GSMA

5G in Africa: realising the potential

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Preface

Commercial 5G services are now available in every region of the world, making it a truly global technology. Today, nearly 220 operators in over 80 markets around the world have launched commercial 5G services. By 2030, there will be more than 5.3 billion 5G connections, representing over half of total mobile connections globally. At least 60% of the world's population will be covered by 5G networks.[1]

In Africa, the journey to 5G has begun but it is still early stages for network deployment and commercialisation. Governments and enterprises in the region are increasingly using technology to tackle the biggest challenges faced by society, and 5G will no doubt play a key role in this area. This is especially important in the context of Covid-19 and ongoing efforts to build more resilient economies and meet the growing demand for enhanced connectivity.

To understand the opportunities of 5G in Africa, in the context of the region's connectivity and socioeconomic landscape, the GSMA, in collaboration with the ITU, conducted a survey (the 5G Africa Survey) of key stakeholders to capture on-the-ground perspectives of the 5G era in countries across the region. There were 48 respondents, drawn from:

- policymakers and telecoms regulators
- mobile operators (group level and local operators) with a combined share of more than 90% of total connections in the region
- equipment vendors with a combined share of more than 90% of the network infrastructure market in the region
- global device and chipset manufacturers with growing presence in Africa
- enterprises across key verticals, including ports and the extractive industries
- tech innovators and streaming content providers
- multilateral stakeholders representing 5G ecosystem players.

The insights in this report have been generated from analysis of anonymised and aggregated responses (interviews and questionnaires) to the 5G Africa Survey. We have also used GSMA Intelligence data and other related market surveys. These include the GSMA Intelligence Consumers in Focus Survey 2021, the GSMA Intelligence Enterprise in Focus Survey 2021 and the GSMA Intelligence Operators in Focus: Network Transformation Survey 2021.

1 GSMA Intelligence data

Foreword

Angela Wamola
Head of Sub-Saharan Africa, GSMA

Ready or not, the 5G era has already begun in Africa. This will be driven not only by the benefits of the network economics and innovation that this evolutionary broadband technology promises, but also by the region's digital natives who will be front and centre in fuelling consumer interest in non-connectivity offerings, such as video and music streaming, gaming and metaverse applications.

4G still has a lot of room to grow in the region. With device affordability still a challenge and 60% of the adult population yet to connect to the mobile internet, despite living within range of a 3G or 4G signal, 5G mass-market adoption and ecosystem maturity is more of a long-term prospect in most countries in the region.

However, the case for 5G in Africa is strong. In a post-pandemic world, businesses and governments are intent on building resilient, inclusive and sustainable digital economies that can withstand current and future shocks. Africa's retail, financial services, agriculture, extractive and manufacturing industries present clear opportunities for 5G to enable digital transformation, which will avert the risk of exacerbating the digital divide with the rest of the world. Furthermore, Africa's vibrant tech startup ecosystem is well placed to leverage the capabilities of 5G to develop innovative solutions to address local challenges.

We recognise the role and responsibility of the private sector in investing in future network technologies and accelerating the development of locally relevant use cases, for example through 5G labs and ecosystem partnerships to co-create new solutions. All efforts are welcomed towards achieving cost-effective network rollout, innovative use cases and applications, and affordable devices that appeal to African consumers and enterprises.

We equally acknowledge the role that governments can play in accelerating 5G rollout and adoption in Africa. Fostering a pro-investment and pro-innovation environment is critical for stimulating network rollout and demand for new services. In particular, addressing the affordability challenge should be top of mind for governments and policymakers. This can be achieved by aligning policies and regulations, especially around spectrum and taxation, with digital transformation objectives.

The opportunities are tremendous but so are the challenges. In this 5G era, as in the old African proverb, if we want to go further, we have to go together.

Executive summary

With more than 1.2 billion connections and over 650 million unique mobile users by the end of 2022, mobile has a greater reach in Africa than any other technology, making it an important enabler of social and economic progress in the region.

In this sense, 5G is a necessary upgrade to the mobile product, ensuring that it continues to remain relevant to consumers, enterprises, governments and society as a whole. The importance of mobile, and 5G in particular, will become even more profound as the world emerges into a post-Covid-19 scenario where digital technologies and services are increasingly integrated into every aspect of society.

Globally, total 5G connections will pass the 2 billion mark by the end of 2025 and reach around 5.3 billion by the end of this decade. 5G is experiencing a faster rate of adoption compared to 4G and 3G in the first few years after launch: the total number of 5G connections will reach 1 billion by the end of 2022, just under four years from the launch of the first commercial network, while it took 4G around eight years and 3G nearly 11 years after their respective launches to reach the same milestone. Momentum has been boosted by a number of factors, including the economic recovery from the pandemic, rising 5G handset sales, network coverage expansions and overall marketing efforts.

The case for 5G in Africa

5G in Africa is a matter of when, not if. The decision on when to launch 5G is often based on a number of factors in the local market that reflect the readiness of operators to roll out 5G networks and readiness of customers (consumers and enterprises) to adopt 5G services and 5G-enabled solutions. In Africa, the present-day scenario suggests that 5G mass-market readiness is some way off. Despite a sizeable market opportunity of a total population of more than 1.3 billion people in total, with most individual markets having populations of 5 million or more, 4G is still in infancy (accounting for just 25% of connections, on average, compared to 60% globally) and affordability of devices and digital literacy remain challenges.

Despite the challenge of mass-market 5G readiness in Africa, there are reasons to welcome the 5G era, not least because there would otherwise be a risk of exacerbating the digital divide that already exists between Africa and more advanced regions. Beyond that, digital connectivity, with 5G at the core, will shape the way people live and businesses operate in a post-pandemic world, including the potential for:

- **improving connectivity for homes and enterprises,** given the limited access to fixed broadband connectivity (fixed broadband penetration is typically below 2% in African countries).
- **enabling the digital transformation of enterprises** by supporting governments efforts to drive the fourth industrial revolution.
- **boosting tech innovation** by creating new opportunities for tech startups to develop innovative and locally relevant solutions for the benefit of society.
- **meeting the connectivity needs of young consumers** who, as digital natives, would be after contemporary data-hungry digital services, such as live video streaming and gaming and metaverse applications.

5G growth outlook for Africa

In 2020, Vodacom and MTN launched the first major 5G networks in the region, offering 5G mobile and fixed wireless access (FWA) services in South Africa and formally kicking off the 5G era in Africa. There are now commercial 5G networks in more than 10 countries in the region, with stakeholders in many more countries expecting commercial 5G to be available in their markets by 2025. By the end of this decade, there will be more than 340 million 5G connections in Africa, equivalent to a fifth of total mobile connections. Together, 4G and 5G will account for nearly two thirds of total mobile connections at the end of 2030.

5G networks bring substantial improvements over previous generations, including higher connection speeds, greater capacity and lower latency. With this increased performance, 5G networks can enable new use cases and applications that will positively impact many industry sectors. In the period to 2030, 5G is expected to contribute around $26 billion to Africa's economy. Retail, manufacturing and agriculture are among the sectors that will see the most impact.

Realising 5G's potential in Africa

Over the last five years, mobile operators in Africa have invested nearly $45 billion in capex – mostly on deploying and expanding 4G networks. In the coming years, operators will progressively increase investment in 5G as they step up preparations for 5G rollout. Key focus areas will include investments in fibre backhaul and cell site densification, and network virtualisation and automation capabilities. To build cost-effective networks, operators and other ecosystem players will need to increase their focus on the use of renewable energy for network operations amid rising energy costs and sustainability targets, and accelerate the rollout of voice over LTE (VoLTE) as a precursor to shutting down legacy networks (2G and 3G) and freeing up valuable spectrum for modern networks.

Beyond network deployment, customer (consumers and enterprises) adoption and usage are critical to scaling 5G in Africa and improving the business case for more widespread 5G rollout. The greatest potential obstacle to consumer 5G adoption and usage in Africa is device cost and availability. Given the impact of device affordability on 4G adoption, device financing schemes will likely be necessary to improve affordability. On the enterprise front, the industry needs to better articulate the capabilities and value proposition of 5G (including FWA, network slicing, edge computing and IoT technologies) to customers. The industry also needs to work collaboratively with various stakeholders to develop innovative use cases specifically for local markets in the region, taking into account the unique social, economic and environmental factors at play.

An enabling policy environment is also essential for the success of 5G in Africa. Accordingly, governments and regulators need to foster a pro-investment and pro-innovation environment to support cost-effective network rollout and the development of innovative use cases to stimulate demand. In practice, this means:

- providing timely access to the right amount of spectrum for 5G, under the right conditions
- implementing policies and regulation to support cost-effective network rollout, especially around right-of-way (RoW) approvals, electromagnetic field (EMF) rules and small cell deployment
- supporting operators' transition to renewable energy
- facilitating use case development and content creation to stimulate demand
- using fiscal and regulatory measures to improve the affordability of devices
- addressing public concerns and misconceptions about 5G.

1 5G in a global context

5G is now live in every region, making it a truly global technology. The 5G era formally began in 2019 with the launch of mobile 5G services in South Korea and the US. Since then, 5G commercialisation has gained momentum, with new network launches and operators scaling existing networks and services to reach more customers.

As of September 2022, there were 218 commercial 5G networks in 83 countries around the world. The Covid-19 pandemic has further boosted 5G momentum, with many governments and operators speeding up their 5G rollouts to meet the growing demand for enhanced connectivity as well as establishing the foundation for a digital future.

This chapter explains the capabilities of 5G and how it differs from previous generations and highlights global 5G adoption trends, growth drivers and use cases.

1.1 Understanding 5G

5G is a global and multi-stakeholder technology with a range of design goals. Discussions between mobile industry stakeholders from different countries to define and shape 5G began in 2012, culminating in the IMT-2020 requirements proposed by the International Telecommunications Union Radiocommunication Sector (ITU-R), which are seen as the definitive 5G design goals.[2]

Figure 1

IMT-2020 5G requirements

Source: ITU-R

Requirement		Value	
Data rate	Peak	Downlink: 20 Gb/s	Uplink: 10 Gb/s
	User experience	Downlink: 100 Mb/s	Uplink: 50 Mb/s
Spectral efficiency	Peak	Downlink: 30 bit/s/Hz	Uplink: 15 bit/s/Hz
	5th percentile user	Downlink: 0.12–0.3 bit/s/Hz	Uplink: 0.045–0.21 bit/s/Hz
	Average	Downlink: 3.3–9 bit/s/Hz	Uplink: 1.6–6.75 bit/s/Hz
Area traffic capacity		10 Mb/s/m^2	
Latency	User plane	1–4 ms	
	Control plane	20 ms	
Connection density		1,000,000 devices per km^2	
Energy efficiency		Loaded: see average spectral efficiency	No data: sleep ratio
Reliability		This is 1–10^{-5} success probability of transmitting a layer 2 protocol data unit of 32 bytes within 1 ms	
Mobility		0–500 km/hr	
Mobility interruption time		0 ms	
Bandwidth		100 MHz	

2 https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx

The 3rd Generation Partnership Project (3GPP) approved the non-standalone 5G new radio (5G NR) specifications in 2017, allowing many operators to bring forward their 5G commercial launch plans. The standalone version was approved in June 2018, which represented the full 3GPP Release 15. 5G NR is designed to deliver faster and better mobile broadband services compared to 4G, and to enable new services for verticals, including mission-critical communications and massive IoT. 3GPP completed 5G NR Release 16 and Release 17 in 2020 and 2022, respectively, expanding the reach of 5G to new services, spectrum, deployments and devices (see Figure 2).

Figure 2

The features of 5G NR Release 16 and 17

Source: 3GPP

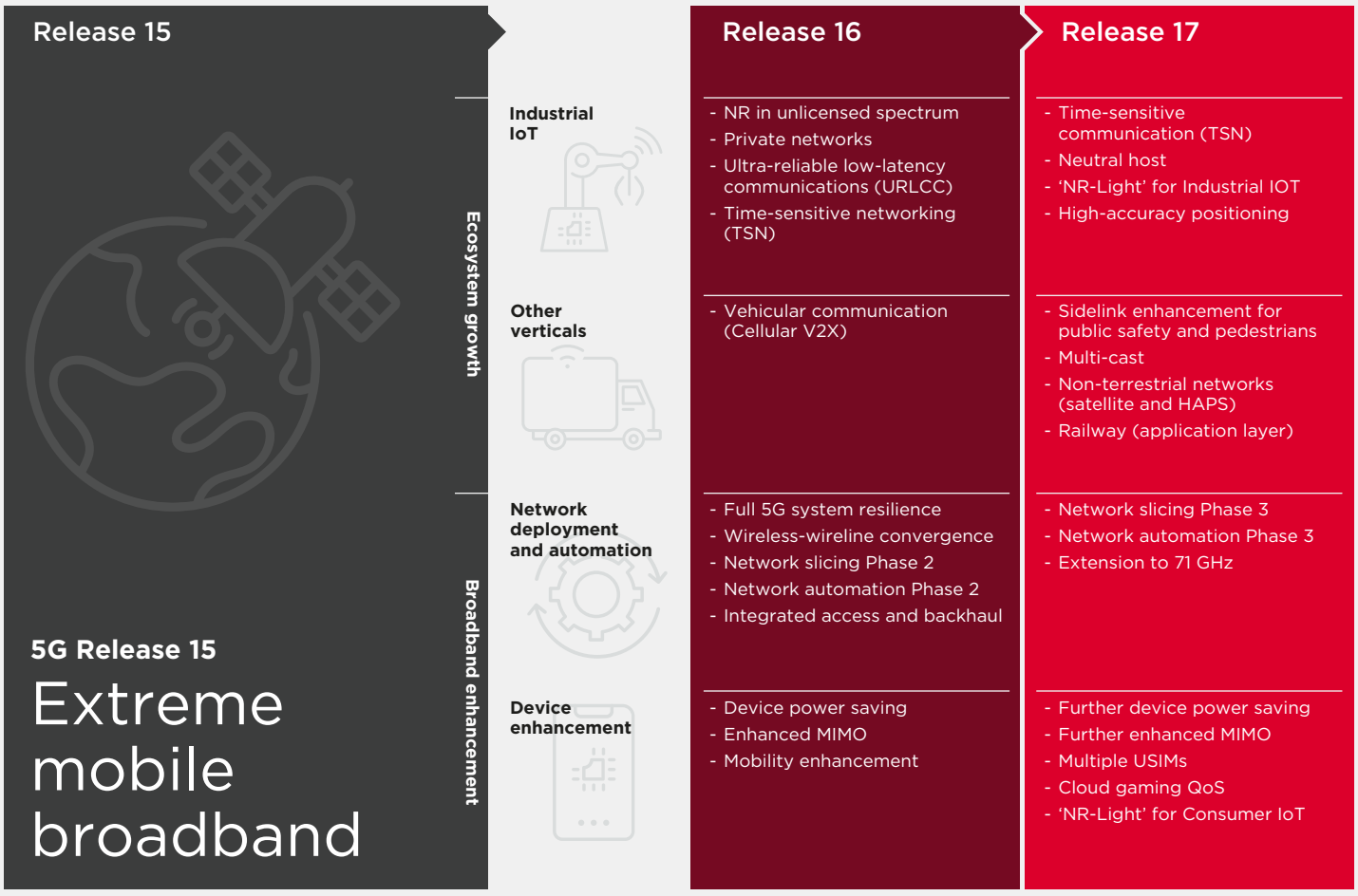
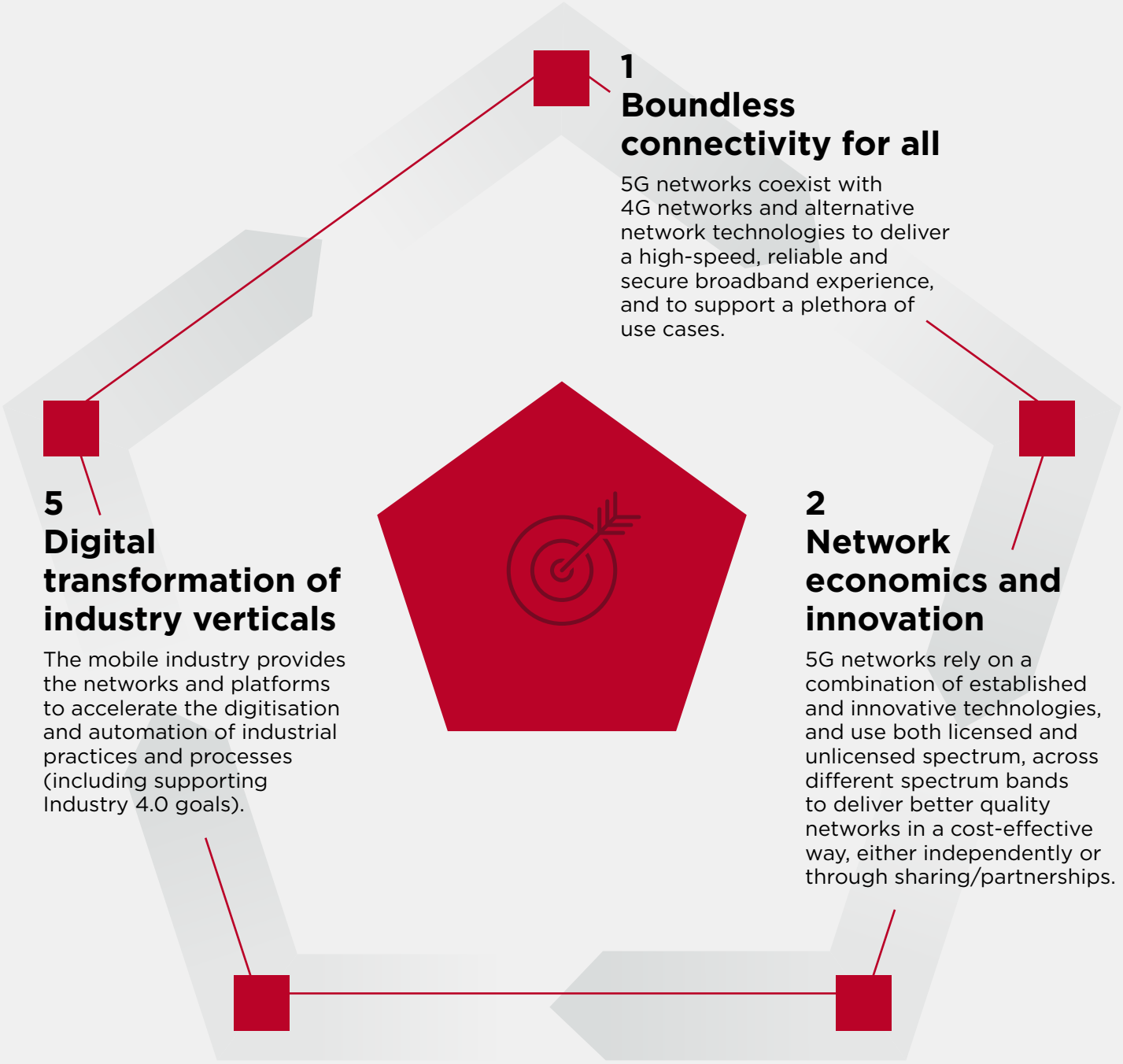


Figure 3

The mobile industry's goals for the 5G era

Source: GSMA



1 Boundless connectivity for all

5G networks coexist with 4G networks and alternative network technologies to deliver a high-speed, reliable and secure broadband experience, and to support a plethora of use cases.

2 Network economics and innovation

5G networks rely on a combination of established and innovative technologies, and use both licensed and unlicensed spectrum, across different spectrum bands to deliver better quality networks in a cost-effective way, either independently or through sharing/partnerships.

3 Enhanced mobile broadband

5G networks enable an enhanced broadband experience with speeds of up to 1 Gbps and latency of less than 4 milliseconds; they also provide a platform for cloud and AI-based services.

4 Massive IoT and critical communications

5G networks support the massive rollout of intelligent IoT connections for a multitude of scenarios and provide an enhanced platform to support widespread adoption of critical communication services.

5 Digital transformation of industry verticals

The mobile industry provides the networks and platforms to accelerate the digitisation and automation of industrial practices and processes (including supporting Industry 4.0 goals).

1.2
5G versus previous generations

Legacy mobile technologies (1G, 2G and 3G) were heavily voice-oriented with their primary circuit-switched network architecture. 4G introduced the first fully packet-switched network and the foundation for data services. As an evolutionary technology, 5G performs all the functions of 4G with the potential for more, and at a significantly larger scale: super-fast download speeds, high levels of reliability and extremely low latency.

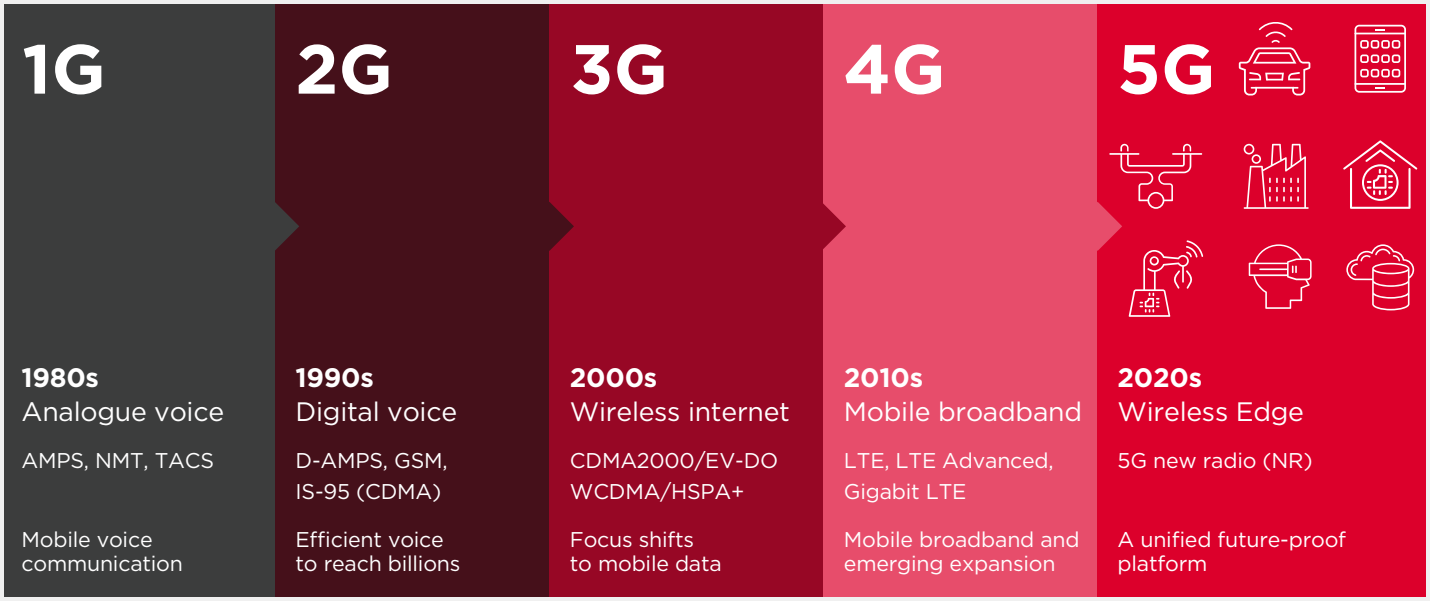
5G builds on 4G's packet-switching capability to deliver a 10–100× increase in data rate, 10× decreased latency, a 10–100× increase in number of connected devices, a 1,000× increase in mobile data volumes, 3× greater spectrum efficiency and a 10× reduction in power consumption.

These improvements are enabled by 5G's more advanced core network technology, along with the use of more efficient radio technologies, more spectrum bandwidth and more densely built networks. However, while 5G offers superior performance over 4G, both network generations will coexist comfortably into the 2030s. Considering the time required to extend 5G coverage into less densely populated areas, users will continue to rely on 4G networks for 5G non-spots for the foreseeable future.

Figure 4

The 2020s will be characterised by the 5G era

Source: GSMA, Qualcomm



1.3
5G connections forecast

5G adoption rates will grow rapidly in the coming years, according to GSMA Intelligence forecasts. Total 5G connections will pass the 2 billion mark by the end of 2025 and reach around 5.3 billion by the end of this decade (see Figure 5) – at this point, 5G connections will account for more than half of the total number of mobile connections. This does not include IoT connections. Separately, GSMA Intelligence forecasts that licensed cellular low-power wide-area (LPWA) connections will reach 2.3 billion by 2030, setting the base for massive IoT, as both long-term evolution for machines (LTE-M) and narrowband IoT (NB-IoT) have a long-term status of 5G standards.

