6 GHz in the 5G Era

Global Insights on 5925-7125 MHz

July 2022

About the GSMA

The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry, and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

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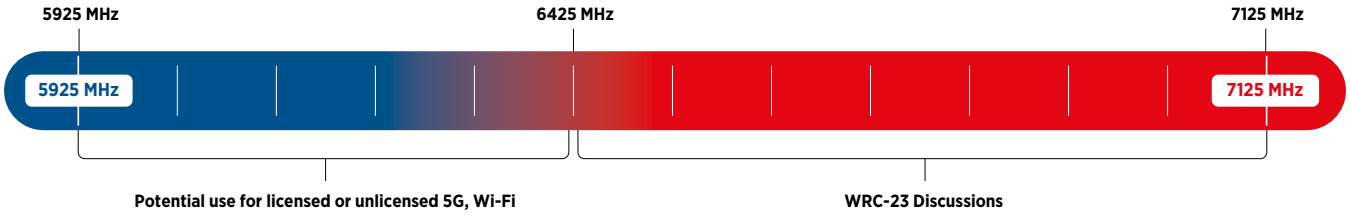
1. Summary

6 GHz 5G spectrum can play a central role in sustainable social and industrial development.

As enhanced broadband, IoT, data, analytics, and insight permeate every aspect of society, smartphones deliver connectivity into our work and play, and enterprises transition from manufacturing or commerce to also becoming industrial data platforms, mobile networks will require spectrum capacity plans that are integrated into a long-term vision of each nation's industrial future.

The race to net zero will be one of the most important features of the industrial landscape for decades to come and intelligent innovation and automation is now happening everywhere. Heavy industry and infrastructure must stay at the cutting edge of sustainable technology while enhanced consumer connectivity can enable smarter, cleaner ways of living.



5G equipment using 6 GHz is under development at network and chipset level and its support from a number of large markets already guarantees its scale. The upper 6 GHz band is now standardised as 3GPP band n104.

An average of 2 GHz of mid-band spectrum is required per market and there are few places in the world where mobile operators will have access to sufficient mid-band spectrum capacity unless the 6 GHz band is used. Constrained mid-band spectrum risks network densification, higher carbon emissions, increased capex and higher consumer tariffs. Without access to 6 GHz capacity, 5G networks will be slower and more expensive – consumers will pay more while commerce that relies on Industry 4.0 capabilities
of 5G will be less competitive. The benefits for the global economy and tax revenue that governments will receive from 5G will be lower.

The GSMA's study on the economic benefits of 5G[1] demonstrates that, by 2030, 5G can be responsible for 0.68% of global GDP. 5G's benefits are precisely linked to its access to spectrum to provide sufficient affordability and throughput to ensure services are accessible. Without enough mid-band spectrum, the 2030 GDP impact will be reduced to 0.42% of global GDP. 6 GHz 5G can prevent this economic loss.

The 6 GHz band is also being considered for licence-exempt access technologies such as Wi-Fi. The economic benefits of additional Wi-Fi spectrum are precisely tied to the capability of fixed line connectivity speeds. Analysis from GSMA Intelligence[2] shows that, on a global basis, the greatest socio-economic benefit from the 6 GHz band will be driven by using it fully for licensed 5G while fibre to the premises (FTTP) speeds remain under 10 Gbps. This speed should be compared to Cisco's predicted global average of 101 Mbps in 2023, meaning fibre speeds will need to increase 100 times beyond this to make any case for licence-exempt use of the 6 GHz band.

Until this point, Wi-Fi 6 and 7 requirements can be met with 2.4 GHz and 5 GHz capacity. Once FTTP speeds reach 10 Gbps (and assuming 60 GHz Wi-Fi spectrum is not used) Wi-Fi in the lower half of the 6 GHz band at 5925-6425 MHz becomes beneficial.

1 https://www.gsma.com/spectrum/resources/mid-band-5g-spectrum-benefits/

2 https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=72941571&file=160622-The-socioeconomic-benefits-of-the-6-GHz-band.pdf

2. GSMA Vision for the 6 GHz Band

Governments around the world need to make a carefully considered decision as to what the most efficient use of 6 GHz spectrum will be. It represents the largest remaining single block of mid-band spectrum that can be allocated to licensed mobile or unlicensed services in the foreseeable future.

6 GHz spectrum can ensure that affordable 5G capacity is available to drive industrial and economic competitiveness in the sustainable, digitised markets of the future.

The GSMA vision for the 6 GHz band states that:

