deployment of 5G. The second item which was widely agreed upon was the need to avoid creating new gaps within the Europe region between EU countries and non-EU countries, as the former take substantial and harmonized steps forward on 5G and the latter proceed independently. It was emphasized that 5G presents common hurdles that should be overcome through international collaboration.

Beyond these challenges, new ones will arise as 5G networks are rolled out in the coming years. ITU's Regional Initiative for Europe EUR 1 on 'Broadband infrastructure, broadcasting and spectrum management' creates a foundation for supporting countries in addressing their needs and priorities on 5G development through technical assistance or by fostering capacity building and exchange of information.

Office of the Director
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax: +41 22 730 5484

Office of Deputy Director and Regional Presence
Field Operations Coordination Department (DDR)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5131
Fax: +41 22 730 5484

Digital Networks and Society (DNS)

Email: bdt-dns@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Digital Knowledge Hub Department (DKH)

Email: bdt-dkh@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Partnerships for Digital Development Department (PDD)

Email: bdt-pdd@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

Africa

Ethiopia

International Telecommunication Union (ITU) Regional Office
Gambia Road
Leghar Ethio Telecom Bldg. 3rd floor
P.O. Box 60 005
Addis Ababa
Ethiopia

Email: itu-ro-africa@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

Cameroon

Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé
Cameroon

Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

Senegal

Union internationale des télécommunications (UIT)
Bureau de zone
8, Route des Almadies
Immeuble Rokhaya, 3e étage
Boîte postale 29471
Dakar - Yoff
Senegal

Email: itu-dakar@itu.int
Tel.: +221 33 859 7010
Tel.: +221 33 859 7021
Fax: +221 33 868 6386

Zimbabwe

International Telecommunication Union (ITU) Area Office
TelOne Centre for Learning
Corner Samora Machel and Hampton Road
P.O. Box BE 792
Belvedere Harare
Zimbabwe

Email: itu-harare@itu.int
Tel.: +263 4 77 5939
Tel.: +263 4 77 5941
Fax: +263 4 77 1257

Americas

Brazil

União Internacional de Telecomunicações (UIT)
Escritório Regional
SAUS Quadra 6 Ed. Luis Eduardo Magalhães,
Bloco "E", 10º andar, Ala Sul (Anatel)
CEP 70070-940 Brasilia - DF
Brazil

Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

Barbados

International Telecommunication Union (ITU) Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown
Barbados

Email: itubridgetown@itu.int
Tel.: +1 246 431 0343
Fax: +1 246 437 7403

Chile

Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Santiago de Chile
Chile

Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

Honduras

Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Altos de Miramontes
Calle principal, Edificio No. 1583
Frente a Santos y Cía
Apartado Postal 976
Tegucigalpa
Honduras

Email: ituteguciglapa@itu.int
Tel.: +504 2235 5470
Fax: +504 2235 5471

Arab States

Egypt

International Telecommunication Union (ITU) Regional Office
Smart Village, Building B 147,
3rd floor
Km 28 Cairo
Alexandria Desert Road
Giza Governorate
Cairo
Egypt

Email: itu-ro-arabstates@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

Asia-Pacific

Thailand

International Telecommunication Union (ITU) Regional Office
Thailand Post Training Center
5th floor
111 Chaengwattana Road
Laksi
Bangkok 10210
Thailand

Mailing address:
P.O. Box 178, Laksi Post Office
Laksi, Bangkok 10210, Thailand

Email: ituasiapacificregion@itu.int
Tel.: +66 2 575 0055
Fax: +66 2 575 3507

Indonesia

International Telecommunication Union (ITU) Area Office
Sapta Pesona Building
13th floor
Jl. Merdan Merdeka Barat No. 17
Jakarta 10110
Indonesia

Mailing address:
c/o UNDP – P.O. Box 2338
Jakarta 10110, Indonesia

Email: ituasiapacificregion@itu.int
Tel.: +62 21 381 3572
Tel.: +62 21 380 2322/2324
Fax: +62 21 389 5521

CIS

Russian Federation

International Telecommunication Union (ITU) Regional Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation

Email: itumoscow@itu.int
Tel.: +7 495 926 6070

Europe

Switzerland

International Telecommunication Union (ITU) Office for Europe
Place des Nations
CH-1211 Geneva 20
Switzerland
Email: eurregion@itu.int
Tel.: +41 22 730 5467
Fax: +41 22 730 5484

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland

ISBN 978-92-61-33211-2

Published in Switzerland
Geneva, 2021
Photo credits: Shutterstock