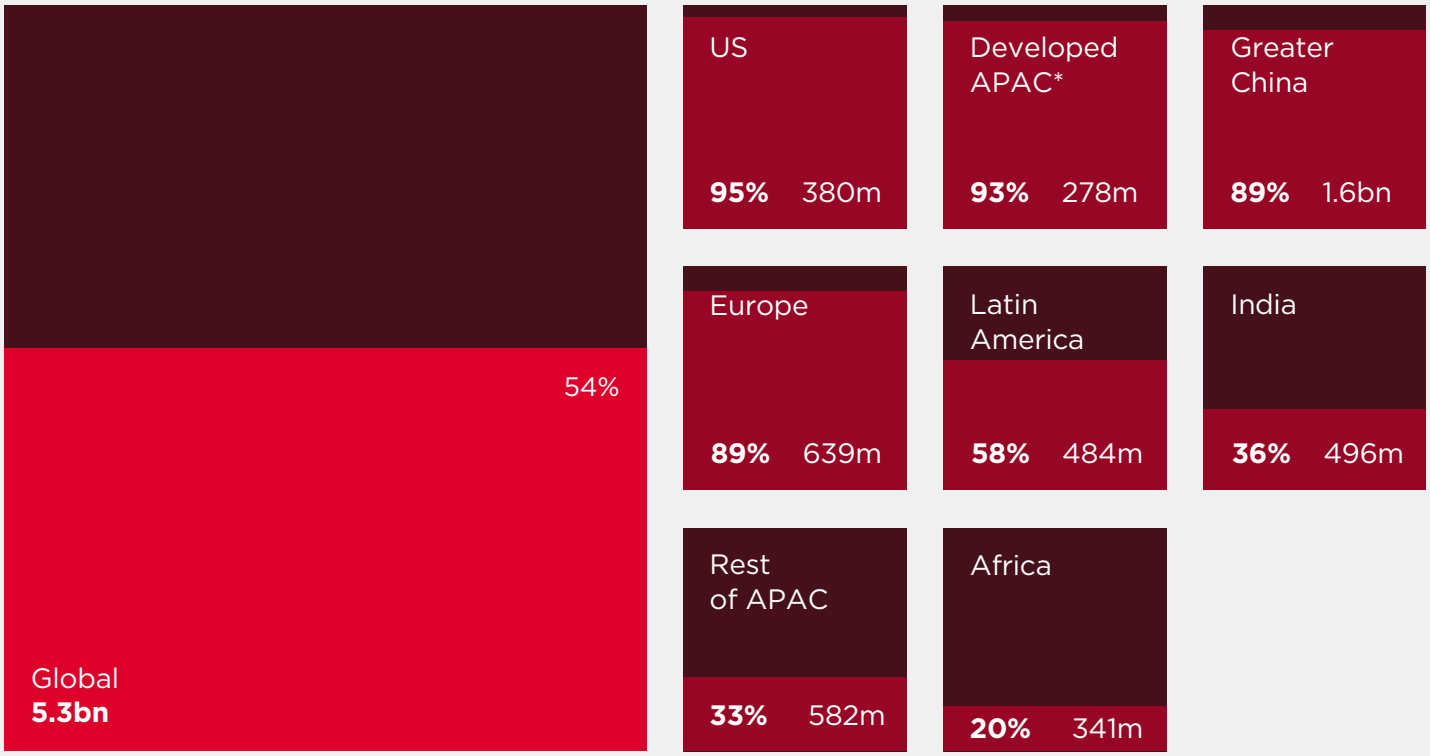
GSMA Intelligence data also shows that adoption of 5G is faster compared to 4G and 3G in the first few years after their respective launches. The total number of 5G connections will reach the 1 billion mark by the end of 2022, just under four years from the launch of the first commercial network. In comparison, it took 4G around eight years and 3G nearly 11 years to reach the same milestone (see Figure 6). The rapid growth of 5G is primarily due to China's earlier launch and adoption of 5G compared to previous generations. Strong 5G demand in China means that it represents the single largest 5G market in the world, accounting for three in five connections of the global total by the end of 2022.

Figure 5

5G mobile adoption in selected markets by 2030

Percentage of connections (excluding licensed cellular IoT and FWA) and number of connections

Source: GSMA Intelligence



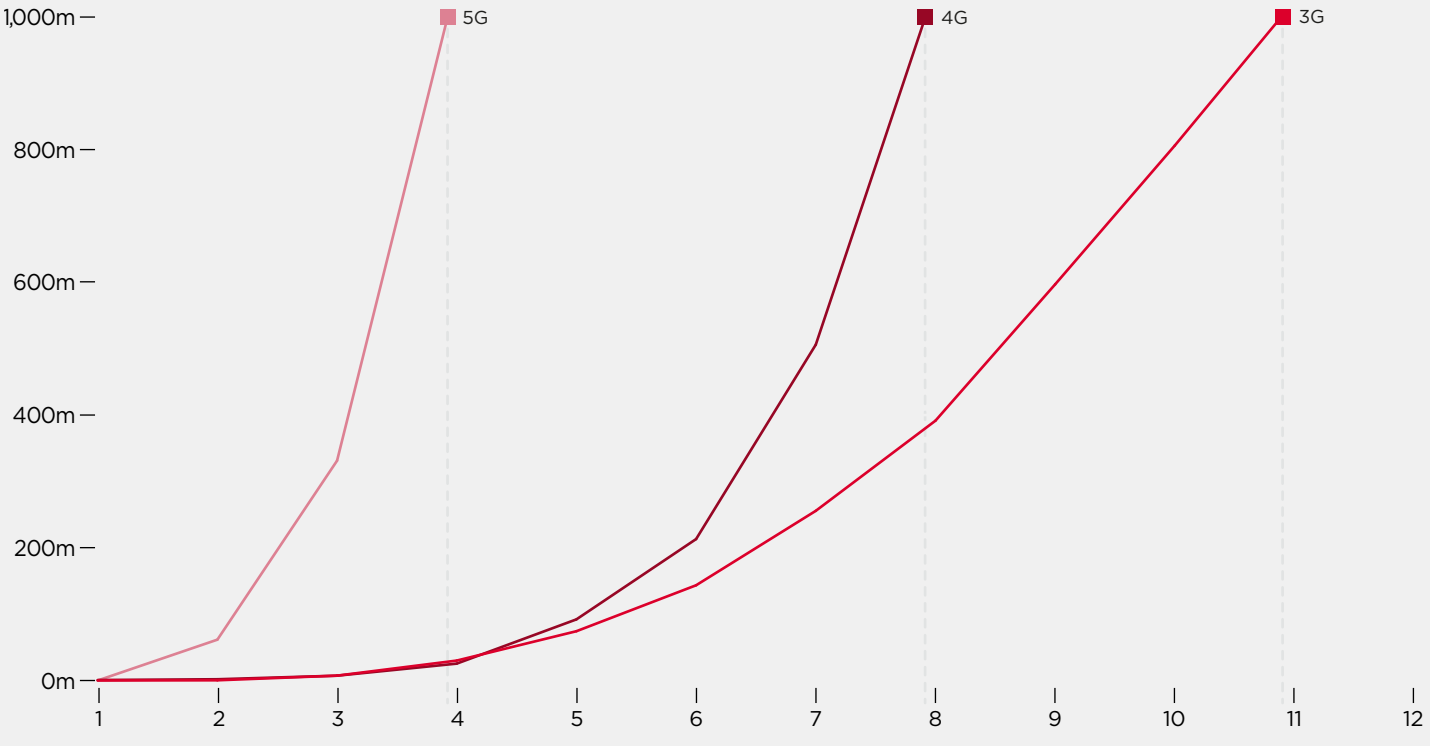
* Australia, Japan, Singapore, South Korea

Figure 6

Adoption of 5G versus 4G and 3G

Years to reach 1 billion connections from launch

Source: GSMA Intelligence



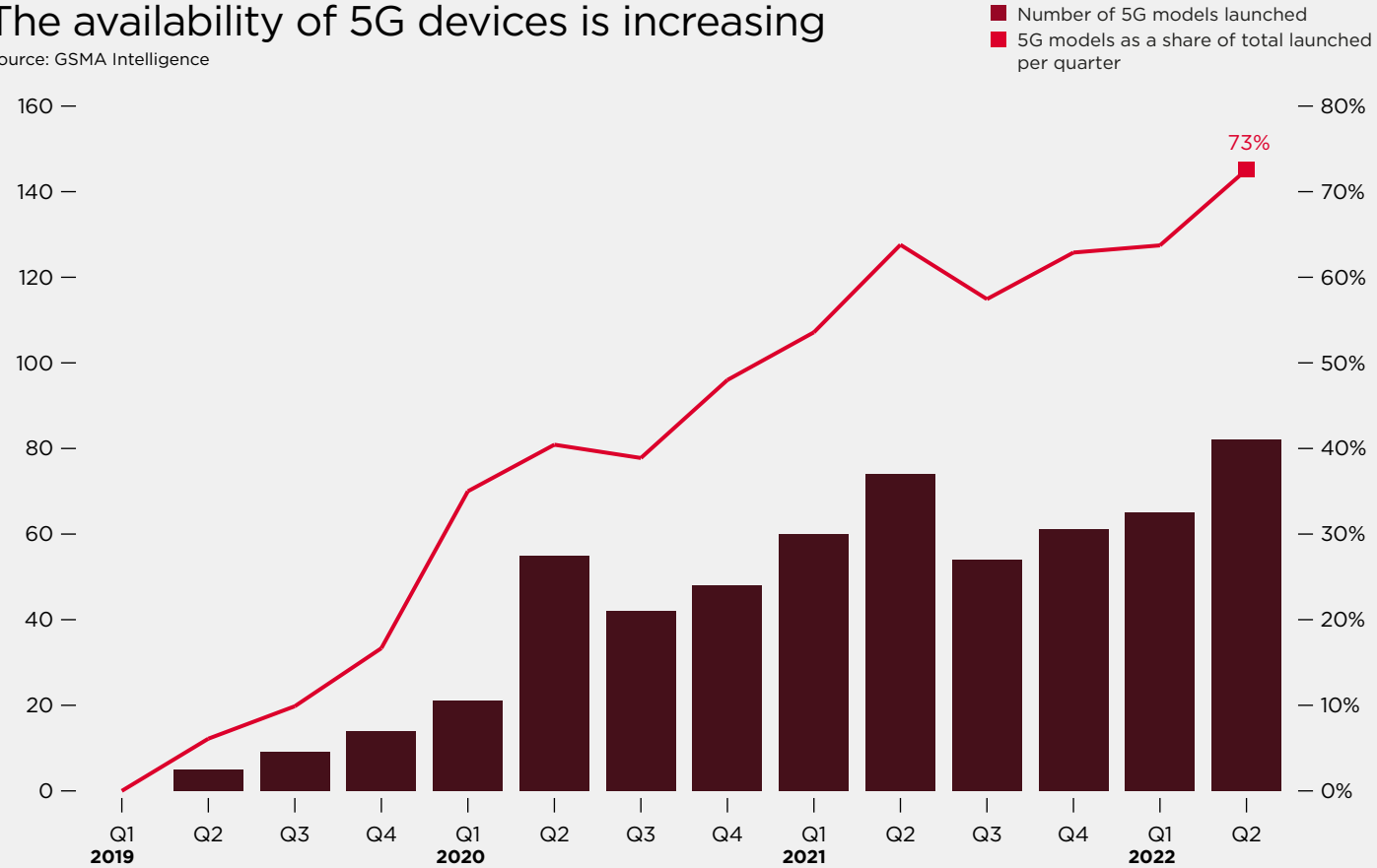
1.4
5G growth drivers

5G has become mainstream in many pioneer markets (notably China, South Korea and the US) and is making considerable progress elsewhere. Momentum has been boosted by a number of factors, including the economic recovery from the pandemic, rising 5G handset sales, network coverage expansions and overall marketing efforts. 5G is present in over two thirds of the smartphone models launched by the top 20 manufacturers in the first half of 2022, up from 40% in 2020. Xiaomi, Vivo and Oppo lead the way, accounting for around half of the 120 new 5G smartphones launched in that period. The fall in device prices is also a factor, with the average price of 5G-ready devices globally now less than $500, compared to nearly $900 in 2019.

Figure 7

The availability of 5G devices is increasing

Source: GSMA Intelligence



Note: A total of 1,355 smartphone models were launched from the top 20 brands globally during the period shown, according to GSMA Intelligence research.

1.5
Emerging consumer 5G use cases

Monetising 5G is still top of mind for operators. Enhanced mobile broadband (eMBB) and FWA connectivity remain the dominant 5G use cases, helped by an ever-growing portfolio of 5G-enabled smartphones across various price points. However, existing 5G users are increasingly interested in adding content and services (video streaming, music, gaming, live sports, cloud storage etc.) to their 5G plans (see Figure 8). The shift of gaming consumption from consoles to mobile devices, combined with the rise of cloud-based gaming, offers new opportunities for monetising digital gaming. 5G can play a role in providing the high-speed connectivity and low latencies required for cloud-based content access, delivery and consumption.

Entertainment experiences (e.g. sporting activities and venues, concerts, gaming labs, movies and theatres), which customers pay a premium, also provide avenues for operators to demonstrate the value of 5G. For example, Telstra has partnered with Google and Accenture to develop an AR app over its 5G network to help sports fans navigate a stadium in Melbourne, and Verizon offered fans a new experience with its 5G Multi-View platform at the 2022 Miami Formula 1 Grand Prix, enabling real-time views of seven unique, live camera angles in high definition.

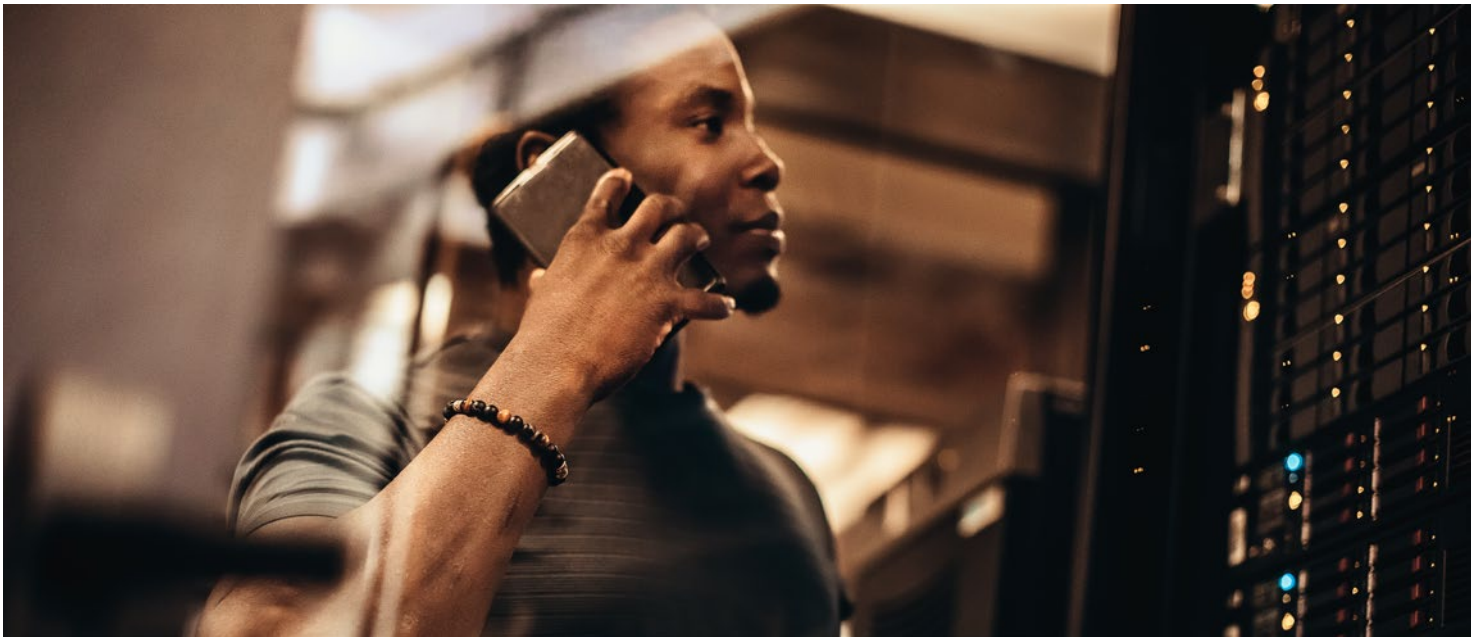
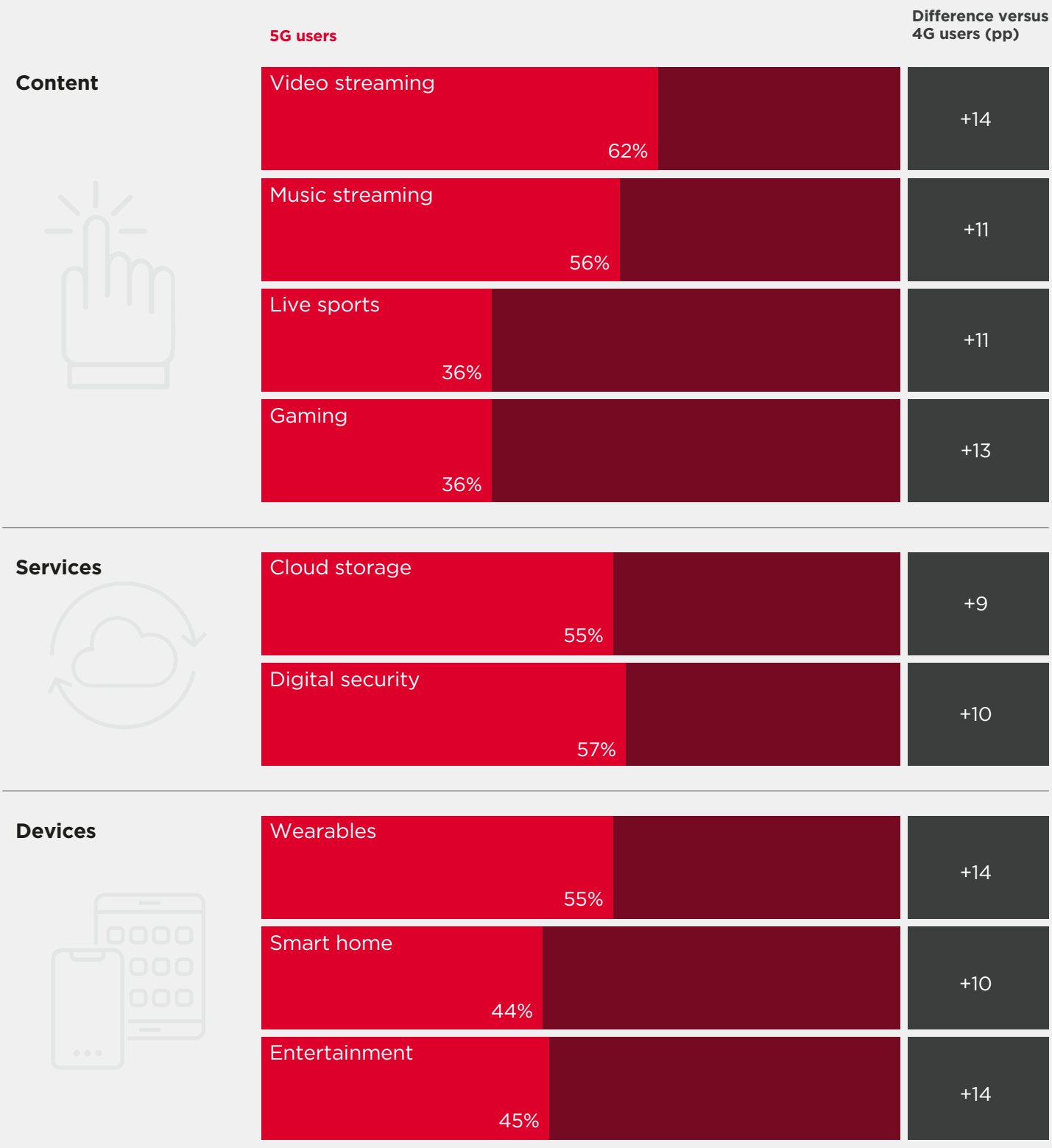


Figure 8

5G drives consumer interest in non-connectivity offerings

Percentage of contract mobile subscribers who have added or are interested in adding the following to their contract subscriptions (aggregate)

Source: GSMA Intelligence Consumers in Focus Survey 2021



Base: Smartphone users who are most frequently connected to 5G or 4G networks.

1.6
5G standalone networks come to fruition

Operators around the world began their 5G deployment efforts with the non-standalone (NSA) version of the technology. However, 5G standalone (SA) deployments ramped up in 2021 and 2022. In total, around 115 operators from 54 countries across all regions have launched or demonstrated intent to launch 5G SA networks.[3] The added functionalities enabled by 5G SA are key to delivering on the 5G promise of fully supporting eMBB, ultra-reliable low-latency communications (URLLC) and massive IoT use cases.

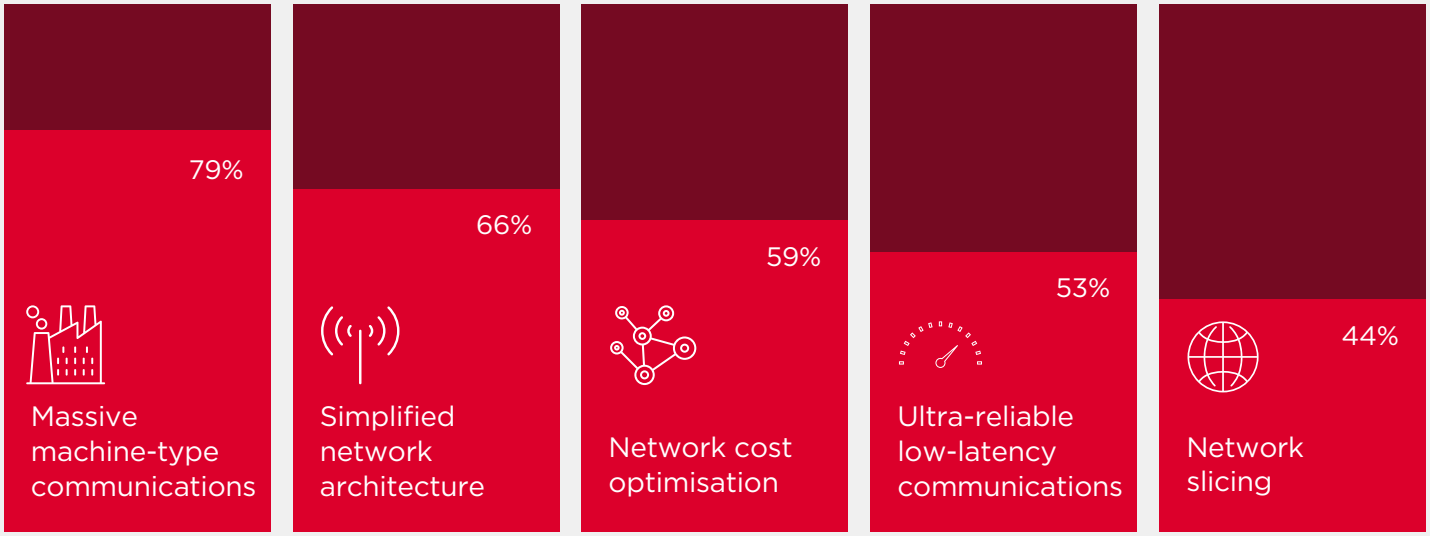
Much of the enterprise opportunity will rely on the deployment of SA networks to benefit from 5G's superior capabilities. Mobile operators are collaborating with vendors and enterprises to explore the potential of 5G SA. In Spain, Telefónica is targeting three enterprise 5G use cases for its 5G SA network: automated guided robot vehicles for use in places such as warehouses; remote maintenance systems using technology such as smart glasses; and drones for site surveillance. In October 2021, Taiwan Mobile received a 5G SA system certification from the National Communications Commission, allowing it to provide advanced mobile broadband services for enterprises to embrace Industry 4.0.