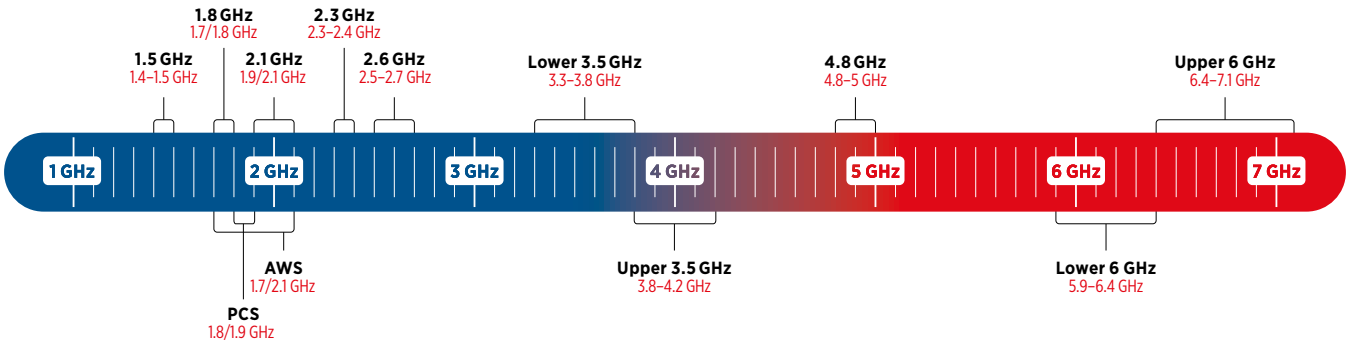
- **Mobile networks will need, on average, 2 GHz of mid-band spectrum per country by 2030. This is challenging to achieve without 6 GHz.**
- **6 GHz capacity will be required to meet increasing customer demand at the required speeds of ITU IMT-2020.**
- **Mobile networks are already highly densified, but 6 GHz can enable the growth of sustainable 5G capacity on existing sites.**
- **Timely availability of 6 GHz, at reasonable conditions and price, will drive cost-efficient network deployment, help lower the broadband usage gap and support digital inclusion.**

Therefore, according to market demand:

- **The GSMA recommends that at least 6425-7125 MHz is made available for licensed 5G by 2030.**
- **5925-6425 MHz should be considered for licensed 5G, or licence-exempt on a technology neutral basis.**

3. Mid-band spectrum

Global mid-band options



Globally, progress has been made in the use of the 3.5 GHz range as the 5G launch band. Around 80% of 5G launches are being made using this band and – today – this has the largest 5G device ecosystem linked to it.

Beyond 5G launches, government plans are not always clear. Some already have clearly defined plans to support 6 GHz capacity and there is also the anticipated development of 1500 MHz, possible development of 4.8 GHz, and potential refarming of the limited-capacity lower bands for 5G. However, these will not be sufficient to meet 5G demand by 2030.

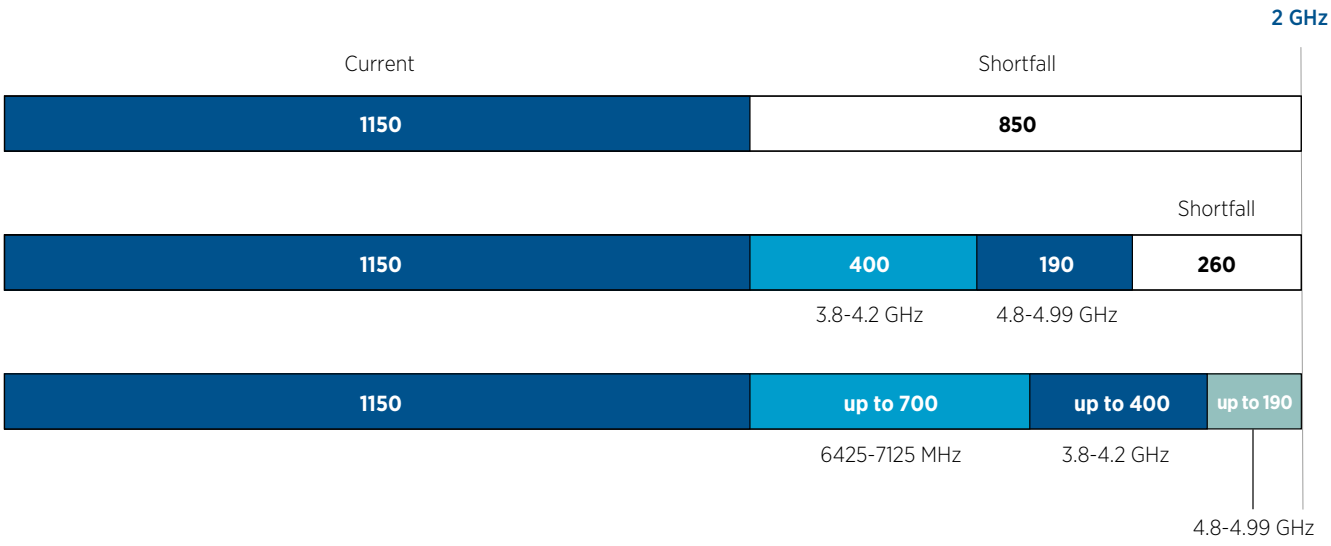
Network densification in some areas will be possible, including use of mmWaves. However, outside of the most densely populated hot-spots, additional mid-band spectrum combined with low and mmWave bands will be the only answer to avoiding densification and to bring affordable fibre-like FWA services, therefore benefiting everyone.

3.8-4.2 GHz is one option being considered by some countries. However, even with every other piece of mid-band spectrum currently being used it is not possible to get to the 2 GHz demand. Countries which empower their 5G infrastructure with the 700 MHz available in the upper 6 GHz band will have a clear advantage in terms of spectrum capacity. This raises the impact of 5G on their economies, will increase the agility of their industrial sectors and will enhance the productivity of 5G for their citizens.

Mid-band spectrum needs

Operator investment in every new frequency layer is significant, both through the acquisition of spectrum and subsequent network upgrades. Investing in a spectrum asset that can allow service to be developed affordably is important. Channel size is paramount, and harmonisation is also vital.