Figure 9

Top benefits of 5G SA

Rank the following benefits of 5G standalone (select top three)*

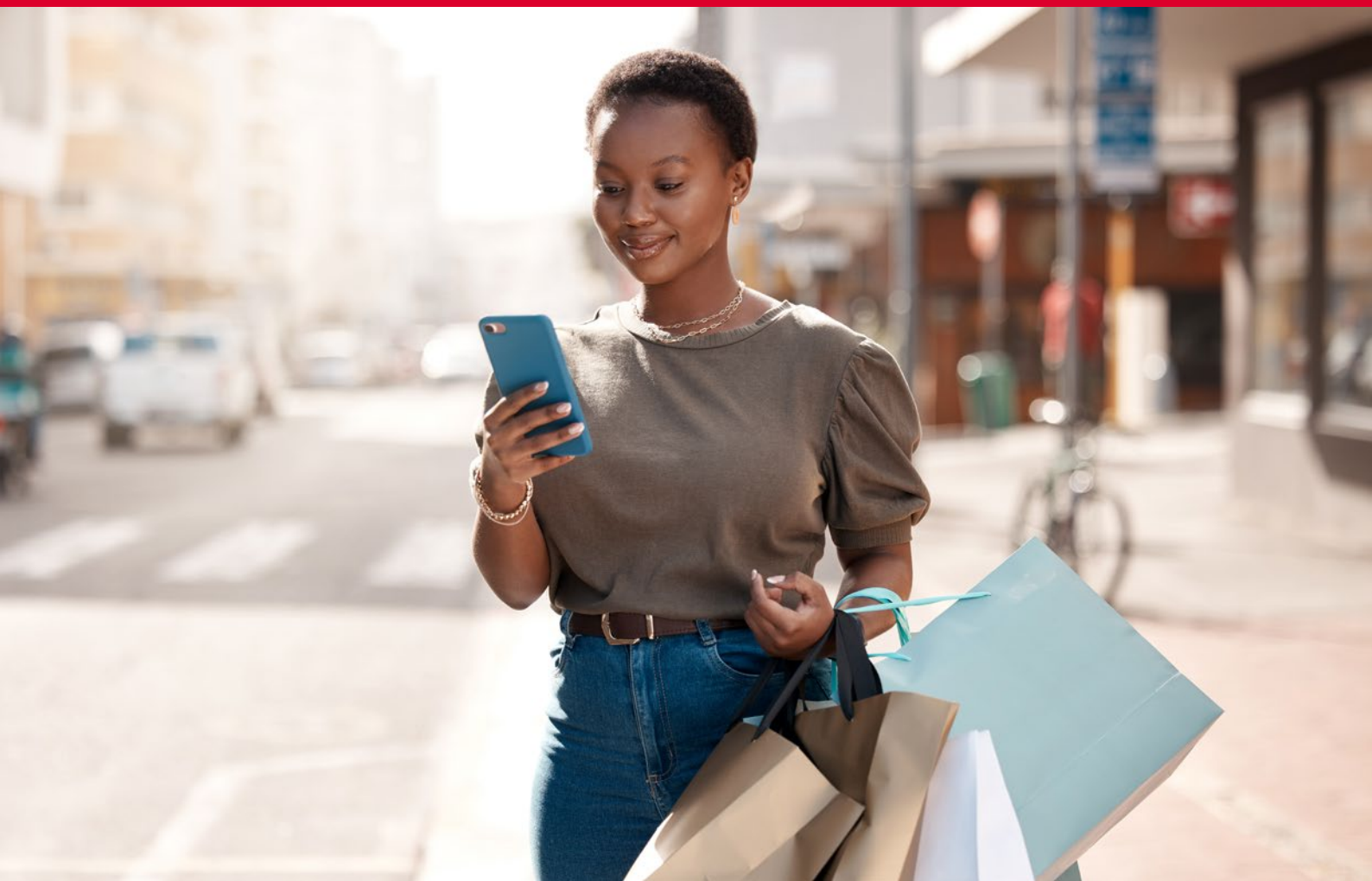
Source: GSMA Intelligence Operators in Focus: Network Transformation Survey 2021, N=101



* Score (%) calculated as a sum of top three answers

3 5G in Context, Q2 2022, GSMA Intelligence, 2022

2 5G in Africa's connectivity landscape



5G is a question of when, not if, for most markets and operators. In many cases, the decision on when to launch 5G is based on a number of factors in the local market that reflect the readiness of operators to roll out 5G networks and readiness of customers (consumers and enterprises) to adopt 5G services and 5G-enabled solutions.

While these factors vary across markets, there are common prerequisites, enabling conditions and key considerations that indicate the readiness for 5G rollout and adoption.

This chapter assesses Africa's readiness for mass 5G rollout, the case for 5G in Africa, the 5G deployment scenario in the context of the current connectivity landscape and 5G's growth outlook and economic contribution in Africa.

2.1
Assessing Africa's readiness for 5G

In 2019, the GSMA developed a framework to assess 5G mass-market readiness across different countries. The framework is based on six broad enablers – Basic, Economic, Market, Enterprise, Consumer and Spectrum (BEMECS) – each of which includes a set of indicators that encompass the different perspectives from which 5G readiness can be analysed. The Basic and Economic enablers mostly include exogenous indicators (e.g. urbanisation, GDP per capita, literacy rates), which act as external variables that impact 5G readiness and over which telecoms industry stakeholders have little or no control. The Market, Enterprise, Consumer and Spectrum enablers mostly include indicators that are endogenous to the telecoms ecosystem and which can be influenced by its stakeholders.

Figure 10

Overview of the BEMECS framework

Source: GSMA

Enabler	Description
Basic	Socio-political context that shapes 5G rollout and adoption e.g. population, population density, urbanisation
Economic	Macroeconomic context that shapes 5G rollout and adoption e.g. GDP growth, GDP per capita
Market	Industry context that reflects the maturity of the telecoms ecosystem e.g. 4G adoption, smartphone adoption, FTTx penetration, ARPU growth
Enterprise	Opportunities and capacity for enterprises to adopt 5G e.g. IoT penetration, Ease of Doing Business, Registered websites per 1,000 people
Consumer	Ability of consumers to adopt and use 5G services e.g. device and service affordability and usability
Spectrum	Availability of spectrum in low (<1 GHz), mid- (1–6 GHz) and high bands (>6 GHz) for 5G

See Appendix for a detailed list and description of the indicators in each enabler

Sizeable market opportunity for 5G but economic outlook is challenging

Africa has a total population of more than 1.3 billion people and most individual markets have populations of 5 million or more. However, more than half of the population lives in rural areas where network deployment can be challenging. The region is susceptible to the economic impacts of the Covid-19 pandemic and the conflict in Ukraine: the African Development Bank (AfDB) estimates that around 30 million people in Africa were pushed into extreme poverty in 2021 as a result of the pandemic and a further 3.9 million will be pushed into poverty by 2023 as a result of the Russia-Ukraine conflict.[4] GDP per capita for most countries in Africa is below $5,000, compared to the global average of $12,000.[5]

4G is still growing

In most regions around the world, 4G was already the dominant technology when 5G arrived. In contrast, the 5G era in Africa has come at a time when legacy networks still account for the majority of mobile connections. This presents a variety of unique challenges that will shape the rollout and adoption of 5G in Africa. 4G adoption has been held back by device affordability and a lack of sufficient digital content to stimulate demand. 4G networks now reach around 76% of the population in Africa, but the technology accounts for just 25% of connections, on average, compared to 60% globally (see Appendix for 4G adoption in countries across Africa).

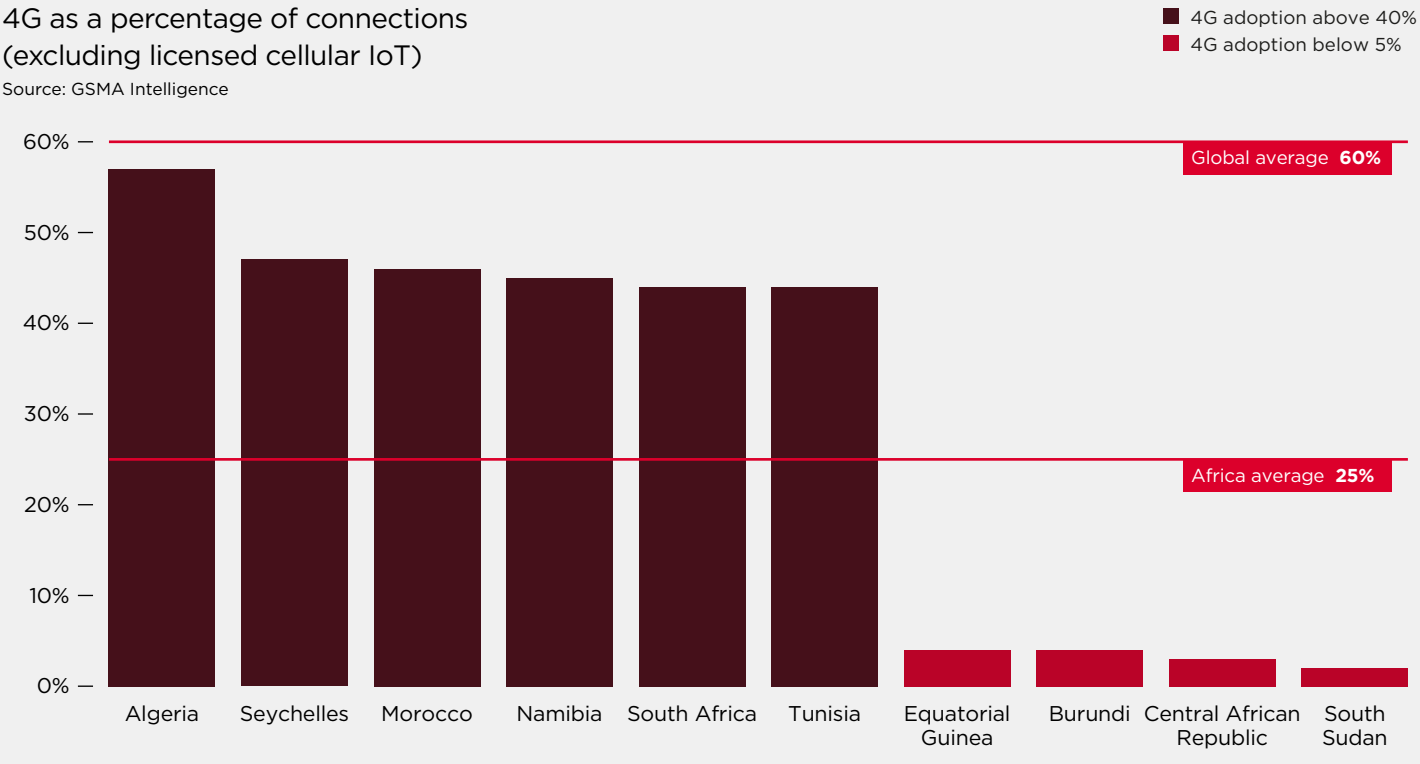
With 4G adoption still growing and significant unused 4G capacity, the focus for operators in Africa in the near term will be on increasing 4G uptake. This will involve strategies to make 4G devices more affordable and the provision of relevant digital content to drive demand for enhanced connectivity. The average selling price of smartphones has reduced significantly in recent years due to the influx of sub-$100 devices, mainly from Chinese brands such as Tecno and Infinix. However, many consumers are still unable to afford the one-off upfront cost of purchasing a device. This has given rise to smartphone financing schemes and other initiatives aimed at making 4G smartphones accessible to more consumers in Africa.[6] Safaricom's launch of a 4G smartphone package – in partnership with Google and aimed at customers currently on 2G – is an example of emerging financing models to accelerate the transition to 4G.

Figure 11

4G adoption in Africa

4G as a percentage of connections (excluding licensed cellular IoT)

Source: GSMA Intelligence



4 African Economic Outlook 2022, African Development Bank, 2022

5 IMF data

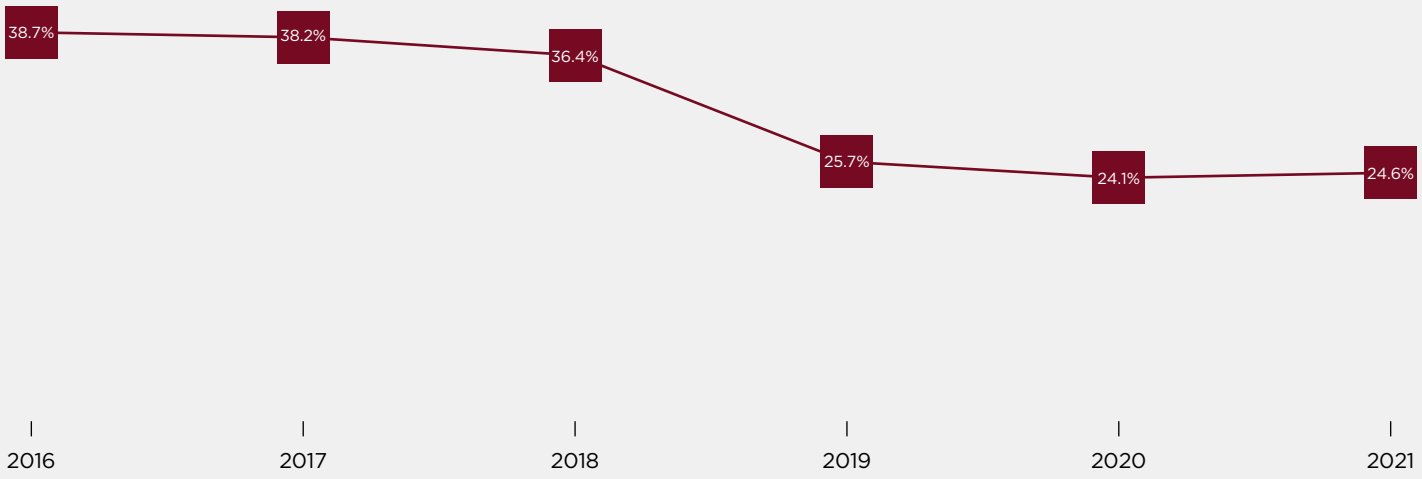
6 Making internet-enabled phones more affordable in low- and middle-income countries, GSMA, 2022

Figure 12

Price of entry-level devices as a percentage of GDP is still high in Africa

Device price as a share of monthly GDP

Source: GSMA Intelligence calculations based on pricing data from Tarifica



Note: Price of device is the cheapest 3G or 4G feature phone or smartphone available (at the time of collecting data) sold by mobile operators or mobile phone retailers. To determine affordability, we divide the price by monthly GDP per capita (sourced from the IMF World Economic Outlook).

Device affordability and usability remains a challenge

Some 5G-based services, such as live gaming and metaverse applications, utilise a device ecosystem – underpinned by AR, VR and other cutting-edge technologies – that is yet to be fully established in Africa. In this context, low incomes and a lack of digital skills mean that affordability and usability of 5G devices and services could be a challenge for significant swathes of the population. At $39, the median cost of an entry-level internet-enabled handset is a significant proportion of the household income of the average consumer in the region (see Figure 12). On the enterprise front, the budding tech ecosystem is supporting the growth of the app economy in Africa. However, the majority of micro, small and medium-sized enterprises (MSMEs), which make up the bulk of businesses in the region, have yet to fully adopt digital solutions for their operations.

Progress is being made on 5G spectrum assignment but at a slow pace

Most 5G launches globally (around 80%) have relied on 3.5 GHz spectrum. The 3.5 GHz range (3.3–4.2 GHz) has been adopted as the 5G launch band because it supports the required bandwidth and speeds for initial 5G services. As adoption increases and more consumers and diverse services migrate to 5G networks, more spectrum across low, mid- and high bands will be needed in order to deliver widespread coverage and enough capacity to support the delivery of 5G:

- Low-band spectrum (sub-1 GHz) supports widespread coverage across urban, suburban and rural areas and helps support IoT services.
- Mid-band spectrum (e.g. 3.5, 4.8 and 6 GHz) typically offers a good mix of coverage and capacity benefits.
- mmWave bands (24 GHz and above) will meet peak traffic demand speeds to maintain the performance and quality requirements of 5G services.

Some countries in Africa have recently assigned spectrum for 5G services to operators, notably Nigeria and South Africa. However, 5G spectrum assignment is still underdeveloped when compared to the rest of the world. A further complication is the use of valuable spectrum in the low and mid-bands by legacy networks, potentially delaying 5G rollout in the affected markets. Where fragmented legacy assignments exist, replanning based on internationally harmonised approaches will bring the greatest value from spectrum.

Figure 13

5G spectrum assignments in Africa

Source: GSMA Intelligence

Country	Date	Bands	Number of winners	
Angola	Dec 2021	3.5 Ghz	3	Africell (Lintel), Movicel, Unitel
Kenya	May 2022	2600 MHz	2	Safaricom, Airtel Kenya
Mauritius	Jun 2021	2600 MHz 3.5 GHz	3	Emtel (Currimjee), Chili (MTML), my.t (Mauritius Telecom)
Nigeria	Dec 2021	3.5/3.7 GHz	2	MTN, Mafab Communications
South Africa	Mar 2022	700 MHz 800 MHz 2600 MHz 3.5 GHz	6	Rain, Vodacom, Telkom Mobile, Neotel, Cell C, MTN
Tanzania	Oct 2022	700 MHz 2300 MHz 2600 MHz 3.5 GHz	4	Airtel, Millicom, Viettel and Vodacom
Zambia	Oct 2022	800 MHz 2600 MHz	1	Airtel

Data correct to September 2022

Key survey insight

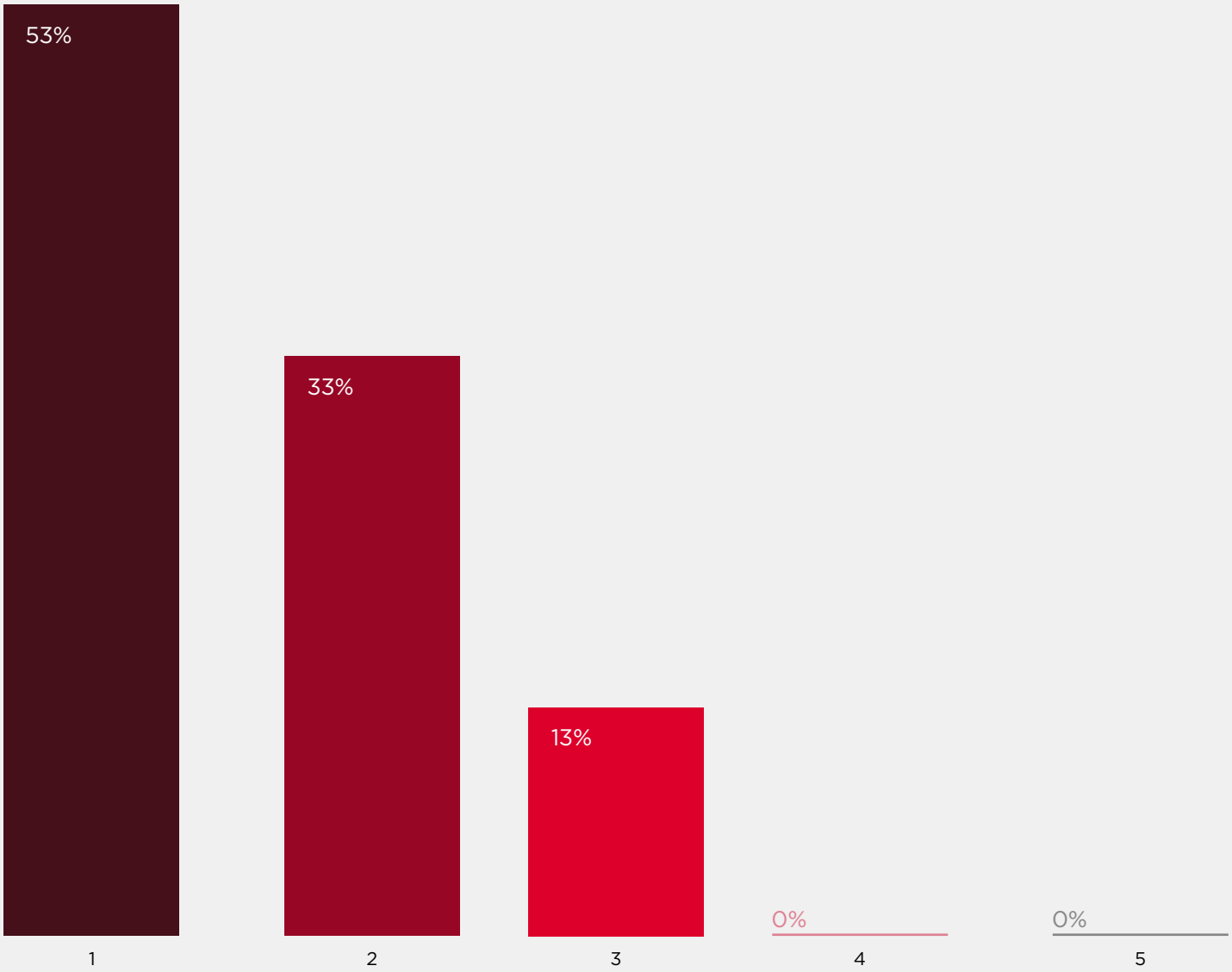
It is still early days for 5G mass-market readiness and ecosystem maturity in Africa. The majority of stakeholders in the region believe that the 5G ecosystem in their respective markets is not sufficiently developed.

Figure 14

5G mass-market readiness and ecosystem maturity

On a scale of 1 to 5, with 1 being the lowest and 5 the highest, how mature is the 5G ecosystem in your market? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey



2.2 The case for 5G in Africa

The above analysis reveals a challenging scenario at present for 5G mass-market readiness in Africa. However, there are reasons to welcome the 5G era, not least because there would otherwise be a risk of exacerbating the digital divide that already exists between Africa and more advanced regions. Beyond that, digital connectivity, with 5G at the core, will shape the way people live and businesses operate in a post-pandemic world, including the potential for the following:

- **Improving connectivity for homes and enterprises:** Given the limited access to fixed broadband connectivity (fixed broadband penetration is typically below 2% in African countries), the immediate opportunity for 5G is to use FWA to bridge the gap for enhanced broadband connectivity for homes and enterprises, both large and small. Indeed, increased demand for enhanced connectivity or an identified enterprise need in a market are credible triggers for 5G rollout. In South Africa, for example, the government assigned temporary spectrum in the 3.5 GHz range in the wake of the pandemic to boost capacity at a time of heightened demand.
- **Enabling the digital transformation of enterprises:** Before the pandemic, some governments in Africa publicised their ambition to implement the concept of the fourth industrial revolution. The pandemic has made such plans even more imperative as governments step up efforts to build resilient, sustainable and inclusive economies that can withstand current and future shocks. 5G is an important enabler of digital transformation and new capabilities across key industries and sectors, such as manufacturing, agriculture, financial services and the extractive industries.
- **Boosting tech innovation:** Africa has a vibrant tech ecosystem, supported by a network of more than 600 tech hubs, a growing number and wide variety of investors and the activities of mobile operators. 5G-specific attributes, such as low latency and high device density, will create new opportunities for tech startups to develop innovative and locally relevant solutions for the benefit of society. Key sectors that can benefit from 5G-enabled transformative tech include healthcare, education, agriculture and entertainment.
- **Meeting the connectivity needs of young consumers:** Around 60% of Africa's population, equivalent to over 800 million people, are under the age of 25. As digital natives, much of this population will be after contemporary data-hungry digital services, such as live video streaming and gaming and metaverse applications, which require high-performance networks. In the absence of widespread fibre connectivity, 5G will be essential for consumers to access these services.

2.3
A phased approach to 5G rollout

Africa's approach to 5G needs to account for the current connectivity landscape and unique market features that could impact 5G rollout and adoption. In practice, this means phased and targeted 5G deployment in specific locations where customers have a need for 5G capabilities – for example, using FWA to provide fibre-like home broadband services to support remote working or URLLC to support low-latency control systems in industrial premises.

The phased approach would allow operators to roll out 5G infrastructure at a sustainable pace and progressively build up the business case for more widespread rollout. It would also allow operators to maintain their focus on increasing 4G uptake in the near term, especially as there are significant returns still to be had on investments in 4G networks.

A possible downside to the phased approach is that it could limit the opportunity for local operators and other ecosystem players to realise economies of scale from 5G deployment. The telecoms sector is a capital-intensive industry and having sufficient scale can provide huge benefits for all stakeholders in a market. Markets with sufficient scale can better influence the global trajectory of 5G development and are also able to achieve low unit costs of network rollout (i.e. economies of scale). To mitigate this, operators in individual markets can collaborate or align their 5G strategies to achieve better economies of scale, such as through network sharing.

Key survey insight

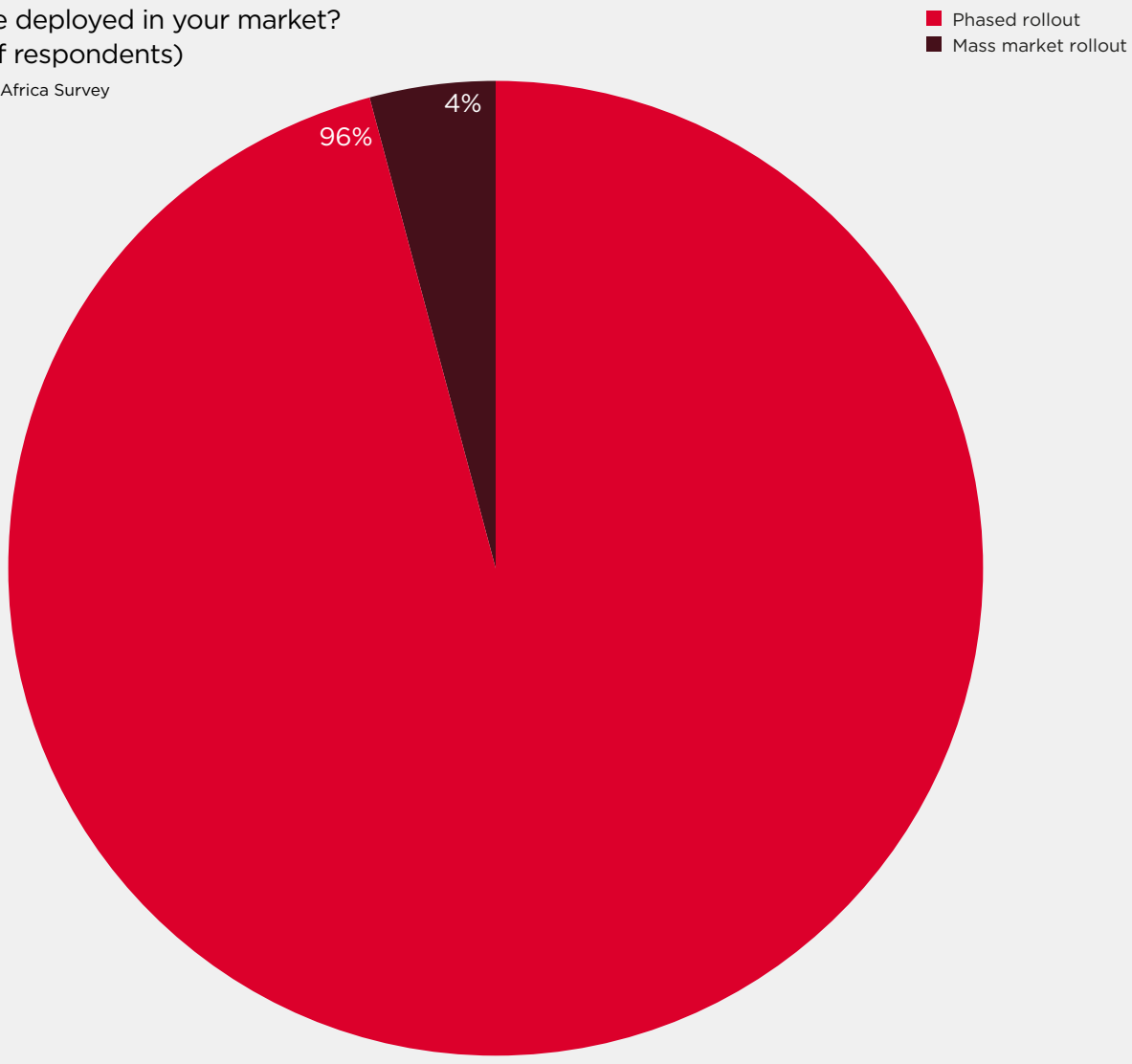
The majority of stakeholders in the region expect initial 5G rollout to take a phased approach (see Figure 15). This is in contrast to the fast population coverage approach that has been adopted in more advanced markets. For example, 5G population coverage in South Korea and the US reached 90% within a year of commercial launch. In Africa, the timeline to reach such coverage levels will vary from market to market, depend on the demand for 5G services and need to factor in the economics of 5G rollout in various locations.

Figure 15

Stakeholders expect 5G rollout in Africa to take a phased approach

How will 5G be deployed in your market? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey



2.4
5G adoption outlook

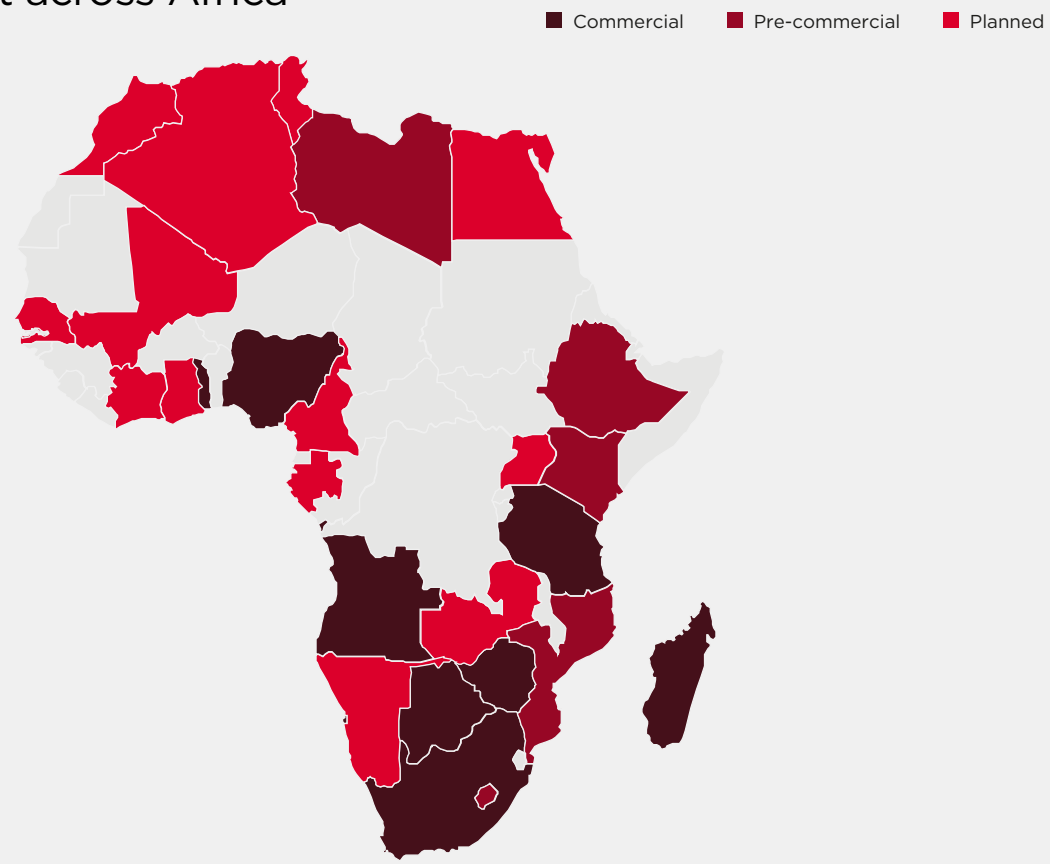
In 2019, data-only network provider Rain began offering commercial FWA services in South Africa, while Vodacom and MTN launched the first major 5G networks in 2020, offering 5G mobile and FWA services in South Africa and formally kicking off the 5G era in Africa. 5G activities have since gained momentum, with several more commercial and pre-commercial launches (see Figure 16).

The 2020–2030 period will be pivotal for the connectivity landscape in Africa as 4G hits the mass market and 5G rollout and adoption gather pace. There will be a flurry of activities over the next three years in the 5G market as more operators in the region launch commercial 5G services. All stakeholders in the 5G Africa Survey expect commercial 5G services to be available in their market by 2030, with the majority predicting this to be within the 2023–2025 time frame. By the end of this decade, 4G and 5G will account for nearly two thirds of total mobile connections in Africa (see Figure 17).

Figure 16

The 5G footprint across Africa

Source: GSMA Intelligence



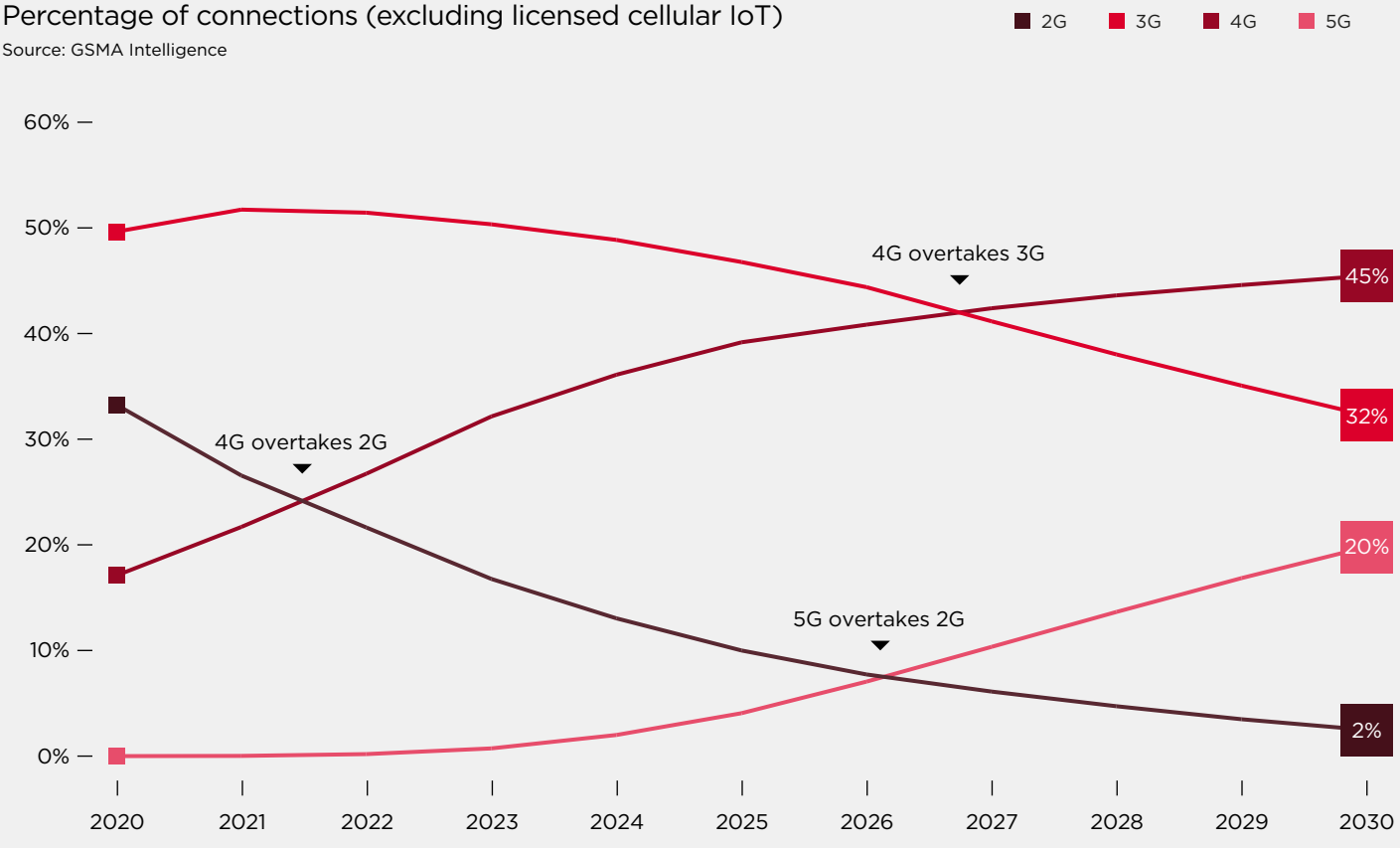
Data correct to September 2022

Figure 17

4G will be the dominant technology in Africa for the foreseeable future, but 5G is set to gain momentum

Percentage of connections (excluding licensed cellular IoT)

Source: GSMA Intelligence



2.5
5G economic impact

5G networks bring substantial improvements over previous generations, including higher connection speeds, greater capacity and lower latency. With this increased performance, 5G networks can enable new use cases and applications that will positively impact many industry sectors. Figures 18 and 19 show the expected contribution of 5G to Africa's GDP, according to GSMA Intelligence, providing insight into the role it will play in helping deliver global economic growth. This forecast is based on unique access to operator and mobile ecosystem data, economic statistics and a proprietary economic model.

In addition to the measurable socioeconomic impact of 5G technology and services, further benefits are expected, such as improved access to healthcare and education, increased public security and response times, safer driving conditions and reduced pollution.

Figure 18

5G could benefit the African economy by $26 billion between 2021 and 2030

GDP uplift (billion)

Source: GSMA Intelligence

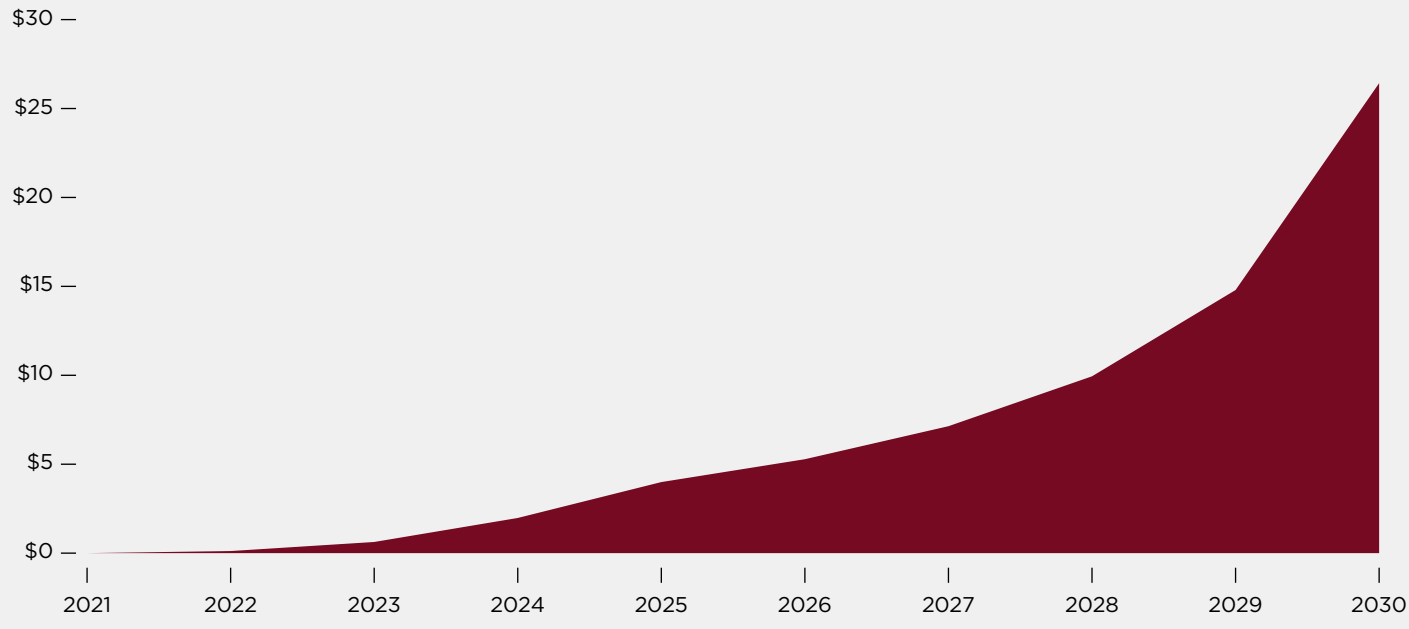
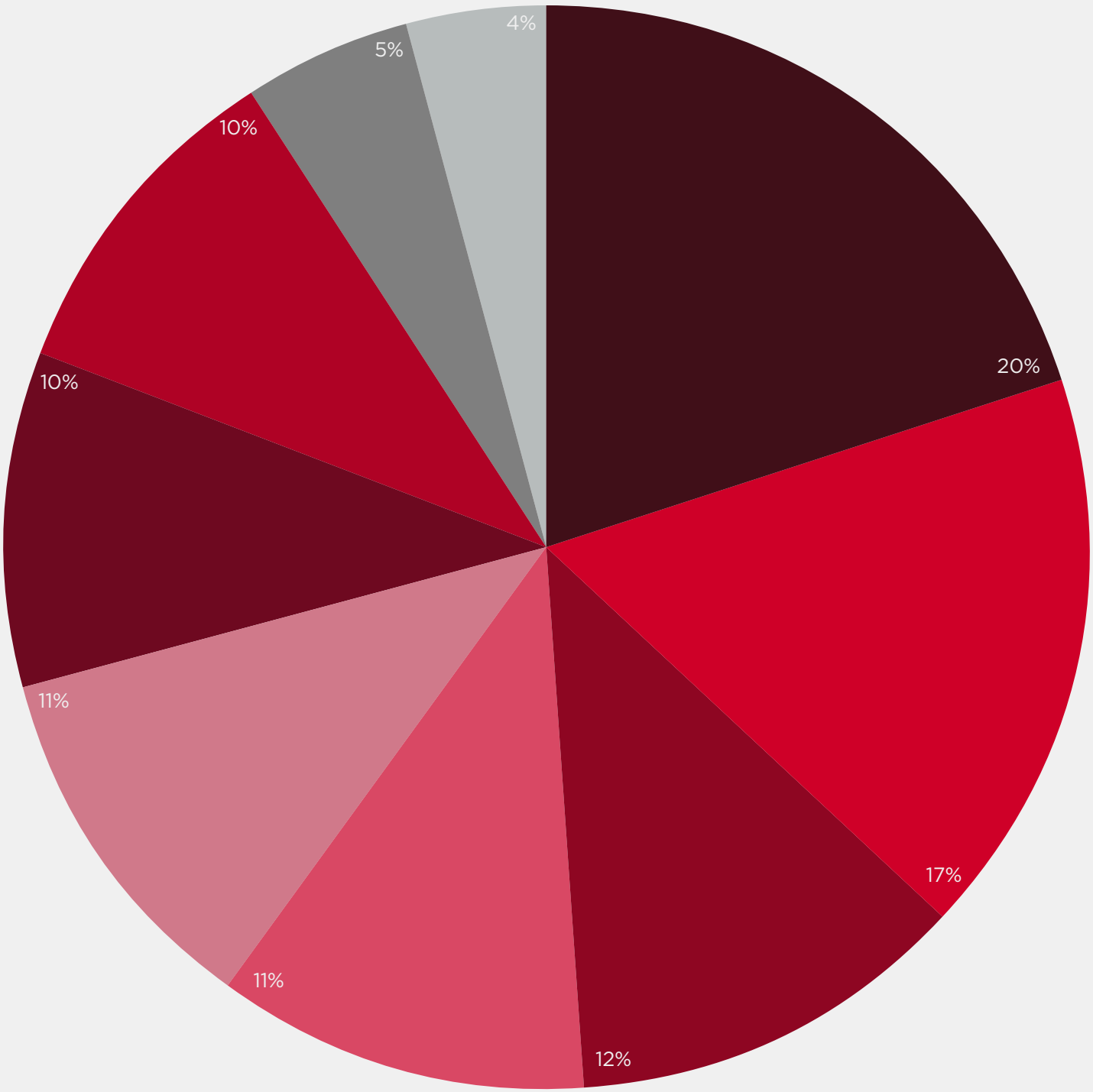


Figure 19

Retail, manufacturing and agriculture are expected to be the sectors that will benefit most from 5G

5G benefit by sector, 2030 (percentage of total benefit)

Source: GSMA Intelligence



* Includes mining and quarrying, construction and real estate, and arts, entertainment and recreation

3 Building the networks of the future

5G will need to coexist and interwork with 4G for many years to come. As such, the vast majority of initial deployments will be NSA as a way of reducing time to market and ensuring good coverage and mobility.

There will, however, be instances of SA deployment – for example, a new mobile market entrant or private 5G network deployments at specific location areas. In either case, the challenge for the 5G network ecosystem players revolves around delivering cost-effective and efficient 5G networks with an implementation strategy that balances investment and value creation.

This chapter looks at the main opportunities and challenges operators will face as they prepare their networks for 5G.

3.1 The 5G networks ecosystem

The mobile industry is experiencing a paradigm shift in network infrastructure models, with operators, both large and small, increasingly considering new network deployment and operations models. This trend has received further impetus in the 5G era, with the cloud native design of the 5G core and adoption of a service-based architecture driving the disruption of the network equipment and services supply chain. This is resulting in the entry of new players in the mobile ecosystem.

Notable new ecosystem players include the hyperscalers and open RAN vendors. Operator collaborations with cloud providers are more prominent in advanced markets, such as the US; the potential benefits are centred around creating new customer experiences and use cases for 5G and mobile edge computing solutions. Today, the major hyperscalers – including AWS, Google and Microsoft Azure – are considering new opportunities and partnerships in Africa's 5G ecosystem. For its part, open RAN is gaining traction in Africa, with a growing list of open RAN vendors already present in the region.

In the 5G era in Africa operators will increasingly forge business relationships with these new partners and adapt to new network deployment models. In March 2022, MTN signed a memorandum of understanding with Rakuten to deploy an unspecified number of open RAN–enabled 4G and 5G proof of concept sites for live trials in South Africa, Nigeria and Liberia. MTN has also worked with Altiostar, Mavenir, Parallel Wireless, Tech Mahindra and Voyage in earlier open RAN trials.

Figure 20

Examples of 5G ecosystem players in Africa

Source: GSMA Intelligence

Mobile operators

- Airtel Africa
- Etisalat
- Ethio Telecom
- Maroc Telecom
- MTN
- Orange
- Safaricom
- Telkom
- Vodacom

Towers

- America Tower
- Helios Towers
- IHS Towers
- SBA Communications

Network equipment

RAN

- Altiostar
- Ericsson
- Huawei
- Mavenir
- Nokia
- Parallel Wireless
- Samsung
- ZTE

Core

- Affirmed
- Cisco
- Ericsson
- Mavenir
- Metaswitch
- Huawei
- Nokia
- Samsung
- ZTE

Transport

- Aviat
- Ceragon
- Cisco
- DragonWave-X
- Ericsson
- Huawei
- NEC
- Nokia
- ZTE

OSS/ BSS

- Accenture Amdocs
- Ericsson
- Huawei
- Nutcracker
- Nokia
- Oracle
- Tata Consultancy Services

Network chipset

- Arm
- Intel
- Marvell
- Qualcomm

Cloud services

- Alibaba
- AWS
- Inq
- Google
- IBM
- Microsoft Azure
- Tencent

Note: List of companies is not exhaustive.

3.2 Network modernisation on the front burner

Over the last five years, mobile operators in Africa have invested nearly $45 billion in capex – mostly on deploying and expanding 4G networks. This includes investments in in the latest LTE-Advanced technologies such as multiple-input multiple-output (MIMO) to increase coverage and capacity without having to deploy additional sites. Operators will progressively increase investment in 5G as they step up preparations for 5G rollout.

5G sites will rely on a combination of fibre and microwave backhaul solutions. Fibre is the ideal option for 5G, as capacity demands are significantly higher compared to current typical microwave installations. A site hosting a 5G radio base station operating on 100 MHz of spectrum using beamforming and MIMO is expected to require up to 10 Gbps (depending on site size and access spectrum) for backhauling. For comparison, LTE backhaul demand is around 1–2 Gbps per site. In addition, latency and reliability need to be considered in backhaul technology selection and design processes.

Based on the use of higher-frequency spectrum and rising mobile data traffic, 5G requires a denser network, with more sites to deploy, monitor and service. In Africa, 5G will mostly be initially deployed using existing sites, meaning that operators may need to densify their networks to provide ample capacity in traffic hotspots in the future. This will largely be achieved by deploying more small cells on public infrastructure such as lamp posts and bus shelters, or in the premises of large enterprises such as stadia and bus stations.

Despite the shift to fibre, microwave will continue to account for a significant share of 5G backhaul infrastructure by 2030. As such, operators plan to upgrade their microwave backhaul links using new technical solutions that operate in the E-band (71–86 GHz) to increase the reach and capacity of microwave backhaul. E-band's importance is mostly because of its large bandwidth (10 GHz), which makes it ideal for meeting the backhaul capacity requirements of cell sites in traffic hotspots.