Around 650-750 MHz of mobile spectrum is typically available between 1-3 GHz and, in the more mature 5G markets, 4-500 MHz of 3.5 GHz spectrum usually supports city-wide 5G. This total of around 1150 MHz leaves a shortfall and while the size of this shortfall varies, there is work to be done in all cases to meet demand by 2030.



Assigning enough mid-band spectrum to meet the 2 GHz requirement is a challenge for governments and regulators all over the world and today only the most advanced markets are getting there. The use of the 6 GHz band for mobile presents a unique opportunity to meet spectrum needs because, even with all other harmonised mid-bands assigned, it is impossible to reach 2 GHz without it.

The table above shows how use of all the current 5G mid-bands leaves a shortfall of 850 MHz. Countries have already moved beyond this in their roadmap plans, through looking at the 3.8-4.2 GHz, 4.8-4.99 GHz or 6 GHz bands. The earliest adopter markets such all have plans to assign close to the 2 GHz figure.

4. Cost-Benefit Analysis of the 6 GHz Band

5G adoption continues to grow rapidly in pioneer markets, with the total number of connections set to reach 1 billion in 2022. 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 by mobile operators.

Meanwhile, a new wave of 5G rollouts in large middle-income markets (such as Brazil, Indonesia and India) could further incentivise the mass production of more affordable 5G devices. By the end of 2025, 5G will account for around a quarter of total mobile connections and more than two in five people around the world will live within reach of a 5G network.

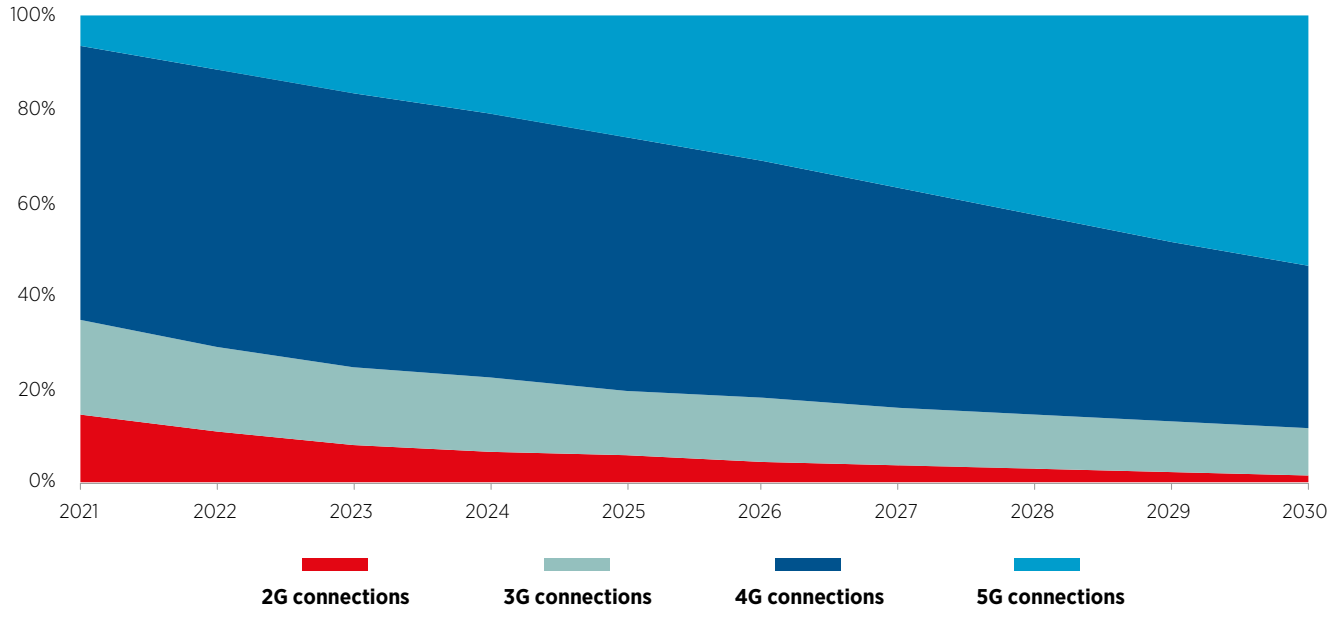
Vision for 2030

Over the course of the next decade, 5G will become the dominant mobile technology. At that point 5G will be at the height of its impact on our businesses, economies and lives, and consequently the greatest demand will be placed on mid-band spectrum.

GLOBAL 5G DATA

	2021	2025	2030
Unique mobile subscribers	5.3bn	5.8bn	6.2bn
% mobile internet subscribers	79.10%	85.77%	89.16%
% 5G connections	6.57%	25.9%	53.61%

GLOBAL TECHNOLOGY DEVELOPMENT 2018-2030



Wi-Fi-only approach will widen economic divide

Global analysis by GSMA Intelligence[3] shows that enabling only those consumers that have access to fibre while lowering the access to connectivity of those without fibre will widen the global connectivity and financial divide.

Globally, the link between a state's wealth and its fixed-line penetration is very clear meaning that Wi-Fi use of 6 GHz spectrum will benefit the wealthiest states the most. There is also, within countries, a direct link between the area of the country's wealth and its fibre penetration as well: the poorer the area, the lower the penetration. However, in all countries, assigning all of 6 GHz to Wi-Fi will damage 5G.

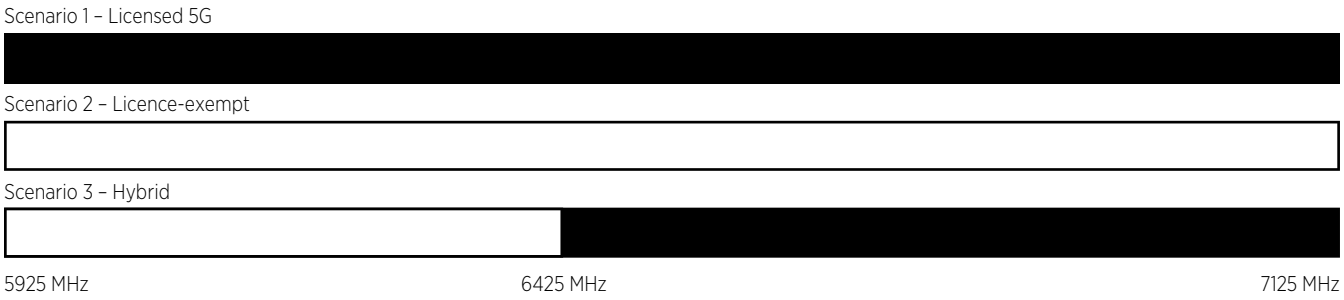
5G is at a crossroads. One road means that it will be restricted and constrained by limited spectrum assignment, and its economic value to the people of the world repressed.

The other road will see governments create a clear pathway towards assigning the resources required to enable 5G to flourish, drive business productivity and become a launchpad for industrial growth.

3 https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=72941571&file=160622-The-socioeconomic-benefits-of-the-6-GHz-band.pdf

GSMA Intelligence: socio-economic benefits of the 6 GHz band

A recent study by GSMA Intelligence outlines the economic benefits of allocating all of the 6 GHz band to licensed (Scenario 1); all of the 6 GHz band to unlicensed (Scenario 2); and the lower part of the band for unlicensed use and the upper part of the band for licensed (Scenario 3).



The study made two core findings:

- **For all countries studied the most benefit to society comes from assigning between 700-1200 MHz of 6 GHz spectrum to IMT.**
- **For all countries studied, there is never a scenario where the allocation of the full 6 GHz band to unlicensed use (Scenario 2) generates the greatest benefit to society.**

The capacity of a mobile network depends on the amount of spectrum that operators have access to – more spectrum enables greater throughput and higher data rates. If there is not enough spectrum to meet demand, then network congestion will reduce the quality of service experienced by the end user.

The goal for IMT 2020 – the ITU requirement for 5G – is of download speeds of 100 Mbps and upload speeds of 50 Mbps. This is part of the mobile industry's vision for connectivity this decade.

There is a direct correlation between a country's income level and its level of fixed broadband penetration and there is great discrepancy. While 46% of North Americans are forecast to have access to fixed download speeds of over 100 Mbps by 2023[4], only 2% of people in Latin America and Africa will have the same access. In Western Europe that figure is 22% and this is the figure averaged out across the country meaning that in the poorer areas, download speeds will in practice be far lower.

Increasing Wi-Fi access spectrum will not solve this divide. The capacity of a Wi-Fi network depends on the fixed broadband capability and only with sufficient fixed broadband speed is any additional unlicensed spectrum able to allow higher data rates.

As Cisco states in its annual internet report: "Wi-Fi speeds inherently depend on the quality of the broadband connection to the premises."

4 https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.pdf

Economic impact of 6 GHz scenarios

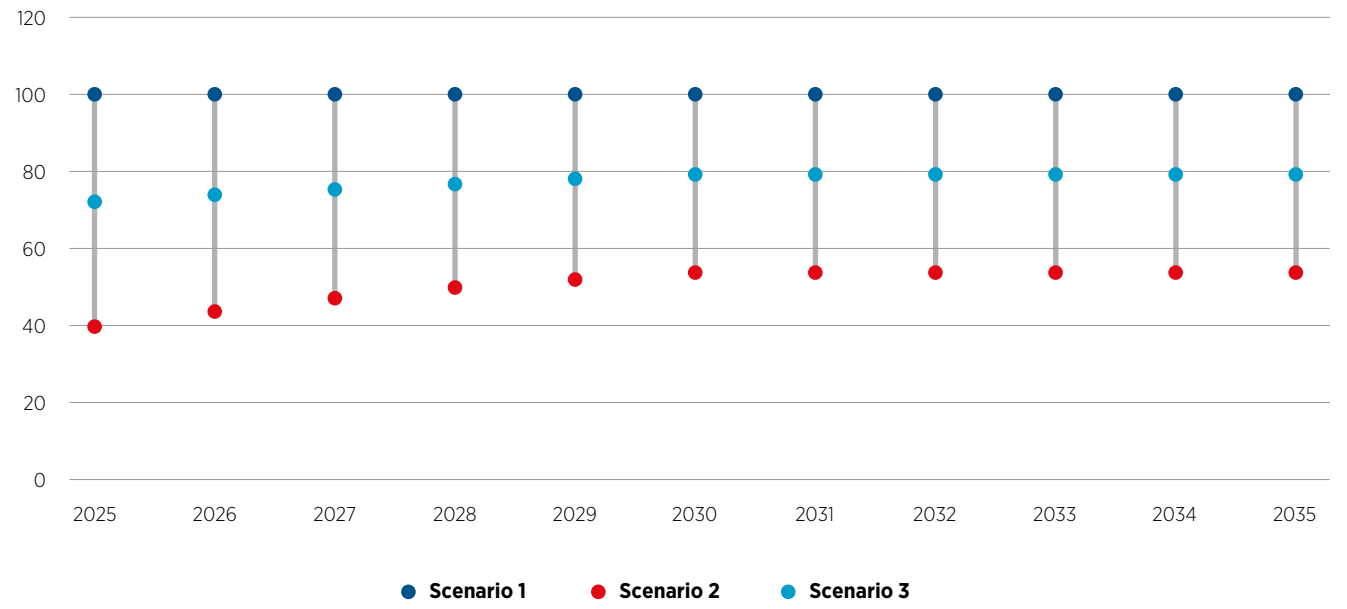
GSMA Intelligence looked at a total of 24 countries in its study of the benefits of 6 GHz spectrum. These vary according to levels a number of factors and full details of this are available in the report.