In addition, band and carrier aggregation (BCA) makes it possible to use E-band spectrum in conjunction with traditional lower-frequency bands to provide higher capacity and longer link distances as Etisalat and Huawei have demonstrated in Egypt.[7] In 2020, Huawei introduced a 5G microwave long-reach E-band solution designed to extend the reach of microwave backhaul to 3–5 km (from typically 3 km or less) while providing 20 Gbps capacity.[8] In 2022, Ericsson demonstrated 5G wireless backhaul for rural and suburban coverage, delivering speeds of up to 10 Gbps over a distance of more than 10 km.[9]

7 "Huawei works with Etisalat Misr for Gigabit backhaul in Egypt", TelecomTV, May 2016
8 "Huawei Launches 5G Microwave Long-Reach E-band Solution to Scale Up 5G Deployment", Huawei, November 2020
9 "Fiber-like connectivity: Ericsson and O2 Telefónica successfully demo 5G wireless backhaul for non-urban areas", Ericsson, September 2022

Key survey insight

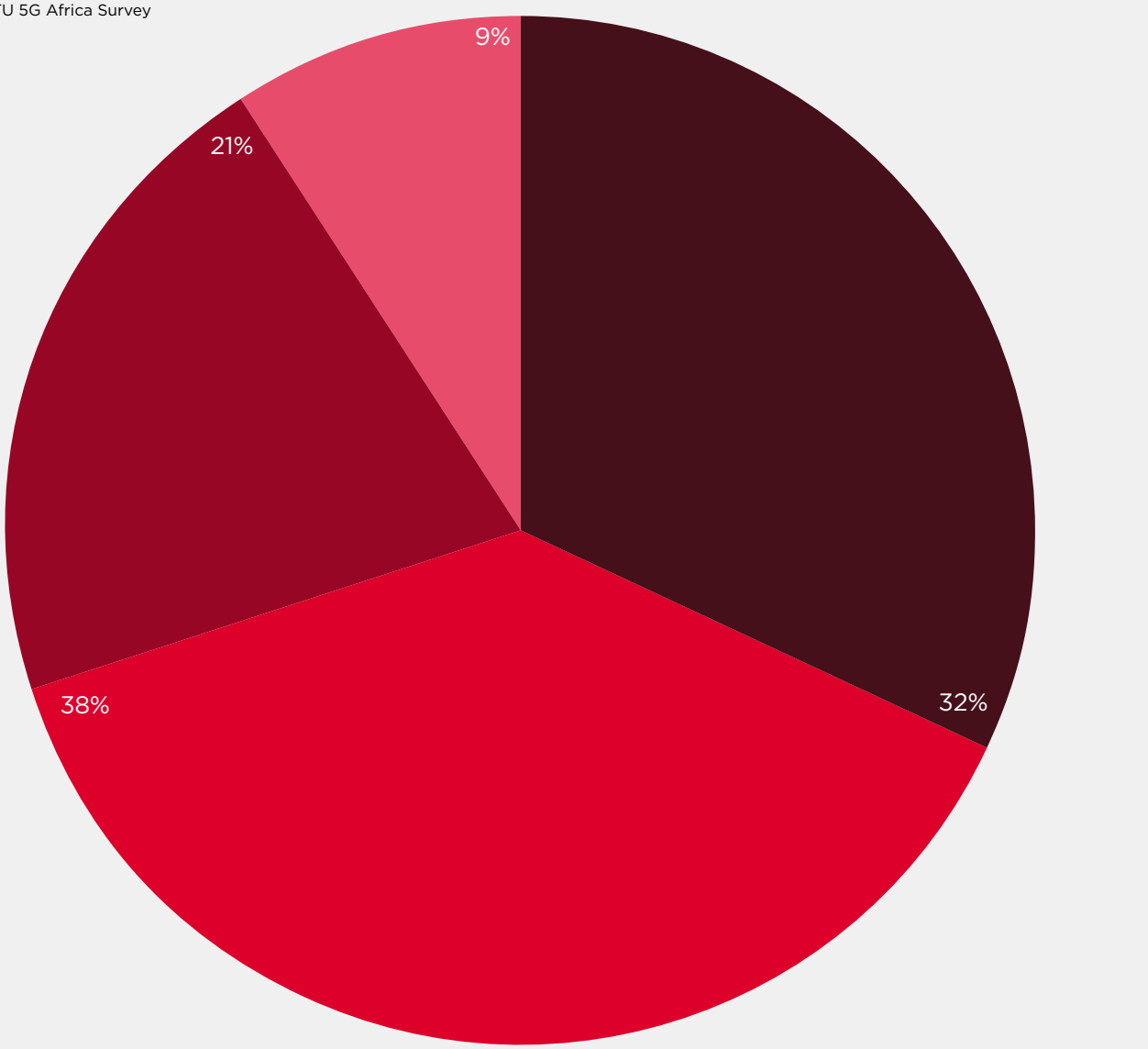
In the 5G Africa Survey, 87% of operator respondents indicated that they have started upgrading and preparing their networks for 5G. The main focus areas for operators include transport, with efforts to deploy more fibre backhaul, and cell site densification.

Figure 21

Network modernisation focus areas for operators

If you have started preparing/upgrading your network for 5G, what part(s) of the network have so far received attention? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey



Key survey insight

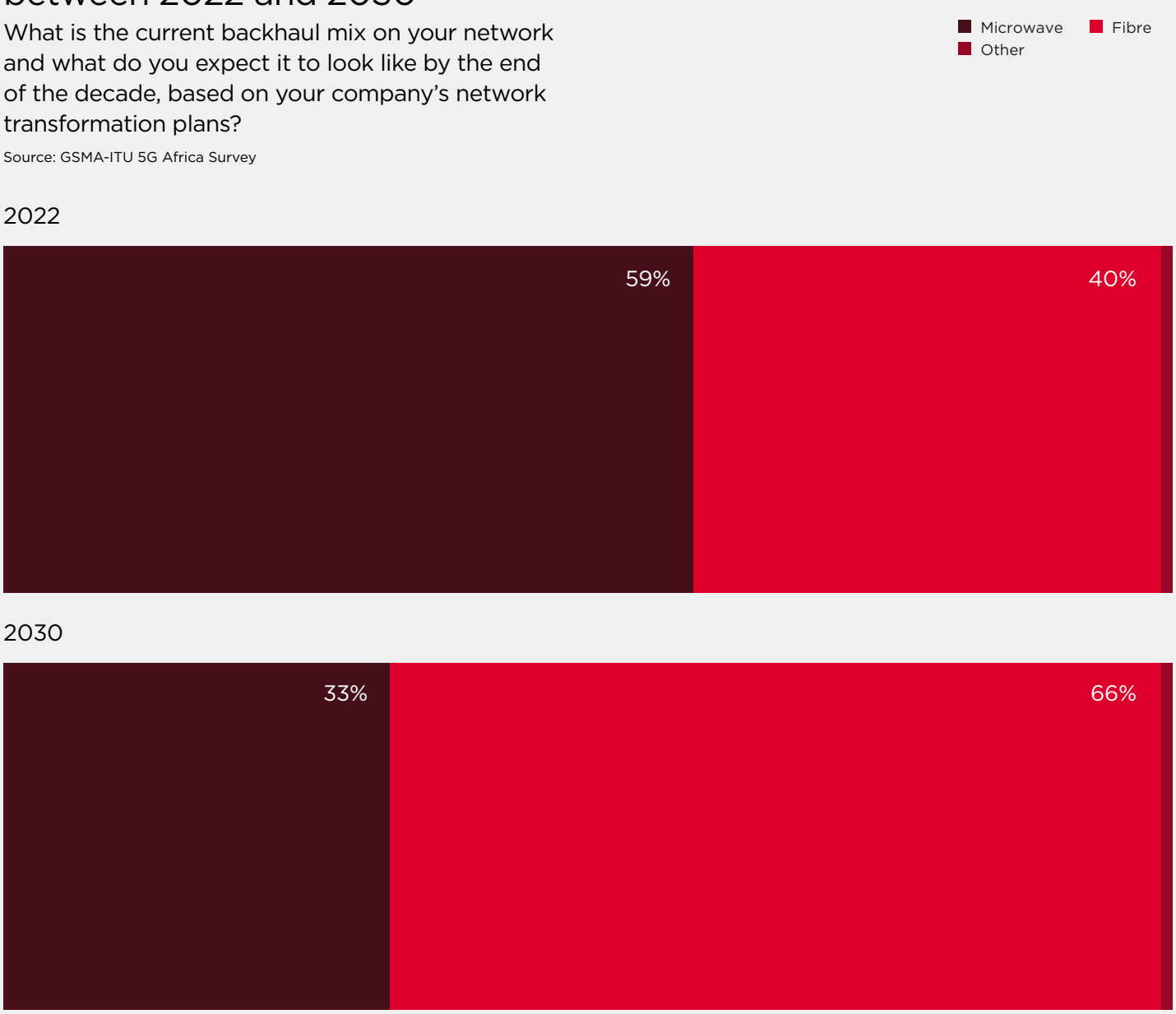
The backhaul mix varies considerably across Africa, from over 60% fibre backhaul in some markets, such as Angola, Kenya and South Africa, to below 10% in several other markets. In every market, however, operators and tower companies plan to deploy more fibre backhaul in the coming years. Figure 22 shows a clear shift in the aggregated backhaul mix towards more fibre between now and the end of this decade.

Figure 22

Evolution of backhaul mix between 2022 and 2030

What is the current backhaul mix on your network and what do you expect it to look like by the end of the decade, based on your company's network transformation plans?

Source: GSMA-ITU 5G Africa Survey



3.3 Achieving cost-effective 5G rollout

5G networks are expected to incur a higher cost of deployment to meet throughput requirement and demand. Radio access networks already comprise the largest portion of the cost in network deployment and operation. To meet mobile broadband demand, 5G is likely to be offered on higher frequency radio spectrum above 6 GHZ. While the 6 GHz band itself is expected to use the existing grid structure of 3.5 GHz networks, higher frequencies can mean that cells offer a smaller radius of coverage and so achieving widespread coverage may be challenging.

In Africa, the scale of fibre rollout and cell site densification required for widespread 5G rollout is much larger than in most other regions. Given the low spending power of most 5G customers in Africa, relative to developed markets, operators need to adopt network rollout solutions that allows them to minimise capital and operational expenses.

Network virtualisation promises to accelerate the time to market for existing and new services, as well as enabling more flexible networks that can scale and evolve as needed. Many of the solutions for virtualisation are devised in groups adopting open source, meaning operators will work with new suppliers and a new layer of configurability in the future. The transition to new architectures (such as cloud-based networks) could deliver savings in the long run, while network and service automation can achieve more immediate opex efficiencies by replacing manual operations, which will become untenable with the added complexity introduced by 5G networks.

Network sharing is not new in Africa, particularly the passive form through cell site co-location and tower sale-and-leaseback deals with independent tower companies. Africa is witnessing a new wave of tower deals as operators explore new network infrastructure models and seek further operational efficiencies in the context of the network densification requirements of 5G. Recently, IHS Towers completed the acquisition of 5,701 tower from MTN in South Africa, and Airtel Africa agreed a sale-and-leaseback deal for 2,227 towers in Madagascar, Malawi, Chad and Gabon with Helios Towers.

Tower companies will play a vital role in the rollout of 5G services in Africa. Beyond managing the tower assets acquired from operators, many of them are also involved in building new sites, which will be crucial for network densification, as well as investing in fibre infrastructure to connect new and existing sites. IHS Towers, for example, is laying fibres to its towers in Nigeria and other markets to prepare them for the expected increase in data traffic as customers move to 4G and 5G networks.

Evidence from China underscores the benefits of 5G network sharing. Under a ‘co-build, co-share’ agreement, China Telecom and China Unicom had jointly deployed more than 400,000 5G base stations across China as of H1 2021 – a move that has helped them to save RMB80 billion ($12.4 billion) in capex and about RMB8 billion ($1.3 billion) in annual opex.

Key survey insight

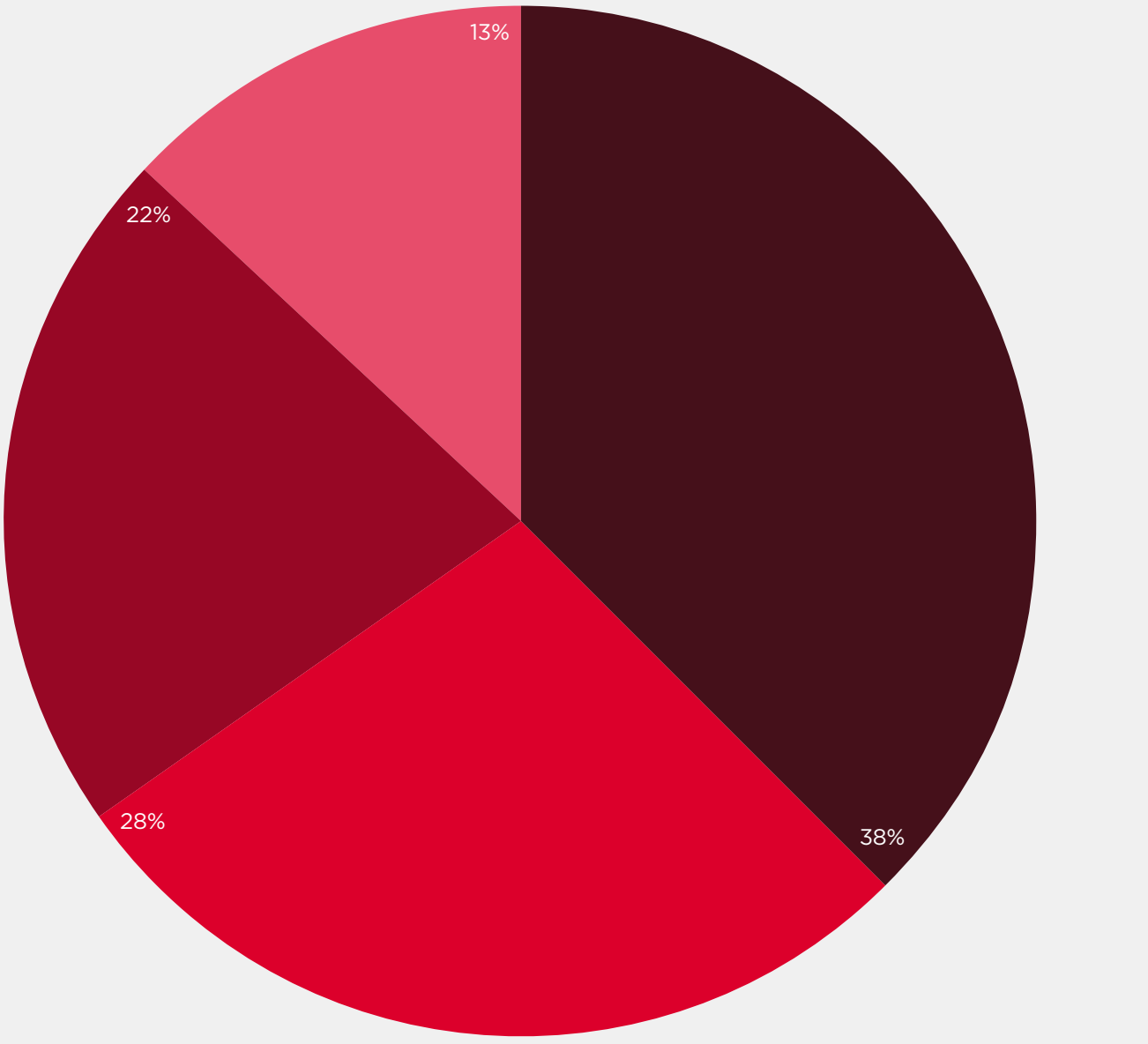
Operators in Africa are in the early stages of their network virtualisation and automation strategies. However, most of them are unequivocal about its potential to unlock cost savings.

Figure 23

Network rollout and operations solutions

Which of the following network solutions will you consider for your 5G network rollout?

Source: GSMA-ITU 5G Africa Survey



Addressing the digital divide through the power of technology with Arm

Today, nearly half of the world's population has no access to the internet and this digital divide is even more emphasized under the stress of a global pandemic. Of those who are connected, the majority access is through mobile devices. While the pervasiveness of mobile devices has lowered the cost of access around the world, there is still a significant gap between the cost of access in Africa compared to the world average. As an industry we have the responsibility to close this gap and bring the benefits of technology to everyone in the world through better connectivity and access.

Arm's role in this journey is to make it as easy as possible to create solutions that are accessible to a broad userbase from cloud to edge to endpoint devices. To do that, Arm remains committed to building solutions that are performant, power efficient and pervasive. For the world of connectivity, one such project that Arm is contributing is Magma – a low-cost, scalable disaggregated core network solution which simplifies the task of extending network access out to remote regions and communities. The Magma core supports LTE and the latest release of 5G.

Some of the key features of Magma include:

- **An open source solution:** Magma core is open source and comes with a permissive license that allows its users to commercially deploy it. The Magma Core Foundation is the organisation that oversees the Magma open source project. In February 2021, the Magma Core Foundation joined the Linux Foundation.
- **Use of commodity hardware:** Most traditional networking equipment is proprietary, bundling the software with precisely specified and configured hardware. However, Magma has been designed to operate on commodity hardware, allowing any component to be replaced at minimal cost and disruption to the network. Multiple original design manufacturers, such as Nexcom, Sercomm and Hawkeye, have incorporated the Magma stack into their network appliances.
- **Heterogeneity by design:** Magma supports heterogeneity by design, both in the types of devices to be connected and the spectrum used to connect them. That means Magma can be used with any generation of cellular technology using licensed spectrum, flexible models for spectrum sharing (e.g. CBRS), radio technologies (e.g. LTE and 5G) or unlicensed spectrum (e.g. Wi-Fi).
- **Small fault domains:** In any cloud system, it is expected that individual components will fail; therefore, failure is treated as a common part of the operational flow of the system. Magma uses small fault domains (another contrast to traditional mobile network architectures) to ensure that individual modules can restart and be upgraded independently of each other.
- **Simplified operations:** Magma draws from software-defined networking (SDN) and large-scale data centre design to deliver an architecture that is robust and easy to manage. Whereas traditional mobile networks are made up of components that are managed individually, Magma adopts a centralised controller (an orchestrator) that allows an entire mobile network to be centrally managed from a single API.

Magma is well suited to providing small-scale, low-cost community networks in addition to coverage extension through federation with existing mobile networks. The solution is already being used in national parks and Native American reservations in the US and remote communities in Brazil.[10] Magma has also been deployed in Africa to provide connectivity to underserved rural areas, demonstrated by DishNet Africa's deployment of the technology in South Sudan. Magma is also exploring other mobile use cases, including FWA.

The pairing of the Magma Access Gateway stack and vast ecosystem of Arm partner devices enables the choice to scale deployments up and down as needed for the application, optimising for cost and power.

10 "Software is Eating the Edge" Magma, May 2021

3.4 Addressing the energy conundrum

5G is more energy efficient per gigabyte over previous network generations. However, 5G massive MIMO and the power requirements for cell site densification also exacerbate the network energy management challenge.

Operators in Africa face a particularly dire situation from an energy-management viewpoint. The traditional approach for wireless networks has been to use grid-supplied electricity as a primary power source and diesel generators to provide back-up power. However, the reach of grid electricity is limited (specially outside of urban areas), often unreliable and sometimes lack the capacity to power network infrastructure.

Historically, operators in Africa have mostly relied on diesel generators to power off-grid and 'bad-grid' sites. This is unsustainable in the long term, given the industry's commitment to reducing its carbon footprint and rising fossil energy prices due to the conflict in Ukraine. In 2019, the GSMA Board, comprising members from the largest mobile network operators in the world, set a milestone ambition: to transform the mobile industry to reach net-zero carbon emissions by 2050, at the latest. The mobile industry was the first sector to commit to the UN's 17 Sustainable Development Goals (SDGs), including climate action, in 2016.

Against this backdrop, operators are increasingly turning to renewable energy sources for their operations. In many cases, solar energy is particularly promising, given the decreasing cost of photovoltaic panels and improvements in battery solutions, with the use of more cost-effective lithium batteries rather than traditional acid battery options.

For the majority of operators in Africa, solar still accounts for less than 10% of the energy mix, despite the region's favourable sunshine duration ratio. Operators and tower companies operating in the region have pointed to the following as the main barriers to using more solar: high upfront cost for solar panels and batteries; theft and vandalism, especially in remote locations; and space limitation on cell sites to assemble the solar components.

Another way operators can increase the use of renewable energy is through power purchase agreements (PPAs) with local energy suppliers. With PPAs, an operator (or company from any industry) invests capital with a renewable energy provider to fund capacity at a specific generation facility, such as a solar or wind farm. To meet its commitment to halve its environmental impact by 2025 and accelerate the reduction of greenhouse gas (GHG) emissions, Vodacom aims to buy electricity needed for its operations from renewable energy sources using PPAs. Vodacom recently sourced 1,183,898 kWh of energy through such PPAs, which helped to save 11,971 MWh of electricity, while reducing its GHG emissions by 12,272 metric tons of carbon dioxide equivalent.

Orange at the forefront of the transition to solar in Africa

Orange is a founding member of the Net Zero Initiative, which sets out a vision of a carbon-free world with other large organisations. To this end, Orange has put in place several initiatives, including the use of solar energy, to reduce its reliance on diesel generators. Orange is deploying innovative solar solutions and the latest batteries with various partners in the renewable energy space. Several countries are benefiting from this, including the DRC, Guinea, Côte d'Ivoire, Burkina Faso, Sierra Leone, Central African Republic, Liberia and Cameroon.

Orange now has the biggest deployment of solar panels in several of these markets, with renewable energy accounting for more than 50% of energy use Guinea, 41% in Madagascar and 40% in Sierra Leone. Orange MEA (including Jordan) has installed solar panels at 6,000 of its sites, saving 55 million litres of fuel each year. In some sites, solar power has reduced the use of diesel by up to 80%. In January 2022, Orange announced a partnership with utility company Engie to build a solar plant that will supply 60% of daytime energy needs at its Côte d'Ivoire data centre. The plant will comprise 784 photovoltaic cells that will generate an estimated 527 MWh/year of renewable energy.

3.5 Network rationalisation is a long-term prospect

Across the world, operators are increasingly outlining plans to shut down 2G and 3G networks as the transition to 5G gathers pace. This is with a view to optimise network operations given the cost and complexity of simultaneously running multiple network generations, the need to repurpose spectrum assets for more efficient 4G and 5G networks and the opportunity to improve energy efficiency in the network (since legacy networks are less energy efficient). In addition, the standardisation and maintenance of legacy equipment is slowing, with some equipment due to lose support within a few years. This could result in higher security risks and a greater incidence of outages on these networks.

Telkom South Africa retired its 2G network in 2020 and had shut down 80% of its 3G network as of January 2022. The operator is, however, an exception in Africa. On average, 2G and 3G account for 23% and 53% of mobile connections, respectively (as of September 2022), making their closure more of a long-term prospect.

The slow pace of migration from legacy networks in Africa is a function of both demand-side and supply-side factors. On the demand side, the affordability of 4G devices remains a challenge for most consumers, alongside low digital skills and a lack of relevant content to drive demand. On the supply side, over a fifth of the region's population live in areas not yet covered by 4G networks, limiting access to 2G and 3G services only.

In addition, only around 10% of 4G operators in Africa have deployed commercial Voice over LTE (VoLTE) technology, which allows voice and SMS services to be delivered to LTE devices. To drive the migration to 4G, operators in Africa need to accelerate VoLTE deployment, taking advantage of the increasing availability of VoLTE-enabled devices. On average, it takes 2–4 years between the shutdown announcement to the actual network switch-off. This means that operators need to begin formulating their network shutdown plans by the mid-2020s, including VoLTE deployment, to ensure a smooth customer migration.

In the meantime, vendors are providing multi-generational RAN solutions, which allow operators to run 2G, 3G, 4G and 5G on the same radio. This reduces the amount of equipment at each site, generating cost savings for operators. For example, ZTE has implemented a 3G/4G/5G Tri-RAT dynamic spectrum sharing solution to help operators build a lean multi-mode and multi-service network that supports 5G while protecting their legacy investment.

Key survey insight

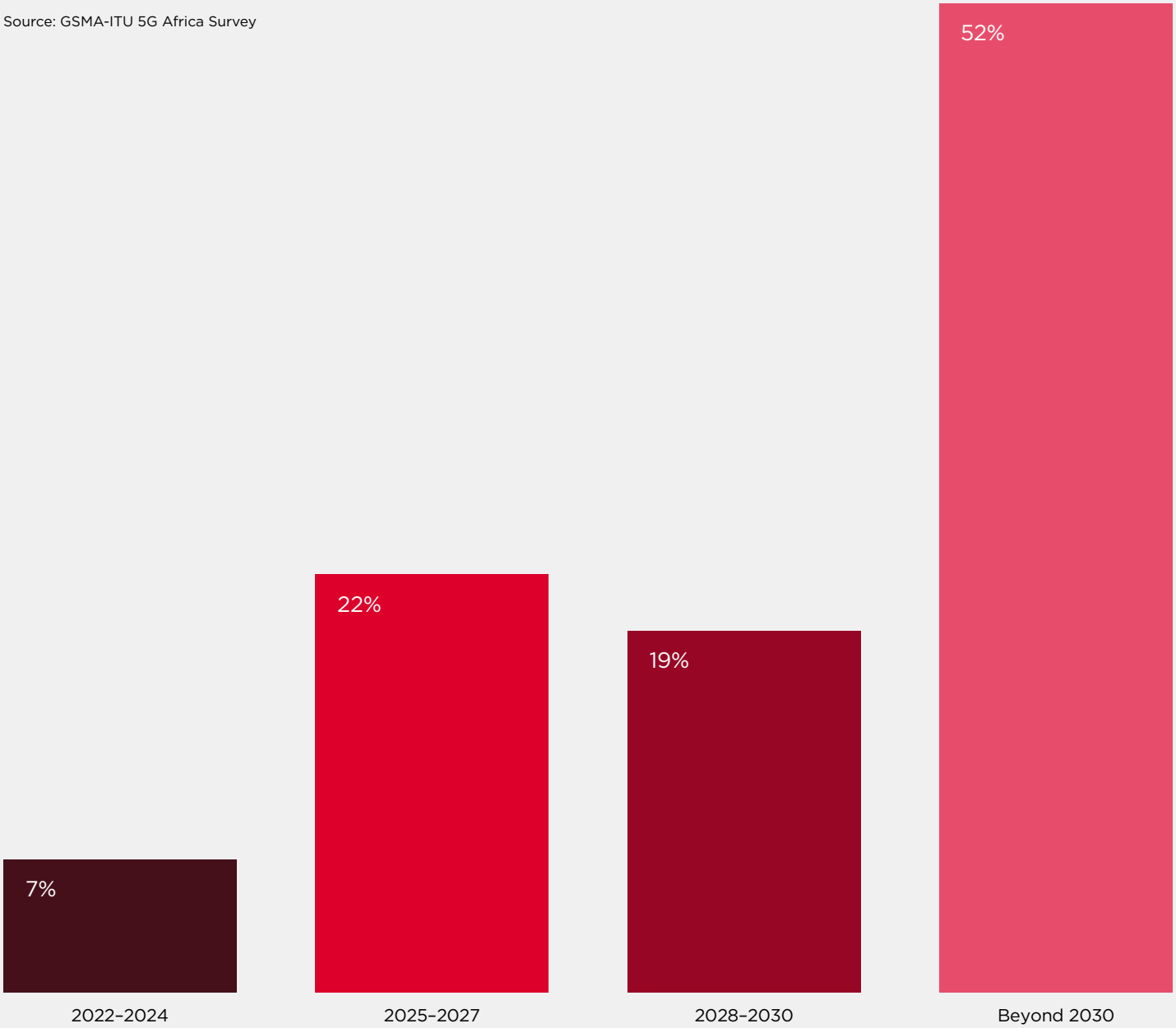
Most stakeholders in Africa expect legacy networks (2G and 3G) to remain operational in their markets beyond 2030.