- There is no point at which having the full 6 GHz band available for licence-exempt / Wi-Fi technologies will bring the highest benefits.
- With FTTP speeds of 1 Gigabit per second or under, all countries benefit most from using the whole band for licensed 5G as these speeds are delivered by 2.4 GHz and 5 GHz Wi-Fi spectrum.
- However, some countries will benefit from the hybrid approach of using the lower part of the band for Wi-Fi and the upper part for 5G sooner than others, as shown in the data below.

5G speed reduction with constrained 6 GHz

The analysis also looked at the impact of reducing the availability of the 6 GHz band on average 5G download speeds. It found that under the full licence-exempt 'Scenario 2', 5G speeds would be constrained to around half their values if all 6 GHz is made available for licensed 5G. If the upper portion of the band is made available to 5G, average download speeds will reach around 80%.

AVERAGE DOWNLOAD SPEEDS IN SCENARIOS 1, 2 AND 3 (Mbps)

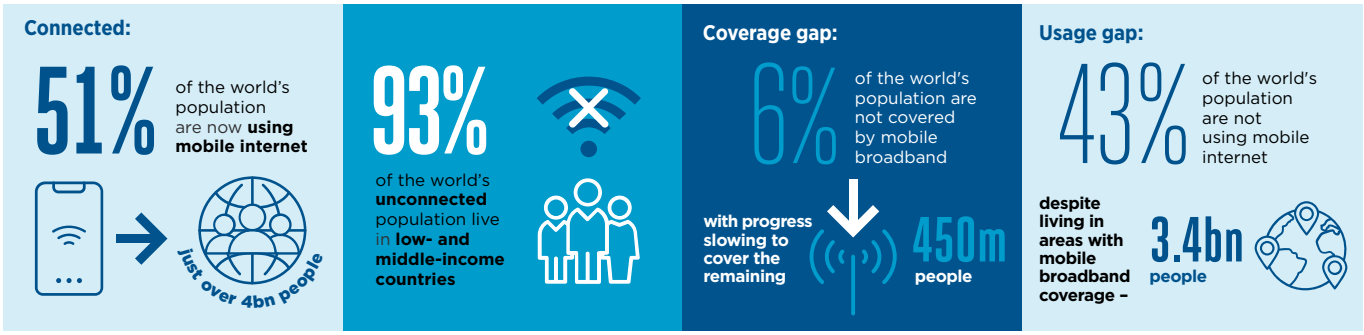


Source: GSMA Intelligence

5. Market Analysis

The GSMA releases figures each year explaining the factors behind non-adoption of mobile services. This looks at the main barriers to internet adoption and use and lays out analysis of:

- **The coverage gap – those who live outside mobile coverage and cannot receive service**
- **The usage gap – those who live within mobile coverage but nevertheless do not use it**



On a global basis, the coverage gap is 6% of the world's population but the usage gap of those who could potentially use mobile internet but do not is much higher. Globally, the usage gap is 43%.

There are two major causes of the usage gap. The first is digital literacy and skills while the second, which can be directly impacted through spectrum policy, is affordability. On a global basis, those without access to connectivity are not just poorer but are also less educated, meaning that lack of affordable connectivity can create a downward spiral and those most in need lack access to smart education and other services.

	Coverage gap	Connected	Usage gap
MENA	7%	45%	48%
Sub-Saharan Africa	19%	28%	53%
North America	1%	77%	22%
Europe and C. Asia	3%	72%	26%
LatAm	4%	56%	40%
E. Asia	2%	64%	34%
S. Asia	5%	34%	61%

Spectrum impact on network cost

Spectrum management has a direct impact on network density as wider channels mean fewer base stations. This in turn has an impact on the cost of rolling out networks and because of this, additional capacity has a direct economic impact on the cost of rolling out 5G services[5].

For example, studies for the 3.5 GHz band[6] showed that reduction in channel size from 100 MHz to 60 MHz created the need for 64% more base stations. Similarly, studies on 6 GHz show the impact of additional spectrum on affordability[7] including how additional spectrum in mid-bands will allow each cell site to support 3.5-6x more homes with 5G FWA.

Mid-band spectrum assignment has a direct impact on network capex. Combined with the right auction and licensing conditions, timely availability of mid-band spectrum will ensure networks can be planned in a cost-efficient manner and ensure 5G is used as widely as possible.

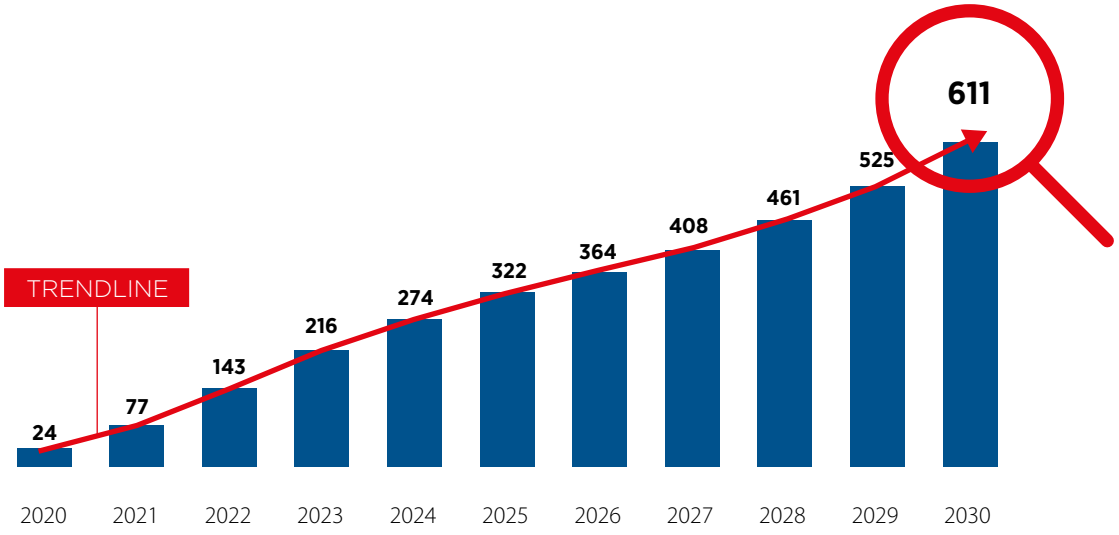
5 https://www.gsma.com/spectrum/wp-content/uploads/2021/03/3.5-GHz-for-5G-Economic-Benefits.pdf

6 https://cept.org/ecc/groups/ecc/ecc-pt1/client/meeting-documents/?flid=8609 ECC PT1(18)168 – Need for contiguous 100 MHz per operator, Huawei and Nokia

7 https://www.gsma.com/spectrum/wp-content/uploads/2021/07/5G-Mid-Band-Spectrum.pdf

6. Socio-Economic Benefits of Mid-Band Spectrum

Mid-band will be the driving force of 5G throughout the 2020s with continued economic impact beyond the end of the decade. The economic impact of mid-band 5G will continue to grow in middle-income countries into the 2030s.



Impact of constrained mid-band on GDP

However, the study also found that if mid-band spectrum was constrained to today's levels, the GDP benefit of 5G would reduce significantly. On a global basis the GDP impact of 5G in 2030 would reduce from $961bn (0.68% of global GDP) to $594bn (0.42% of GDP) without further assignment of harmonised mid-band spectrum in ranges such as 3.5 GHz and 6 GHz.