Figure 24

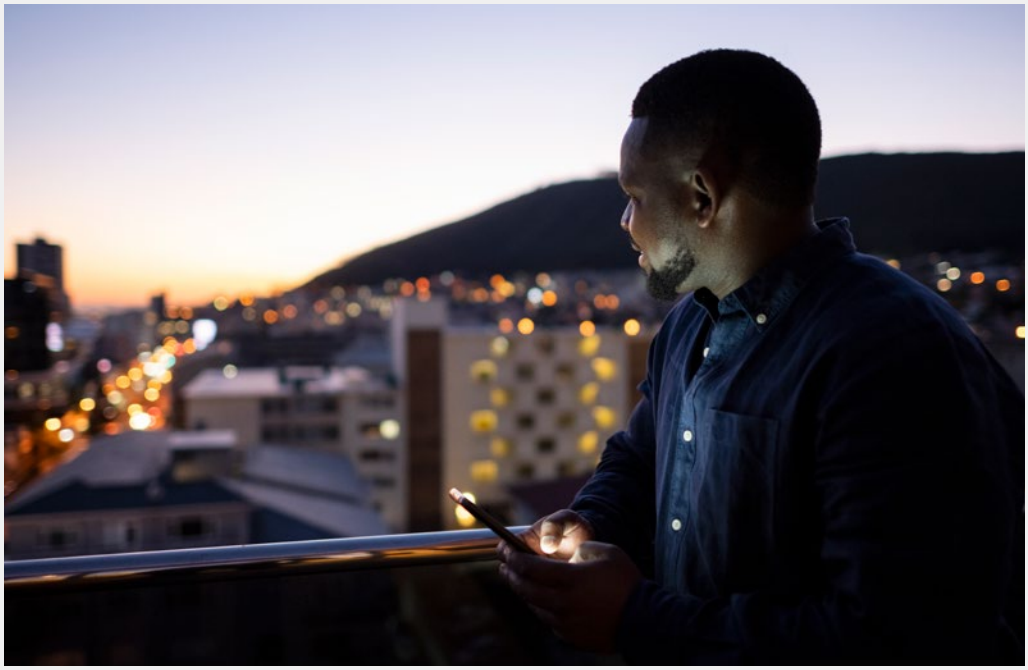
Anticipated timeline for shutdown of legacy networks

In your opinion, what is the realistic timeline for shutting down legacy networks in your market? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey



arm 5G Solutions Lab



Enabling end-to-end 5G networks with Arm 5G Solutions Lab

In the coming years, more infrastructure will be required to achieve the true potential of 5G. Much of this infrastructure will be powered by Arm-based chips. These networks will evolve to enable more complex technology capabilities, improved provisioning and enhanced service offerings that will unlock new use cases and revenue streams. The rapid pace of deployment underscores how critical it is to achieve faster development of network and edge infrastructure solutions to unleash the benefits of 5G to everyone, including those with limited or no access to connectivity. To do this, operators are seeking greater choice and flexibility in future systems.

Arm launched the Arm 5G Solutions Lab in October 2021 to accelerate innovation for network infrastructure by providing a platform for Arm's hardware and software ecosystem partners to come together and demonstrate end-to-end solutions in a live testing environment. The momentum that is building within the open RAN community creates an opportunity for operators and enterprises looking to deploy private networks to gain easy access to multi-vendor platforms. The Lab will provide secure access to partners and operators to validate solutions and increase confidence in new technologies across a range of critical use cases, such as small cells, macro cells, private 5G networks, cloud RAN, the RAN intelligent controllers and the core network.

The Arm 5G Solutions Lab serves as a confluence where software and hardware developers, operators and cloud service providers can come together to define KPIs, blueprints and deployment guides to help bring alive innovations in 5G and, ultimately, generate revenue faster.

The initiative is made possible with the help of the Arm ecosystem, with support from a broad set of industry stakeholders, including Google Cloud, EdgeQ, Gigabyte, Marvell, Nvidia, NXP, Qualcomm Technologies, Dish Network, Vodafone, Accelleran, Mavenir, Parallel Wireless, Radisys, Saankhya Labs and Tech Mahindra. Arm has ambitions to launch 5G solutions labs across Africa, starting with South Africa.

4 Driving customer uptake

Realising the potential of 5G in Africa depends on customer adoption and usage, which in turn strengthens the business case for network rollout.

As with previous mobile generations, the consumer market will be an important growth driver for 5G. Beyond that, enterprise services and solutions will fuel 5G's incremental revenue potential, leveraging the technology's unique capabilities to enable the digital transformation of industries. For both segments, innovative use cases and applications, as well as device availability and affordability, will be crucial to drive uptake.

This chapter looks at the main barriers to customer adoption and usage of 5G services in Africa, the role of FWA as a key use case in Africa and the opportunity to meet enterprise needs through private 5G networks.

Key survey insight

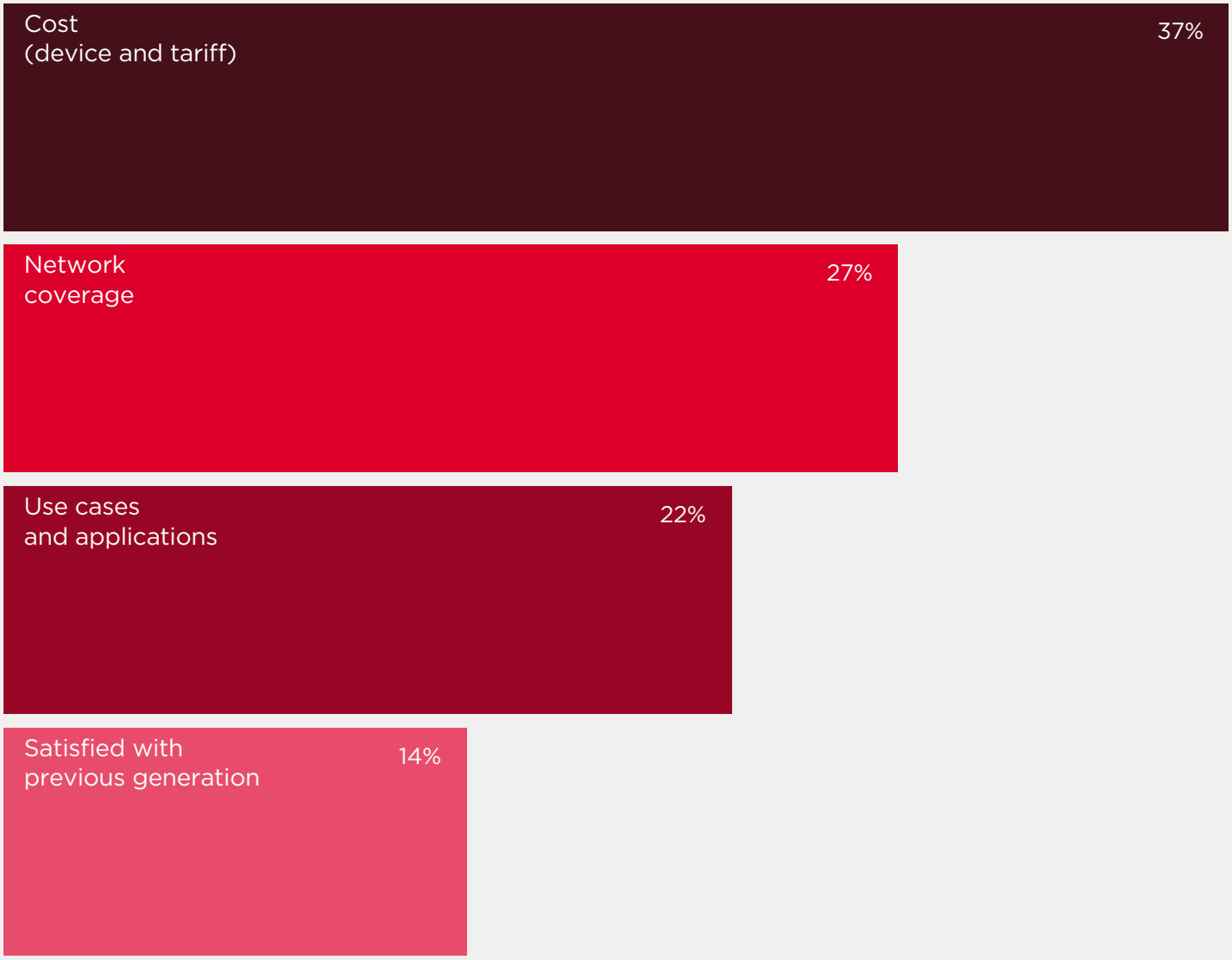
The 5G Africa Survey sought to capture the perspective of stakeholders on the impact of four main factors on consumers' ability and willingness to adopt and use 5G services. Among these, cost emerged as the top factor, underlining the affordability challenge in Africa.

Figure 25

Main factors impacting consumer 5G uptake

What is the biggest barrier to consumer adoption of 5G? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey



4.1 Consumer considerations

Cost

5G devices are usually the biggest cost factor for consumers, given that 5G upgrades are offered at little or no premium in most cases. The first wave of 5G devices targeted the top end of the market, but the development of more-affordable chipset designs has led to a significant decline in the average retail price for 5G smartphones.

Furthermore, the rollout of 5G in large, developing markets with similar income levels to countries in Africa (e.g. India and Indonesia) will further incentivise the mass production of more affordable devices. In India, Reliance Jio and Google worked together to create a sub-$100 lightweight OS 4G smartphone with advanced features (with a 5G version expected in late 2022), serving as an example for operator-OEM partnerships.

5G-ready handsets are now available for as low as $150 from a range of vendors, but this remains prohibitive for most consumers in Africa, especially if they have to pay for the device upfront. Given the impact of device affordability on 4G adoption, device financing schemes will likely be necessary to improve affordability. Financing solutions help to offset the impact of prohibitive upfront costs of purchasing a smartphone, helping consumers afford devices with high specifications and advanced features.

Network coverage

The consumer impact of network coverage stems from the fact that 5G rollout is likely to take a phased approach in Africa. This may be a consideration for users who require mobility across wide geographical areas, but less so for more static use cases – for example, an FWA connection to the home or workplace. As 5G NR supports handover to 4G networks, users can enjoy uninterrupted connectivity, even when they leave a 5G coverage area.

Use cases and applications

The consensus of stakeholders in the 5G Africa Survey was that eMBB and FWA will initially be the dominant 5G use cases in Africa. There is growing demand for enhanced connectivity among consumers in the wake of the pandemic, which has brought about changes in many social and work-related activities. FWA in particular will benefit from the underdevelopment of fixed-line infrastructure in Africa and could emerge as the primary form of fixed connectivity to homes and businesses across the region.

Online streaming services, especially video and gaming, emerged as top applications that will drive demand for enhanced connectivity. Africa has the right mix of factors needed to become a major market for streaming content: a large, youthful and tech-savvy population and a legacy media and entertainment industry that is ripe for digital disruption.

Connectivity and content are arguably the two most important remaining factors to unlock the full potential of the region's streaming market. Indeed, both factors are effectively in a virtuous circle, with improved connectivity creating opportunities for users to consume content and increased consumption of content driving data traffic and strengthening the case for network rollout. This underlines the important role of local content creators, such as Iroko and Showmax, and global players, notably Netflix, in driving demand for connectivity. In South Africa, for example, Netflix has showcased over 200 titles and invested over ZAR2 billion ($110 million) in local productions over the last five years.

5G will also benefit from the growth of the online gaming market in Africa. The number of gamers in the region has more than doubled in the last five years to 186 million people, according to a study commissioned by game analytics company Newzoo and Carry1st, a South African gaming platform. This is largely being driven by mobile gaming, with 95% of gamers across the region playing on a smartphone or tablet, as opposed to consoles and computers. However, immersive reality use cases and applications, requiring dedicated devices such as VR headsets, may struggle to gain momentum in the short term due to device availability and costs.

Satisfaction with previous generation

While 5G promises to deliver new experiences for the consumer, such as faster speeds and lower latencies, some consumers may wish to remain with an older network generation. This may be the result of several factors, including a lack of awareness of the benefits of 5G, affordability of 5G devices and services and a lack of new use cases that necessitate the capabilities of 5G. Given the likelihood of this scenario, operators should consider strengthening consumer messaging to drive demand prior to service launch. This includes building awareness of the broad range of 5G benefits, such as speed, latency, capacity and resilience, and showcasing these benefits with tangible new use cases that consumers can relate to.

Qualcomm

Qualcomm launches the Snapdragon 480 Plus chipset

The average retail price for a 5G smartphone has fallen significantly since the early days of 5G, reaching less than $500 in 2022. This has been a key driver of 5G adoption in pioneer markets. However, for Africa, a true mass-market 5G phone will have to be much more localised and affordable. This requires stakeholders to deliver cost efficiencies across the smartphone value chain, including lower-cost chipsets.

The Snapdragon 480, launched in December 2020, was Qualcomm's first 5G chipset aimed at the entry-level tier of the market. The Snapdragon 480 Plus is a follow-up to the Snapdragon 480 with improved performance for both productivity and entertainment. By the second quarter of 2022, more than 100 devices based on the Snapdragon 480 or 480 Plus had been announced or were in development, highlighting the chipset vendor's reach. Key features include the following:

- **Truly global 5G connectivity support:** The 480 Plus uses the Snapdragon X51 5G Modem-RF System, which supports sub-6 GHz and mmWave frequencies, as well as 5G SA and NSA modes. It also provides support for TDD, FDD and dynamic spectrum sharing.
- **Boosted performance:** The Qualcomm Adreno GPU, Qualcomm AI Engine and 8 nm process combine to offer improved processing and improved battery life. According to the GSMA Intelligence Consumers in Focus Survey 2021, battery life is the most important feature for customers when choosing their next smartphone.
- **Enhanced mobile gaming experience:** The 480 Plus leverages best-in-series CPU and GPU to ensure smooth visuals in games on an FHD+ 120Hz display. This expands the range of games that can be played on a mobile device, creating new opportunities to monetise mobile gaming.

Qualcomm's expansion into the entry-level tier of the 5G market is enabling device makers to deliver advanced features while also bringing the cost of 5G handsets down to around $250. These designs are still priced too high for most consumers in Africa, but they highlight the progress made since the launch of 5G in addition to the effectiveness of Qualcomm's strategy. This relies on heavy investment in R&D and the commercialisation of its premium Snapdragon chipsets to generate cash to develop lower-cost chipsets. This formula will prove pivotal to creating the budget smartphones needed to stimulate 5G adoption in Africa and other low- and middle-income countries in Asia-Pacific, the Middle East and Latin America.

4.2
The FWA opportunity

FWA networks have been around for decades, with the majority of commercial services using 4G. However, FWA market adoption has been limited so far, mainly due to performance concerns, especially in comparison to fixed-line options. 5G is making FWA a more competitive solution versus FTTH and cable, as it provides speeds of over 10× that of 4G FWA. As of September 2022, 74 fixed broadband service providers had launched commercial 5G FWA services across 38 countries. GSMA Intelligence forecasts show that the number of global 5G FWA connections could reach 40 million by the end of 2025, with the majority in developed countries such as the US.

FWA deployment scenarios

There are four possible FWA deployment scenarios for operators:

- Targeting new fixed broadband users in underserved markets to drive first-time broadband adoption in developing markets such as in Africa. This can be cost effective compared to FTTH, particularly where new fibre infrastructure needs to be built, so it is a suitable and timely tool to tackle the digital divide in emerging markets more quickly.
- Targeting fixed broadband users looking for faster speeds, for instance to tackle the digital divide in rural towns and suburban areas lacking access to FTTH, as well as areas with few alternatives. This occurs in markets where fibre infrastructure is concentrated in urban areas.
- Complementing fibre offerings, generally in urban and suburban areas with difficult terrain and/or regulatory red tape, or areas with few fixed broadband alternatives.
- Targeting enterprise segments to connect MSMEs in underserved areas or areas with few alternatives. The embedded security, reliability and high capacity of 5G make for a valid value proposition for the enterprise segment. Other targets include temporary work sites, such as construction zones, and large campuses, to avoid the cost of wiring the premises.

The above scenarios are all applicable in countries across Africa, with the option of targeting consumers in underserved areas providing one of the biggest FWA opportunities. The pandemic resulted in changes in broadband usage patterns, such as a marked increase in data traffic in residential areas as people worked from home and consumed more streaming content during lockdown. Some of these changes may become more permanent in an increasingly hybrid working environment.

5G FWA will also be a primary 5G use case for enterprises of all sizes, given the challenges around access, cost and reliability of existing connectivity services, including fixed broadband and satellite. As such, early 5G deployments will likely target locations with a high concentration of enterprises, including public institutions.

Apart from demand, the FWA opportunity also benefits from an expanding device ecosystem. According to the Global Mobile Suppliers Association, as of April 2022 there were 120 5G FWA customer-premises equipment (CPE) models available from 72 different vendors, up from just 16 in May 2020. 5G FWA rollout will be boosted by growing CPE model diversity, an expected fall in CPE costs and continuing CPE innovation.

Using mmWave spectrum for FWA

Mid-band spectrum is a good fit for 5G FWA in population clusters such as towns and smaller urban areas, in most cases with a single base station. This is especially true where other options are expensive or unavailable. Low-, mid- and high-band spectrum all have a role to play as FWA connectivity expands. Lower bands (e.g. sub-1 GHz) are useful for rural and remote areas, where populations are more spread out, and mmWave bands can provide access in more densely populated areas with the fastest 5G speeds.

mmWave can handle large amounts of data at very high speeds and very low latency – a combination that is appealing for busy and high-traffic residential areas, transport hubs, private networks and FWA. Further, it is now possible to offer FWA using solely mmWave spectrum (mmWave standalone) with no need for sub-6 GHz spectrum. This provides operators with more flexibility in delivering FWA services.

The momentum behind mmWave spectrum is growing. There is already a harmonised identification of 26, 40 and 66 GHz for ultra-high-speed and ultra-low-latency consumer, business and government services. The next step is for countries to assign it to operators. As of September 2022, 63 operators around the world had been assigned mmWave spectrum, with commercial mmWave 5G networks announced or launched in several countries, including Japan, Singapore and the US. Existing commercial mmWave 5G networks are showing the significant potential these bands have. mmWave spectrum was internationally allocated to mobile services at the World Radiocommunication Conference in November 2019 (WRC-19).

In several instances, mmWave provides an opportunity for operators that are constrained in their mid-band holdings to deploy FWA services as a cost-efficient alternative to FTTH. A GSMA Intelligence study shows that in both urban and rural areas that suffer from difficult terrain characteristics and regulatory red tape, a 5G mmWave FWA network could provide significant cost savings where fibre cables need to be deployed in ducts built by the operator.[11]

The deployment of a large-scale mmWave network is not without challenges. As the size of a mmWave cell, depending on propagation characteristics, is expected to be in the order of 200 to 1,000 metres outdoors and tens of metres indoors, achieving nationwide coverage would be prohibitively expensive. However, vendors are increasingly developing solutions to address these shortcomings. For example, Italian operator TIM, working with Qualcomm and Ericsson, achieved a speed of 1 Gbps on mmWave frequencies at a distance of 6.5 km from the live network site, highlighting the usability of mmWave spectrum for wider 5G FWA coverage beyond high-density urban areas. In February 2022, Qualcomm announced new features and capabilities to its Qualcomm 5G FWA Platform, which services more than 40 OEMs and 125 FWA designs.

Figure 26

The large amount of spectrum provides capacity to support new use cases

Average bandwidth per operator

Source: GSMA Intelligence

11 The 5G FWA opportunity: A TCO model for a 5G mmWave FWA network, GSMA Intelligence, 2022

4.3 Enterprise considerations

With the growing maturity of the consumer mobile segment, and the sufficiency of 4G for many consumer use cases, the enterprise market has an elevated importance in the 5G era. A raft of digital transformation projects across different industries, with enhanced connectivity at the core, further highlight the opportunity for 5G. Even before Covid-19, the global trend towards digitisation was clear – the pandemic has simply accelerated the shift.

Enterprises increasingly see network technologies as part of their digital transformation agenda. This is expected, as modern networks are the backbone of new use cases such as industrial asset monitoring, digital twins enabled by sensors, and digital or as-a-service business models. Recent trends show a growing adoption of enabling technologies such as cloud, edge, AI and IoT across most vertical sectors. These technologies also require better network support for reliable data transport, compute at the edge and automation for mass connected assets and devices. 5G networks are designed to cater for such needs.

Network vendors and systems integrators, as well as operators, are helping drive adoption of 5G for the enterprise segment, mainly through private networks. Technology companies that specialise in niches of 5G, IoT, AI, cloud or end-user applications are indispensable for the use-case discovery that enterprise 5G requires. The more enterprises work with them, the more they will see proof of value for their business.

Figure 27

Key categories of players for enterprise 5G

Source: GSMA Intelligence

Device makers	Operators	Specialised tech companies	Systems integrators	Cloud hyperscalers	Network vendors
5G devices for enterprise use include smartphones, tablets, AR glasses, VR headsets, cameras, industrial sensors, gateways, robots, smart vehicles (autonomous or remote controlled) and drones. Notable players include Qualcomm, Quectel, Siemens, Telit, U-Blox and Fibocom.	Operators are the traditional vendors of connectivity services, including 5G. They also offer digital services such as cloud, security and IoT. Currently, private networks are gaining momentum, but in the longer term operators will introduce slicing and edge computing.	Technological or vertical application expertise is key to servicing enterprises with 5G. Companies that specialise in IT, AI, IoT or security are key to use-case discovery and innovation. Examples include Here Technologies (localisation, navigation), VisionNav (industrial AGVs) and Kudelski (IoT security).	Technological or vertical application expertise is key to servicing enterprises with 5G. Companies that specialise in IT, AI, IoT or security are key to use-case discovery and innovation. Examples include Here Technologies (localisation, navigation), VisionNav (industrial AGVs) and Kudelski (IoT security).	5G devices for enterprise use include smartphones, tablets, AR glasses, VR headsets, cameras, industrial sensors, gateways, robots, smart vehicles (autonomous or remote controlled) and drones. Notable players include Qualcomm, Quectel, Siemens, Telit, U-Blox and Fibocom.	Enterprise cloud computing was introduced around 10 years ago and has since grown rapidly. Hyperscalers are now eyeing enterprise networking as an opportunity to converge their cloud or hybrid compute offerings. Examples include AWS, Google Cloud, Microsoft Azure and IBM.