Optimal Scenario

$961bn

0.68% of GDP

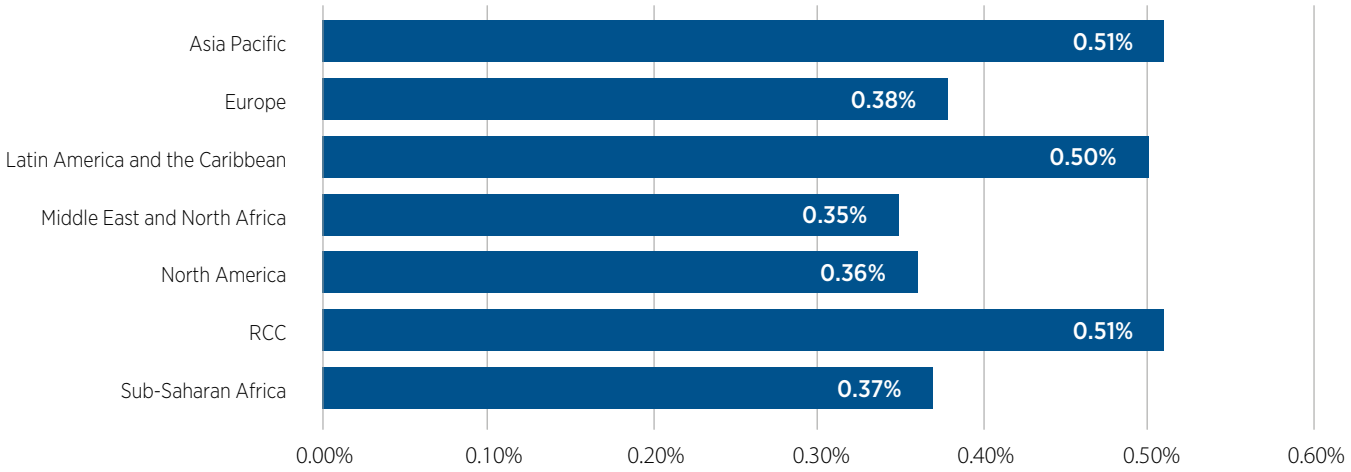
Constrained Scenario

$594bn

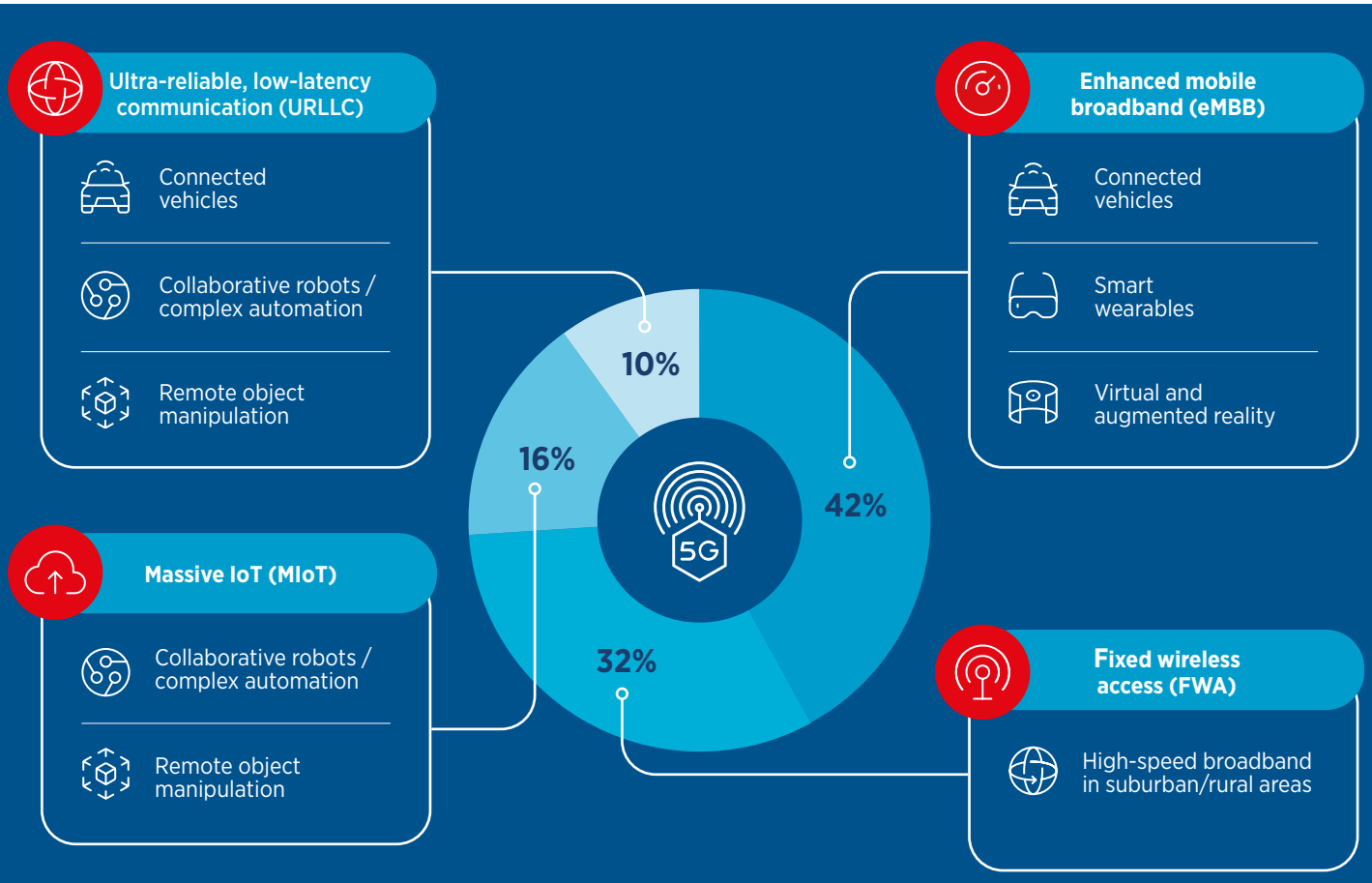
0.42% of GDP

Regional data

On a regional level, unconstrained 5G is expected to impact economies on an even basis as a percentage of GDP by 2030. Going into the 2030s, the 5G is likely to continue benefitting some of the middle-income regions of the world more than any other as by 2030 it will not have reached full maturity in some areas.



The economic impact of 5G on each economic sector will vary in different regions. However, each of the four main 5G use cases will have a global impact.



Source: GSMA Intelligence

7. Mid-Band Spectrum Needs of 5G

Global data

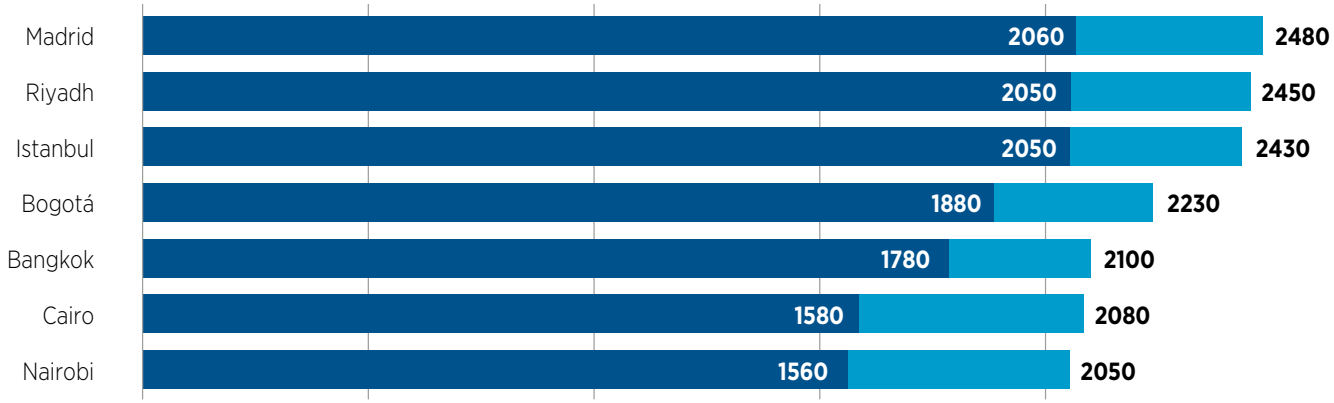
In mid-2021, the GSMA released a report analysing the spectrum needs of 5G by 2030[8]. This presents the GSMA's vision for how much mid-band spectrum mobile operators will require between 2025 and 2030 in order to meet ITU requirements of 100 Mbps DL and 50 Mbps UL in busy periods. The analysis looks at how much mid-band spectrum 5G networks will need for reliable high-speed mobile broadband services in heavily populated urban areas, including delivering FWA.

1. **Densely populated cities need, on average, a total of 2 GHz of mid-band spectrum.**
2. **IMT-2020 requirements will be at risk with less spectrum, and significantly more base stations would be needed without sufficient assignments.**
3. **Additional base stations will generate a carbon footprint 1.8-2.9x higher without sufficient spectrum.**
4. **Affordable fixed wireless access will raise demand. The additional spectrum in mid-bands will allow each cell site to support 3.5-6x more homes with 5G FWA.**

Mid-band needs

The global research analysed the mid-band spectrum needs for 5G in 36 large cities around the world. While factors vary including 5G uptake in the study period and the population density of the city, results were uniform.

GLOBAL SAMPLE OF CITIES STUDIED



8 https://www.gsma.com/spectrum/resources/5g-mid-band-spectrum-needs-vision-2030/

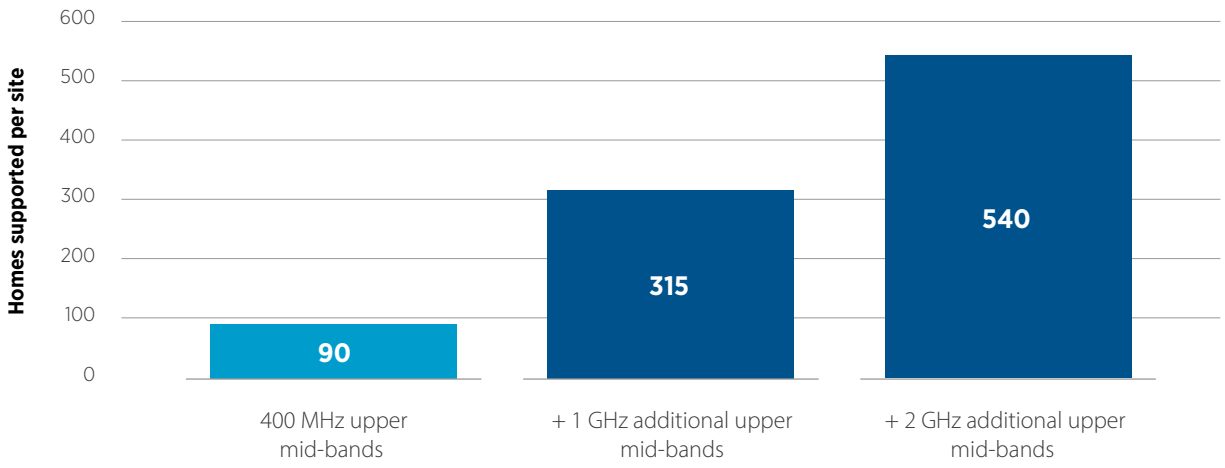
Affordable FWA in non-fibre environments

Many middle-income countries will use the capacity of 5G to provide FWA services to homes and businesses. This allows for vastly accelerated roll-out of high-speed internet compared with digging fibre and comes at a fraction of the cost. Affordable FWA connectivity will thus become an important driver in sustainable development and industrial competitiveness.

FWA connections typically place a much larger capacity burden on mobile networks than a smartphone. Homes or offices can have several concurrent users who often consume large amounts of video, including televisions. To show the economic impact of rolling out FWA in different environments, the GSMA's research analysed how many homes could receive 100 Mbps download and 50 Mbps upload speeds using a single 5G FWA cell site given different amounts of spectrum.

The analysis shows how making sufficient spectrum available for FWA can significantly lower capex in rolling out new services by lowering the need for network densification. Such an environment will create a virtuous circle where roll-out can accelerate, benefits increase as user-experienced data rates rise and as capex is lowered, consumer tariffs can drop.

GLOBAL SAMPLE OF CITIES STUDIED



Typical Mid-Band Mobile Spectrum

Band	Europe	CIS	MENA	SSA	Brazil	LatAm	N America	Japan	APT
1400	90		90	90	90	90		70	
1700						140	140		
1800	150	150	150	150	150			150	150
1850*						130	130		
2100	120	120	120	120	120			120	120
2300	100	100	100	100	100	100	100		100
2600	190	190	190	190	190	190	190	190	190
3300			100	100	100				
3400**	200	200	200	200	200	200	50	200	200
3600 <	200		200		100		390	500	
4800								100	

Total	Europe	CIS	MENA	SSA	Brazil	LatAm	N America	Japan	APT
1-3 GHz	650	560	650	650	650	650	560	530	560
3-6 GHz	400	200	500	300	400	200	440	800	200

* Figure given for extended PCS
** APT figure widely used, not universally harmonised

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