Key survey insight

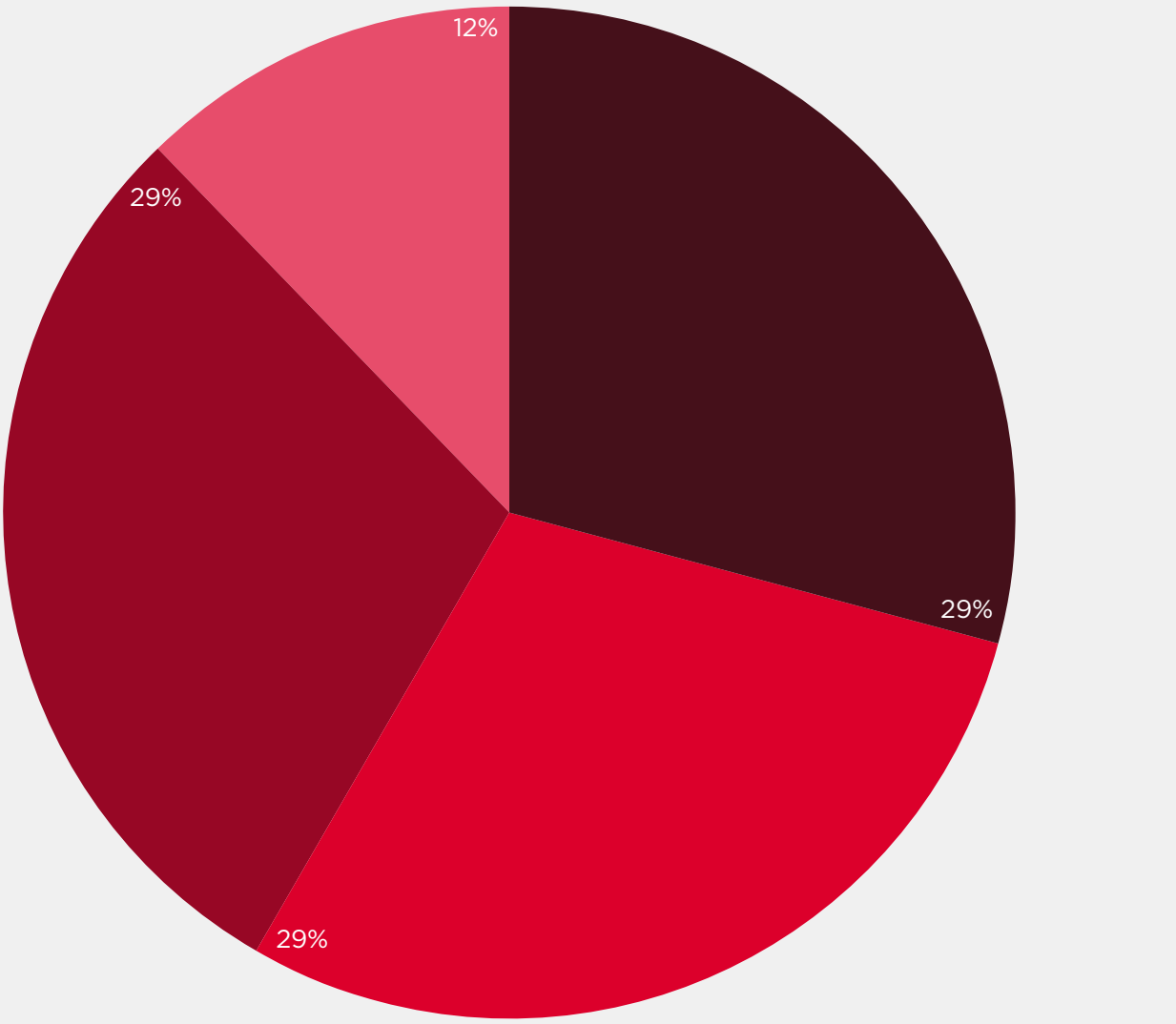
To take advantage of the enterprise opportunity in the 5G era, operators in Africa will need to address a number of challenges, some of which may be unique to the region. The 5G Africa Survey revealed the three jointly top challenges when considering 5G uptake among enterprises in Africa. This serves as a pointer to areas where operators would need to focus efforts in their 5G enterprise strategy.

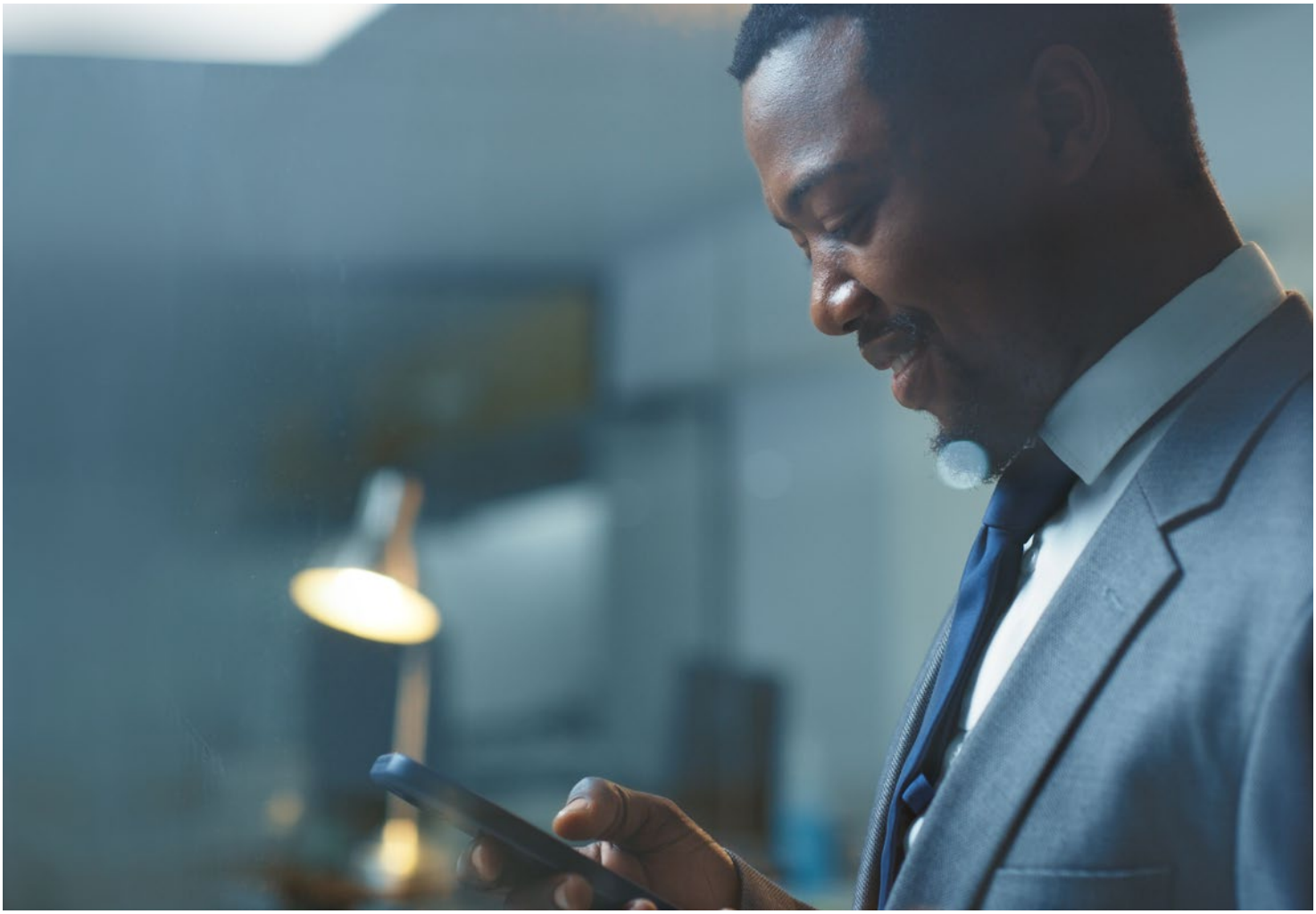
Figure 28

Main factors impacting consumer 5G uptake

What is the biggest challenge in selling 5G to enterprises? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey





Awareness

Enterprises are no strangers to telecoms services. Before, much of the services they used related to basic connectivity services, such as voice and data. However, 5G comes with a suite of new capabilities that can enable innovative solutions for enterprises across different verticals. In the view of stakeholders in the 5G Africa Survey, there is currently a significant knowledge gap among enterprises in Africa on the capabilities of 5G and how to take advantage of these capabilities.

In this context, there is an industry need to better articulate 5G's capabilities and the value proposition to enterprise customers (including FWA, network slicing, edge computing and IoT technologies). The lack of clarity on 5G capabilities and technology migration (timelines and how legacy technology works with new technology) can delay enterprise investment in devices and the potential take-up of service.

The possibility of insufficient technical skills among staff at enterprises is less of a concern for stakeholders – the perception is that IT staff at large enterprises generally keep abreast of new technology. However, efforts to engage with enterprises and improve awareness of 5G and its potential among enterprises would also allow them to identify any skills gap that requires attention in order to take advantage of new 5G services.

Use cases and applications

Operators are acutely aware of the need to develop compelling 5G use cases that leverage the technology's unique capabilities and to support the realisation of IR4.0 objectives. Commercialising 5G across the consumer and enterprise segments will require the development of relevant use cases to drive uptake among target customers.

As with the consumer segment, FWA will be a prime 5G use case for enterprises in Africa, especially in locations outside of fibre coverage. In August 2022, Nokia successfully piloted 4G and 5G FWA network slicing in Kenya for Safaricom. Network slicing allows operators to divide their networks into multiple logical slices, each capable of maintaining independent end-to-end levels of service quality, network performance and security, which lets them provide tailored services to enterprises and other customers through the network slices.

Figure 29

Key categories of players for enterprise 5G

Source: GSMA Intelligence

Sector	Use case description
Smart cities	Orange Romania's 5G network provides solutions for congestion monitoring, parking sensors and smart waste management at the Alba Iulia Smart City.
Autonomous vehicles	O2 is trialling driverless cars in London using its 5G network.
Crowd management at sporting venues	Verizon and Cisco partnered to deliver a number of new capabilities to stadia, such as the ability to use analytics to estimate waiting times at gates, restrooms and concession stands.
Sports broadcasting	5G-enabled cameras eliminate the need to use cables, making it easier to cover sports that take place over a wide area. For example, Fox Sports trialled 5G at the US Open (golf) with Intel, AT&T and Ericsson.
5G drones	Vodafone Spain has trialled a solution to deliver a lightweight defibrillator for use at the scene of a cardiac arrest, using a drone controlled by 5G.
Construction	SK Telecom partnered with Hyundai Construction Equipment and geolocation software company Trimble to use 5G networks to monitor construction equipment.
Manufacturing	AIS Thailand is using 5G connectivity to enable robots to roam manufacturing plants.
Smart factories	Verizon has partnered with specialist glass maker Corning to investigate how 5G can improve the factory environment.
Agriculture	5G sensors collate real-time information about fertilisation, livestock and moisture needs, helping to conserve energy. Moocall's calving sensor, powered by 5G, alerts farmers when a cow is about to give birth.
Ports	PSA International is using 5G to support automated guided vehicles (AGVs) and automated cranes. It has partnered with mobile operators in Singapore to scale these solutions.
Utilities	China Unicom and State Grid Hangzhou Electric Power Company have used a 5G-enabled cable tunnel inspection robot to conduct real-time monitoring of power systems.
Healthcare	Telefónica, in partnership with a hospital in Malaga, developed a solution for remote surgery that runs entirely on 5G.
5G-powered studio lighting	Telia has worked closely with TV 2 and BB&S Lighting in Denmark to test how 5G networking could be employed to improve lightning set-up and cost efficiency in broadcasting.
Oil and gas	Centrica Storage and Vodafone have entered into a partnership to use 5G to automate, monitor and centralise much of the former's critical maintenance and engineering operations.
Aviation	China Mobile Chengdu used Huawei's 5G distributed massive MIMO solution to deliver 5G in the new Chengdu Tianfu International Airport, with smart travel services, such as VIP recognition, luggage tracking and AR map navigation.
Health and safety	Singtel, Gammon Pte. Limited and the Building Construction Authority of Singapore are developing a 5G solution to make building sites safer and more efficient.

Most 5G applications that have been developed to date have focused on use cases and customers in the earliest-adopting markets. In some cases, these can be replicated for enterprises in Africa, such as use cases in agriculture and the extractive sectors, where the operational process are largely uniform. However, there is a strong argument to develop use cases and applications specifically for local markets in the region, taking into account the unique social, economic and environmental factors at play.

Operators should exploit partnerships with enterprises for the purpose of developing 5G use cases in their markets. Examples from other regions highlight how collaboration can enable a faster time to market with solutions that take advantage of unique 5G capabilities. They also demonstrate how operators selling 5G to enterprises are doing so by marketing various 5G benefits rather than focusing on speeds alone.

Operators and equipment vendors have also invested in 5G labs dedicated to co-creating solutions with partners to address specific needs in other regions. This collaborative approach to 5G use case development often brings together key stakeholders – including startups, academia, enterprises, cloud providers and systems integrators – to demonstrate how 5G can enable digital transformation across society.

Orange pioneers 5G labs in Africa

In June 2022, Orange launched the first Orange 5G Lab in Africa, located in Dakar, Senegal. Located in an Orange Digital Center, the lab creates, tests and demonstrates innovative products and services on the 5G network and develops practical 5G applications for local business and consumers. It also aims to give stakeholders greater insight into the opportunities and value of 5G. The idea is to help these stakeholders to test their current solutions and services and think about new 5G-enabled solutions while taking advantage of an ecosystem to co-innovate and change their business model and processes.

Orange is taking a collaborative approach to the development of 5G applications in the lab, with partners working on a range of solutions, including:

- 5G case studies carried out in several areas, including e-Health, smart ports, smart education and smart agriculture, in partnership with equipment vendors Huawei and Nokia
- 5G innovation demonstrations between engineering R&D startup Caytu and the Dakar American University of Science and Technology
- a 5G innovation demonstration between Senvital and Sonatel in the area of occupational health services.

The services at the lab are specifically based around a programme to learn about 5G and the use cases it enables through demonstrations and activities. For innovators, it provides an opportunity to test their products and services in a 5G environment on Orange's experimental network. The facility also includes 5G equipment to support users, including AR glasses, VR headsets, routers and 5G devices. Companies are also supported by Orange's technical, network and product experts, providing synergies and additional resources.

The Orange 5G Lab in Dakar will benefit from the experience and opportunities created by the Orange 5G Lab ecosystem. It joins a network of 13 other labs across Europe – France (10), Romania (1), Belgium (1) and Poland (1). Orange has already welcomed more than 1,200 companies and authorities at its Orange 5G Labs, including 114 who have been able to trial their own practical examples. Having a local presence is a key part of the Orange 5G Lab initiative, to support the digital transformation of the local economy. Orange plans to launch similar 5G labs in other countries in Africa where it is present.

4.4 The private 5G network opportunity for operators

Mobile network operators are responding to demand for private 5G networks. This is a growing part of operators' business as enterprises look to have more control over their connectivity and ensure performance levels that meet their evolving latency, coverage, edge or security requirements. The initial addressable market for private 5G networks is companies with location-specific coverage requirements, such as for a factory, industrial park or construction site. Other sources of demand include private firms and municipal authorities in areas such as public transport and road signage.

A number of examples of use cases have been trialled and commercialised around the world: AT&T launched a private 5G network for healthcare, connecting researchers and patients in the US; Verizon signed a contract with Associated British Ports to equip the UK Port of Southampton, which is responsible for £40 billion in UK exports each year, with a private 5G network; and Singtel is developing a new private 5G network for Hyundai Motor Group to leverage 5G capabilities and mobile edge computing resources.

Private wireless networks are delivered in diverse forms, with varying levels of infrastructure managed by the operator or enterprise. This disaggregation of control further feeds into the opportunity to leverage open network technologies and new vendors supporting different functions. In some cases, public networks will be combined with local infrastructure to support private networks. For prospective enterprise customers, these options entail trade-offs centred on cost versus the level of service customisation (see Figure 30).

Great care needs to be taken to ensure verticals are fully supported without harming other wireless users – especially the consumers and businesses who rely on 4G and 5G. Spectrum that is set aside exclusively for verticals in core mobile bands, for example, risks being underused and can undermine fair spectrum awards, raising affordability issues for consumers. Commercial mobile operators already support the needs of a wide variety of vertical sectors and will have added capabilities with 5G to look after private networks.

Figure 30

Private networks sit on a scale of customisation, control and cost

Source: GSMA Intelligence, GSMA Internet of Things Programme

Public network	Public network with SLAs	Public network with slicing	Public network with local infrastructure	Private network (operator spectrum)	Private network (non-operator spectrum)
— Efficient use of infrastructure and spectrum — Mobile edge computing within public network	— Operator expertise and spectrum portfolio — Superior customer support and SLAs	— Dedicated and customised network resources — Higher data isolation, security and privacy	— Dedicated network equipment — Choices regarding localisation of data/control — On-site mobile edge computing	— Isolated network — Managed service or leasing of spectrum — Customised design, operations and deployment	— Direct responsibility for spectrum access and usage — Independent design, operation, procurement and radio plan

Less customisation
Less control
Lower cost

More customisation
More control
Higher cost

The potential for the private 5G network market in Africa is significant. Given the likelihood that operators will take a phased approach to 5G rollout and that public 5G services may not be available in certain locations initially, the private 5G network option represents a credible alternative for enterprises. Early adopters of private 5G networks are likely to be large enterprises with deep pockets and clear business cases. This offers an opportunity for operators to test 5G and new business models – something as important, if not more important, than pure revenue generation in the early adoption phase.

While the private 5G market in the region is still in its infancy, there are early signs of progress. In South Africa, for example, MTN is building private 5G networks for 14 companies in the mining and ports sectors. Most stakeholders in the 5G Africa Survey envisage demand for private 5G networks in their market, with mining, ports, oil and gas, education and agriculture among the prospective sectors.

For most stakeholders, setting aside 5G spectrum in key bands for non-operator players could mean that a valuable resource goes unused in many areas, limiting the amount of spectrum available for public 5G services, with a direct impact on speeds, coverage and cost. For example, industry verticals are unlikely to use spectrum in priority 5G bands very widely across countries, potentially resulting in unused spectrum assets. As such, spectrum carve-outs for vertical industries should be avoided in priority 5G bands (i.e. 3.5, 26 and 28 GHz). Sharing approaches such as leasing[12] are typically better options in these situations.

Additionally, operators can leverage their larger and more diverse spectrum assets and large-scale deployment experience to build networks more efficiently and effectively. This is especially true in Africa, where most enterprises would not have the scale and resources to build and operate private 5G networks, compared to their counterparts in more advanced markets. Furthermore, partnering with operators to field test 5G offers enterprises an opportunity to reduce the investment burden and ensures a technology partner with interest at stake.

12 Spectrum leasing in the 5G era, GSMA, 2022

Key survey insight

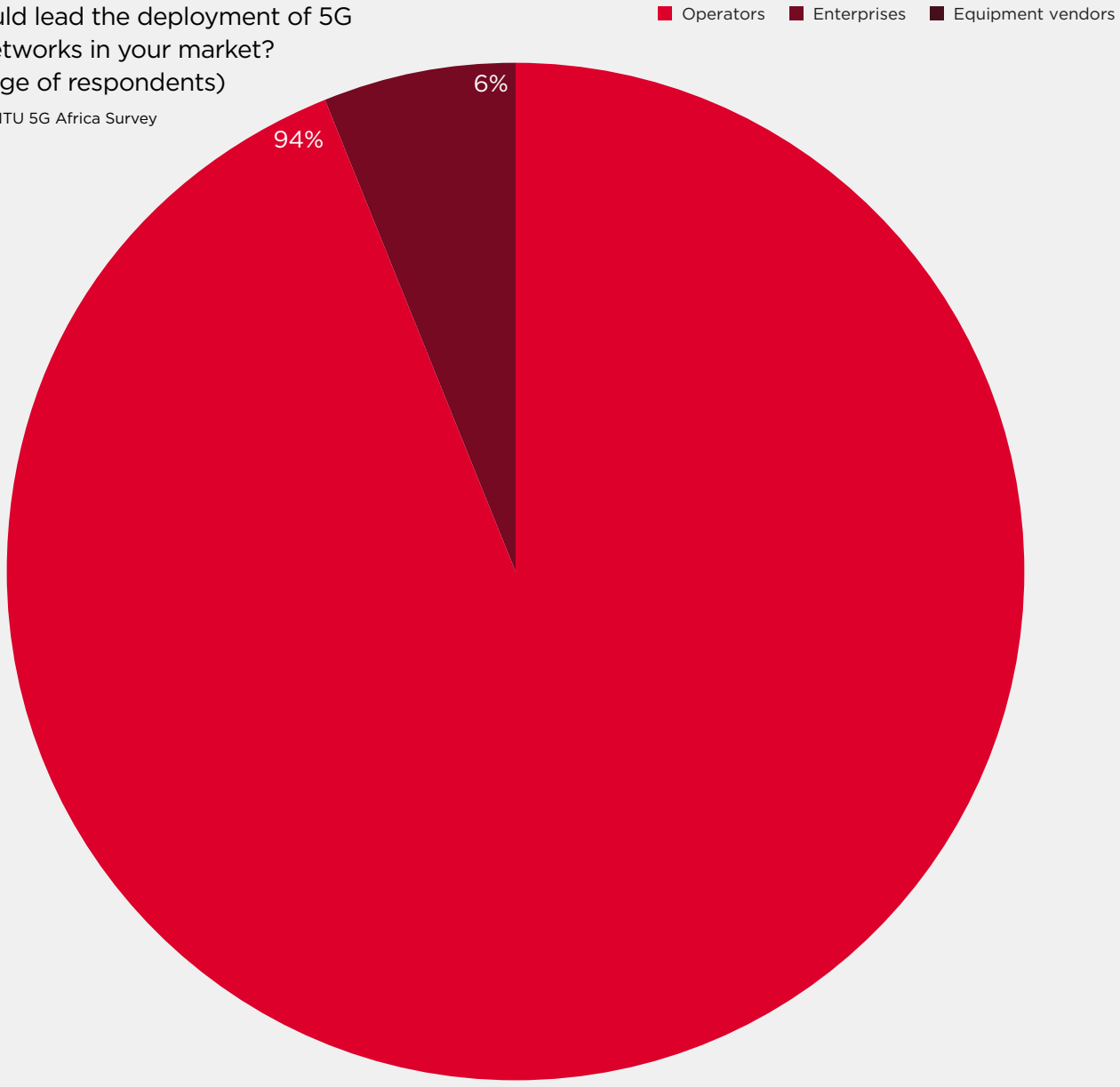
The role that operators will play in the private 5G network market has been open to some debate in more advanced markets, especially with moves in some markets to set aside spectrum in core mobile band for verticals. In Africa, however, the consensus among stakeholders is that operators are best placed to lead the rollout and operation of private 5G networks.

Figure 31

Operators are best placed to drive the private 5G market in Africa

Who should lead the deployment of 5G private networks in your market? (Percentage of respondents)

Source: GSMA-ITU 5G Africa Survey



The GSMA 5G Transformation Hub: unlocking the potential of 5G

5G has the potential to enable a range of new applications and services, but it can be difficult for the mobile industry and its partners to source reliable information on these opportunities. The GSMA 5G Transformation Hub was established in response to this challenge. The hub is an online portal containing information on current live 5G solutions with case studies detailing design, benefits, key players, measured value and the future positive impact of scaling up these solutions worldwide.

As of August 2022, there were 15 case studies on the 5G Transformation Hub, with more to be added in the rest of the year. A wide range of industries are covered, including manufacturing, energy, transportation, live entertainment, smart cities and construction (see below for an example).

By publishing information on innovative 5G services, the GSMA 5G Transformation Hub allows industry stakeholders to gain a better understanding of why 5G is best placed to deliver real value to customers and transform multiple industries. This can help inform the 5G business case and inspire operators, businesses and governments to roll out solutions to unlock the benefits of 5G and accelerate market adoption. This is particularly important in regions that have yet to roll out 5G at scale, such as Africa.

How 5G could help transform construction

Challenge

Both dynamic and temporary in nature, building sites tend to lack the ICT infrastructure to truly harness digital technologies. To properly monitor large and complex construction sites requires mobile high-resolution cameras, supported by high-capacity, low latency connectivity.

Solution

Singtel has deployed a 5G SA network and edge compute capacity to support a Gammon construction site on Sentosa Island in Singapore. 5G is used to connect robots (that can scan the site in 3D), CCTV cameras (that supply footage to image recognition software), headsets (for augmented reality services) and drones.

Impact and statistics

Gammon estimates using 5G connected robots, rather than human beings, to scan construction sites could lead to a 30–40% improvement in productivity for this process. At the same time, it believes 5G connected CCTV cameras will significantly improve safety by enabling image recognition systems to immediately detect potential hazards. It is planning to deploy both these solutions on other construction sites.

Wider implications

5G connectivity could enable contractors to create highly detailed and up-to-date digital models of a building site. These models could be used to monitor progress, verify the quality of work, manage assets and equipment and ensure compliance with safety and environmental regulations. As a result, the construction sector could achieve a major leap forward in both safety and productivity, while boosting customer satisfaction.

Stakeholders

Singtel, the Building Construction Authority of Singapore (BCA), Gammon and Qualcomm[13]

13 For more information, see https://www.gsma.com/5GHub/construction

5 Policies to realise the 5G potential in Africa

An enabling policy environment is essential for the success of 5G in Africa. Accordingly, governments and regulators need to foster a pro-investment and pro-innovation environment to support cost-effective network rollout and the development of innovative use cases to stimulate demand.

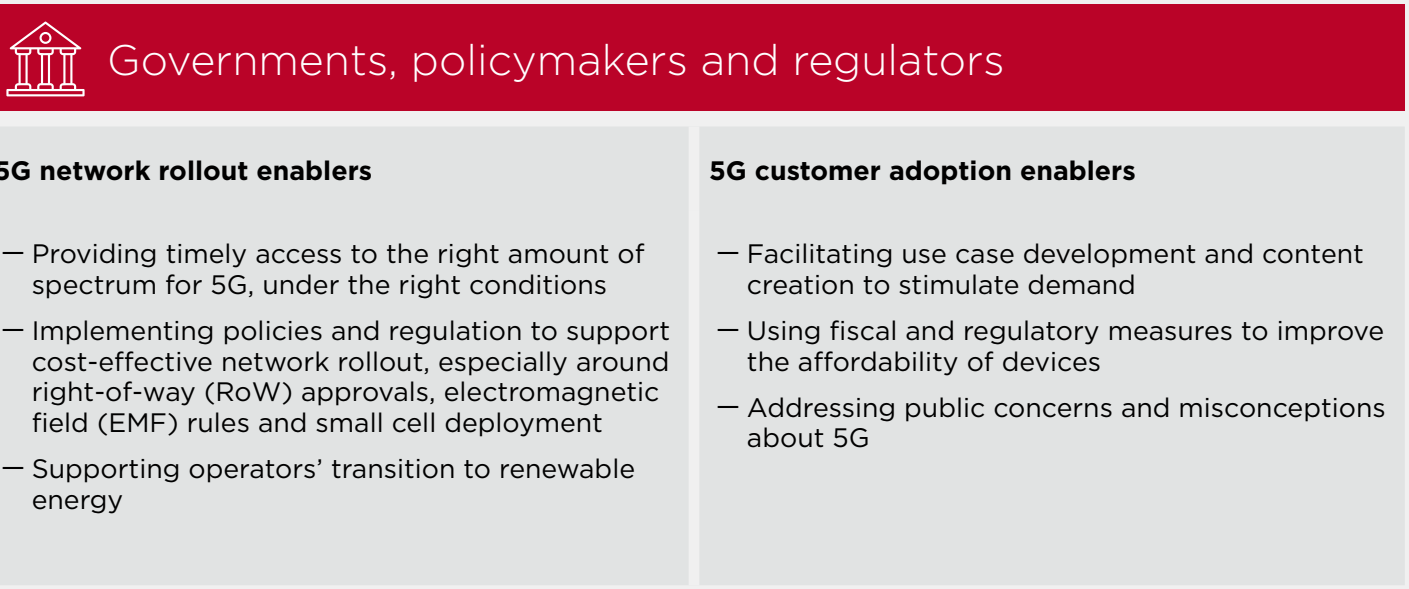
5G can deliver customisable services to meet the needs of a huge variety of users and connection types. However, the success of these services is heavily reliant on national policy decisions and their impact on 5G network deployment and customer adoption.

This chapter outlines key policy and regulatory enablers to support 5G network rollout and customer adoption and usage in Africa.

Figure 32

5G policy considerations

Source: GSMA Intelligence



5.1
5G spectrum policy framework

The speed, reach and quality of 5G services depend on governments and regulators supporting timely access to the right amount and type of affordable spectrum, under the right conditions. There is already a significant variation in the amount of spectrum assigned and the prices paid at auctions, which means the potential of 5G services will vary. This, in turn, directly impacts the socioeconomic benefits of 5G and the competitiveness of national economies.

5G spectrum bands

Effective spectrum licensing is critical to encourage the investment required to expand mobile access, meet the increase in demand for data services and enhance the quality and range of services offered. Successful 5G networks and services depend on a significant amount of new harmonised mobile spectrum. Ensuring the timely availability of prime bands, including those requiring defragmentation, should be prioritised. Initially, regulators should aim to make available 100 MHz of contiguous spectrum per operator in prime 5G mid-bands (e.g. 3.5 GHz) and around 800 MHz per operator of high-band (mmWave) spectrum. Lower bands (below 1 GHz) are also required to provide wide-area capacity and ensure that 5G reaches everyone.

The vast majority of commercial 5G networks around the world depend on mid-band frequencies. This initial focus – particularly on the 3.5 GHz range, which has become the birthplace of commercial 5G – produces the scale needed to bring down the cost of network equipment and mobile devices. At its core, a mobile spectrum licensing framework should:

- ensure operators have access to sufficient spectrum
- provide predictability to support the new network investment needed
- avoid costly restrictions on the use of spectrum beyond those needed to manage interference.

Spectrum harmonisation has always played a vital role in the success of mobile networks and the rollout of 5G is no different. However, more mid-band spectrum beyond the initial 100 MHz per operator will be needed as 5G demand increases. This work is vital to 5G's future and requires forward planning from policymakers. On average, a total of around 2 GHz of mid-band spectrum will be required for 5G per country by 2030.

Refarming 2G, 3G and 4G bands can, in time, contribute to meeting future spectrum requirements, but adding new bands is necessary to keep up with demand. A number of frequency ranges have the potential to help support future mid-band needs. Mobile use within the 3.5 GHz range (3.3–4.2 GHz) is being maximised in some countries, while additional capacity in both 4.8 GHz and 6 GHz benefits from harmonised equipment ecosystems. These bands are all part of the process of the next World Radiocommunication Conference (WRC-23).

While the importance of mid-band spectrum can't be underestimated, the future of 5G also depends on access to more mmWave spectrum. Depending on the urban characteristics of the city analysed and the expected 5G penetration, an average of between 3 GHz and 4.5 GHz of mmWave spectrum will be needed to satisfy demand. This assumes that adequate mid-band spectrum will be assigned by 2030.

For these planning efforts to succeed, countries should develop long-term spectrum roadmaps that reflect growing demand. Roadmaps are an important means of ensuring there is sufficient spectrum for future demand from consumers and new technologies. Information on spectrum releases is critical for businesses to prepare investment plans, secure financing and develop arrangements for deploying particular technologies.

Spectrum pricing and conditions

Beyond spectrum availability, the cost of spectrum also has a major impact. Governments and regulators should assign 5G spectrum to support their digital connectivity goals rather than as a means of maximising state revenues. Effective spectrum pricing policies are vital to support better quality and more affordable 5G services. In turn, that will help address issues such as the usage gap. High reserve prices, artificially limited spectrum supply (including set-asides) and poor auction design can all have a negative impact (i.e. slower mobile broadband and suppressed network investments).

Regulators should apply the right 5G spectrum licence terms and conditions and carefully consider best practice for awarding spectrum. For example, spectrum licences with longer durations provide operators with greater certainty to undertake long-term investments in rolling out networks and in deploying new services. On the basis of the expected payback period for substantial new network investment, many countries have decided to provide for a minimum term of 15 years.

Additionally, licences should be technology and service neutral to allow the upgrade of existing bands to 5G. Consulting with the industry will help maximise consumer benefits and ensure 5G is available for all. To maximise the benefits of 5G, governments and regulators should:

- make available sufficient 5G spectrum across low, mid- and high bands and avoid limiting the supply via set-asides
- set modest reserve prices and annual fees to let the market determine spectrum prices
- carefully consider auction design to avoid unnecessary risks for bidders (e.g. avoiding mismatched lot sizes, which create artificial scarcity)
- develop and publish a 5G spectrum roadmap with the input of stakeholders to help operators plan effectively around future availability
- consult stakeholders on the award rules and licence terms and conditions, and also take them into account when setting prices (onerous obligations reduce the value of spectrum).

Spectrum for 5G backhaul

Regulators should carefully consider 5G backhaul needs, including making additional bands available and supporting wider bandwidths in existing bands. Measures should also be taken to ensure licences are affordable and designed effectively. While fibre has an important role to play, it is essential that regulators plan to make available newer higher-frequency bands that can support wider channels and have a greater total amount of spectrum available. In the near term, the E-band (70–80 GHz) will be most important, especially to support initial 5G growth, but the W-band (92–114 GHz) and D-band (130–175 GHz) will be vital to scale capacity in subsequent years.

Regulators should also review backhaul licensing approaches, including whether the pricing methodology is suitable for the 5G era. There are a variety of licensing approaches for licensing backhaul bands, especially with the emergence of higher-frequency bands and dense small cell networks. Regulators should carefully consider their options to ensure they are encouraging spectrum efficiency, facilitating rapid deployments and ensuring the process can be efficiently managed by all parties. For example, block licensing could play a greater role in new higher-frequency backhaul bands. Supporting longer licence durations and encouraging spectrum trading can also encourage heavier backhaul network investment and more efficient spectrum use.

The price that operators pay for backhaul varies significantly around the world. Higher prices place a significant financial burden on operators, making it more difficult to afford quick 5G rollout, especially outside of urban centres. The formulas used to calculate prices are often designed for legacy narrow backhaul channel sizes, which means costs quickly become unsustainable for newer wider channels. It is essential that regulators ensure formulas contain components that mitigate such price jumps. Some pricing approaches also penalise operators for adopting newer and more spectrum-efficient backhaul technologies. These too should be avoided, as they discourage network upgrades.

Dynamic spectrum sharing

Several 5G RAN vendors now use dynamic spectrum sharing (DSS), which allows mobile operators to use the same spectrum band for different radio access technologies such as 4G and 5G, to combat the absence of new 5G spectrum. It works by allocating spectrum to different technologies in real time, based on demand. As of March 2022, DSS had been deployed for 5G networks by 45 operators across 32 countries. In Africa, MTN has deployed the technology in South Africa, in partnership with Huawei, using DSS on the 2.1 GHz frequency band to upgrade existing 4G base stations to 5G without changing antennas and radio units.

Given that new spectrum earmarked for 5G has only been allocated in a handful of markets across Africa, operators in the region are increasingly considering the technology to accelerate their 5G rollout. As with every new technology, DSS needs to mature further before wider adoption is achieved. DSS solutions could incur trade-offs in overall 4G and 5G capacity due to DSS operational overhead, which can translate into reduced peak data rates. Measurements show that initial 5G data rates in DSS environments are only marginally better than 4G. This is to be expected, as DSS relies on 4G network equipment. Furthermore, spectrum bandwidth available in the bands typically used by DSS is limited.

5.2 Network deployment regulations

The densification of networks to cope with urban capacity demands requires significant new investments in additional sites and supporting infrastructure, including fibre. Small cells are crucial to meeting the densification requirements of 5G, especially considering the shortage of adequate backhaul infrastructure. Complex planning procedures involving multiple layers of approval in some countries create an additional burden, significantly delaying 5G deployment. Policymakers must strive to ensure that the deployment regulations at the local level are aligned with national digital ambitions and market realities. To this end, policymakers are encouraged to:

- simplify planning procedures and regulations for site acquisition, colocation and upgrades of base stations
- provide operators access and rights of way (RoW) to public/government facilities for antenna siting and fibre deployment on reasonable terms and conditions
- establish uniform electromagnetic field rules that are no more restrictive than internationally agreed levels
- encourage and incentivise fibre investments and enact appropriate policies to ease and expedite fibre rollouts
- avoid network monopolies, such as single wholesale networks, which can stifle competition and investments in network rollout
- setting reasonable fees and other conditions for network deployment at local level
- offer a reasonable expectation of approval for voluntary network sharing deals while avoiding mandated sharing agreements that may amount to an access obligation.

Meanwhile, 5G networks are often flexible and modularised by design with technologies such as network slicing, SDN/NFV, cloud RAN and open RAN. At a basic level, these changes in mobile network technology and architecture seek to reduce costs and provide flexibility for customised services tailored for different customers. With 5G, operators can use network virtualisation techniques to dynamically configure network resources to deliver bespoke, managed connectivity services. Regulators should recognise the opportunity new deployment technologies can bring to 5G rollout and adapt their regulatory frameworks to accommodate them.

5.3
The transition to renewable energy

Energy efficiency is a top priority of operators' network transformation strategies and a growing number of operators in Africa have taken a leading role in the use of renewables to meet their ambitious targets. Governments and policymakers have a role play in supporting this drive to reduce dependency on diesel and switch to cleaner technologies, especially for 5G networks, and to achieve local climate targets in the process. In practice, this means creating an appropriate environment for solar panel deployments and advanced energy-efficient technologies.

In some countries, the cost of installing solar power is exacerbated by high duties on imported components. Governments and policymakers can facilitate the transition to renewable energy by easing the cost burden on operators by implementing enabling fiscal measures on solar components. Furthermore, with the increasing reliance on solar energy to power base stations, space and location will become even more important in cell site selection. Government and policymakers will need to factor this in the RoW assessment process.

5.4 Stimulating demand for 5G

In most countries, the government is a major purchaser of ICT products and services, including connectivity. With the advent of 5G, there is a case for governments to make deliberate efforts to integrate the technology within the various tiers of governments and across public institutions as part of their overall digital transformation and national ICT strategies. For example, governments can integrate 5G applications in the public healthcare and education sectors, with use cases around remote and immersive services. In turn, this will increase public awareness of the technology and its benefits and, by extension, drive demand among private users and encourage operators to focus 5G rollout in populated rural areas where peripheral infrastructure such as schools, clinics and governmental offices are located.

Governments can complement the efforts of operators to develop new 5G use cases through various measures, including funding and creating an enabling environment for innovation. Governments can promote further availability of test grounds for innovation and the establishment of 5G sandboxes to serve as areas of shared interest and engagement between the supply and demand sides of the 5G ecosystem.

Given the important role of locally relevant content in stimulating demand for enhanced connectivity, there is a need to enable a conducive environment for content creation to grow and thrive. For example, governments should recognise the unique business model of streaming services and not apply the regulations for traditional linear broadcasting or for services that utilise spectrum/other scarce resources on streaming content providers. Appropriate policy levers should also be utilised to incentivise investment in local content, in collaboration with content creators across the region and beyond.

Spotlight on the EU's support for 5G use case development

The European Commission's Connecting Europe Facility (CEF) Digital programme demonstrates the important role that public funding will play in supporting the deployment of 5G networks and development of innovative use cases. In January 2022, the Commission launched a call as part of CEF Digital to select projects that show concrete 5G use cases and have the potential to incentivise future 5G application development in different sectors. The Commission expects the development of services that impact local communities to help raise awareness about the benefits of bringing 5G to all populated areas in Europe and to help achieve its 5G targets set in its Digital Compass for the end of the decade. The initiative is also expected to create a set of best practice 5G use cases, which can be reused as benchmarks for innovative applications under other funding programmes across the EU.

5.5 Improving affordability

Affordability is a major disincentive that could deter customers from adoption 5G. While device costs are falling, they're still priced at a significant premium over 2G, 3G and 4G devices. For consumers in Africa, 5G uptake will be a function of device affordability. While smartphone financing schemes are predominantly led by the private sector, governments and policymakers have a role to play in providing an enabling environment to support such schemes – for example, allowing operators to offer mobile handsets with fixed SIM (carrier-locked) features as part of measures to de-risk handset financing.

Furthermore, it is important for revenue authorities to reduce or eliminate import and excise duties on 4G and 5G handsets to accelerate the transition to enhanced connectivity. According to GSMA research,[14] post-production costs account for a significant proportion of the retail price. These include VAT, customs taxes and other sector-specific taxes. Ultimately, aligning tax policies with governments' digital transformation objectives will bring sustained long-term benefits through the positive impact of greater connectivity on socioeconomic growth.

Finally, spectrum assignment can impact affordability and sufficient channel bandwidth plays a vital role here. Wider channels lower network density and this is an important factor in determining the cost of 5G services to consumers. However, it also has other advantages, including fewer base stations sites and lower environmental impact. The number of sites is inversely proportional to channel bandwidth: narrower channels mean more sites. Decreasing channel size from 100 MHz to 60 MHz in the 3.5 GHz range will require increasing the number of cell sites by 64%.

14 Making internet-enabled phones more affordable in low- and middle-income countries, GSMA, 2022

5.6 Misconceptions about 5G

5G has been the subject of misconceptions in many countries, including some in Africa. This has resulted in potential customers expressing concerns about the technology and hesitation to adopt 5G services when it becomes available in their markets. As Africa moves into the 5G era, there is an important role for national authorities to communicate accurate and reliable information. Authorities in many countries, including Australia, France, Germany and the UK, have taken steps to both educate the public as well as caution the spread of 5G misinformation.

Policymakers should also take steps to streamline the conditions for efficient 5G deployment by setting a national mobile network deployment policy that simplifies planning procedures for small cells, improves operator access to public sites for antenna siting and establishes uniform radiofrequency exposure rules based on the international safety guidelines. Both the World Health Organization and ITU recommend the human exposure guidelines developed by the International Commission of Non-Ionizing Radiation Protection (ICNIRP). In its recently updated guidelines, the ICNIRP (2020) states that there is no evidence that additional precautionary measures will result in a benefit to the health of the population. The updates to the limits are based on improved scientific accuracy and provide limits for exposure that were not considered in the ICNIRP (1998) guidelines.

The role of multilateral stakeholders

There are a number of multilateral stakeholders and organisations that engage with and represent various parts of the 5G ecosystem. In Africa, these include the African Telecommunications Union (ATU), the ITU, the GSMA, Smart Africa and sub-regional digital and communications authorities.

Based on responses in the 5G Africa Survey, these stakeholders will play vital roles in the transition to 5G, notably by:

- facilitating 5G best practices around spectrum assignment, equipment manufacturing and use case development among members
- facilitating dialogue among ecosystem players – globally, regionally and nationally – based on empirical data through various forums, including workshops and seminars
- providing insights, trends and thought leadership to support decision-making
- supporting advocacy efforts by leveraging platform to engage with policymakers.
- providing capacity building training on various aspects of 5G for policymakers and sharing lessons learned from early adopters
- supporting policymakers with evidence on 5G safety and debunking misinformation
- supporting efforts to create 5G awareness and demonstrate the value of technology with examples and case studies from other markets
- exploring avenues to reduce cost for network equipment and devices, in collaboration with device vendors and other ecosystem players
- promoting the importance of 5G towards achieving digital economy
- ensuring 5G spectrum is harmonised across the region to realise the economies of scale and therefore lower the cost of devices.

Conclusion and call to action

Africa is on the cusp of the 5G era. The opportunities are tremendous, but so are the challenges. Although Africa as a whole is embarking on its 5G journey at a slower pace than more advanced markets, the region is well placed to benefit from an increasingly mature global 5G ecosystem, evidenced by increasing competition in the equipment supply and applications markets.

Ecosystem collaboration will be essential to realising the potential of 5G in Africa. This includes:

- collaboration on cost-effective network rollout solutions, supported by timely access to the right amount and type of affordable spectrum, under the right conditions
- partnerships to develop innovative and locally relevant use cases for consumers and enterprises in Africa
- initiatives to bring affordable 5G-ready smartphones, CPEs and other devices to market.

Mass-market 5G rollout and adoption may be some way off in most markets, with much focus still on ramping up 4G adoption. However, countries in Africa can take a phased approach to 5G rollout, delivering the benefits of enhanced connectivity to consumers and enterprises at a sustainable pace while also improving the business case for more widespread rollout. Meanwhile, it is important for Africa to keep pace with global trends in relation to 5G adoption across society to avoid increasing the significant digital divide that already exists with more advanced markets.

Appendix

Figure A1

The GSMA BEMECS framework indicators

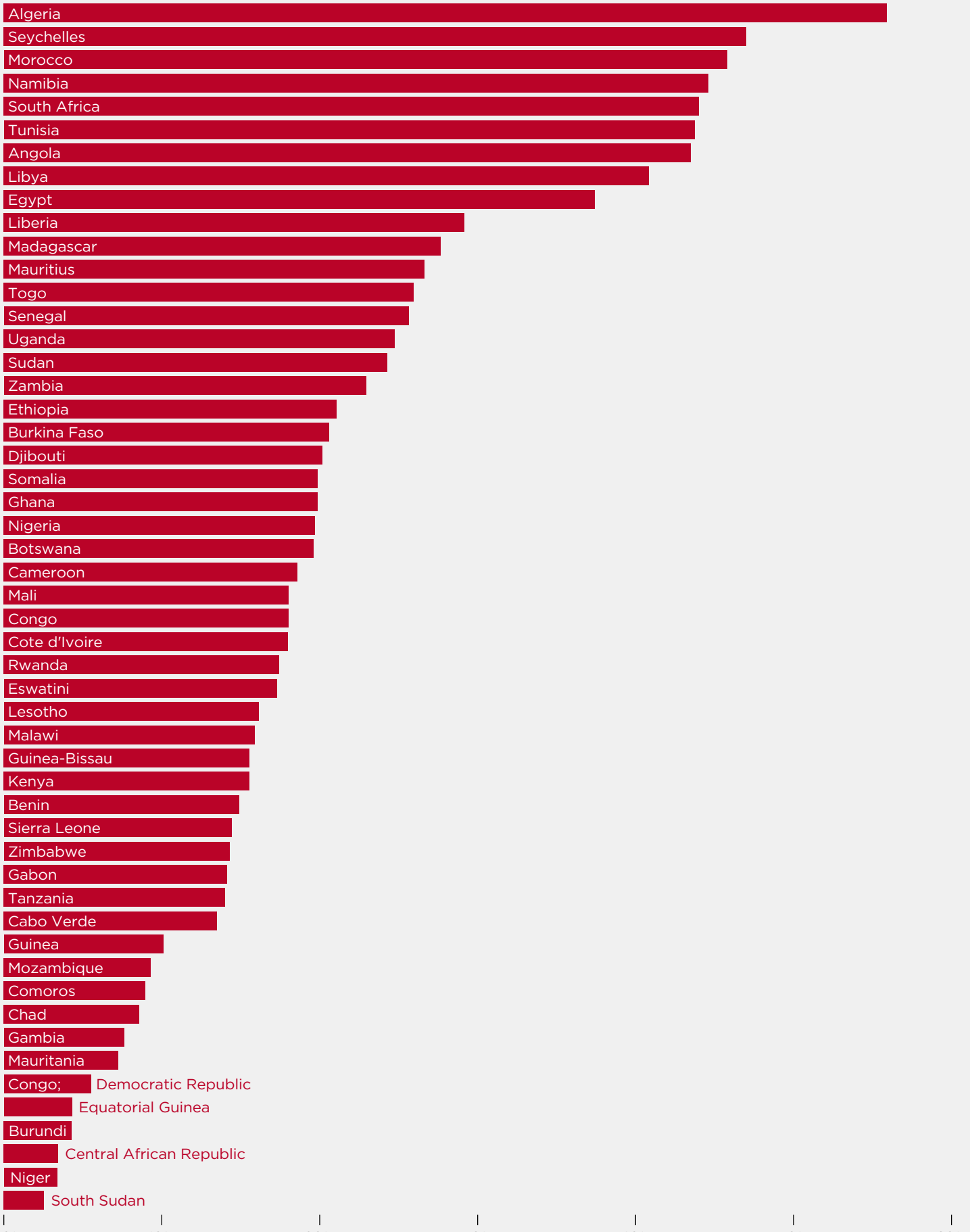
Sources: GSMA Intelligence, GSMA, ITU, SE4ALL, UN, ZookNIC, AppFigures, Ethnologue, World Bank, Tarifica, We Are Social

Basic indicators	Economic indicators	Market indicators	Enterprise indicators	Consumer indicators	Spectrum indicators
Region	GDP (real)	Total subscribers	IoT penetration	Affordability: ARPU/per capita	<1 GHz availability
GSMA Region	GDP growth rate (real)	Average download speed (Mbit/s)	Registered websites per 1000 people	Affordability: device ASP/GDP per capita	1–6 GHz availability
Population	GDP growth rate (constant)	Number of operators	Published apps per 1000 people	Literacy rate	>6 GHz availability
Population Density	GDP growth rate (PPP)	4G penetration	Population with tertiary education	Mobile social media accounts	
Urbanisation	GDP (real) per capita	Mobile connections penetration	Ease of doing business	Personal computer penetration	
		Smartphone penetration	Published apps in national language	FWA opportunity	
		Unique subscribers penetration	E-government availability		
		Fixed broadband penetration			
		Average ARPU (2017–2018)			
		FTTx penetration			
		ARPU Growth (2018–2023)			
		Internet backbone penetration			
		Mobile revenue growth/GDP growth			
		Electricity availability			

Figure A2

4G adoption in countries across Africa

Source: GSMA Intelligence



Data correct to September 2022

Glossary

3GPP	3rd Generation Partnership Project
5G NSA	5G non-standalone
5G SA	5G standalone
AfDB	African Development Bank
AGV	Automated guided vehicle
API	Application programming interface
AR	Augmented reality
ATU	African Telecommunications Union
BCA	Band and carrier aggregation
CBRS	Citizens Broadband Radio Service
CPE	Customer-premises equipment
DSS	Dynamic spectrum sharing
eMBB	Enhanced mobile broadband
EMF	Electromagnetic field
FTTH	Fibre to the home
FWA	Fixed wireless access
GDP	Gross domestic product
GHG	Greenhouse gas
ICNIRP	International Commission of Non-Ionizing Radiation Protection
ICT	Information and communications technology
ITU	International Telecommunications Union
LPWA	Low-power wide-area
LTE-M	Long-term evolution for machines
MIMO	Multiple-input multiple-output
MSMEs	Micro, small and medium-sized enterprises
NB-IoT	Narrowband IoT
NFV	Network functions virtualisation
NR	New radio
PPA	Power purchase agreement
RAN	Radio access network
RoW	Right of way
SDGs	Sustainable Development Goals
SDN	Software-defined networking
URLCC	Ultra-reliable low-latency communications
VAT	Value-added tax
VoLTE	Voice over LTE
VR	Virtual reality
WRC	World Radiocommunication Conference

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