



Vision 2030

Insights for Mid-band Spectrum Needs

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Mid-band spectrum needs

Meeting mid-band spectrum needs is vital to 5G's future and requires forward-planning from policymakers.

Summary

The speed, reach and quality of 5G services depend on mobile operators having timely access to the right amount and type of affordable spectrum. Mid-band spectrum is especially important as it offers a good mixture of coverage and capacity for 5G.

This report presents the GSMA's vision for how much mid-band spectrum mobile operators will require between 2025 and 2030 and provides some options for operators to meet this demand. It includes an overview of research commissioned by the GSMA from Coleago Consulting¹ and helps policymakers understand how much 5G mid-band spectrum is required. It is designed to lay out a vision of how policymakers can make sure 5G reaches its full potential and maximise the socio-economic impact that it can deliver.

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. This spectrum will allow MNOs to provide Fixed Wireless Access with fibre-like speeds.

Commercial mobile operators can also support the needs of a wide variety of use cases from vertical sectors. Each vertical sector will generally have multiple different requirements (e.g., low latency, high throughput, long battery life, localised coverage, wide area coverage, etc). However, these differing requirements need different spectrum and network resources. MNOs are well placed to support such diverse requirements due to their expertise and wider spectrum assets.

The GSMA recommends that governments and regulators:

- Plan to make 2 GHz of mid-band spectrum available in the 2025-2030 time frame. This is the average value needed to guarantee the IMT-2020 requirements for 5G;
- Carefully consider 5G spectrum demands when 5G usage will be reaching its peak, and advanced use cases will carry additional needs;
- Base spectrum decisions on real-world factors including population density and extent of fibre rollout; and
- Support harmonised mid-band 5G spectrum (e.g., within the 3.5 GHz, 4.8 GHz and 6 GHz ranges) and facilitate technology upgrades in existing bands

¹ The full Coleago research report 'IMT spectrum demand: Estimating the mid-bands spectrum needs in the 2025-2030 timeframe' is available on the GSMA's website at <https://www.gsma.com/spectrum/5g-spectrum-guide/>



The research assesses how much spectrum is needed to deliver the ITU IMT-2020 requirements of reliable 100 Mbps end-user download speeds and 50 Mbps upload speeds based on population density metrics as its means of analysis. It excludes large commuting or tourist populations in some of the selected cities. Studying 36 cities in the 2025-2030 time frame shows that:



Densely populated cities need, on average, a total of 2 GHz of mid-band spectrum. Precise spectrum demands vary depending on population density, fibre availability and other factors. This means there is no simple correlation between a country's income level and its spectrum demand. However, additional spectrum is required beyond existing ITU, regional or national plans in all cases.

- **High income countries will require from 1320 MHz to 3630 MHz**
- **Upper middle income countries will require from 1020 MHz to 2870 MHz**
- **Lower middle income countries will require from 1320 MHz to 3020 MHz**



ITU-2020 requirements will be at risk with less spectrum, and significantly more base stations would be needed without sufficient assignments. Where densification is possible, the total cost of networks would be 3-5x higher over a ten-year period if there is a deficit of 800-1000 MHz. This equates to \$782mn-\$5.8bn in extra investment in each city.



Additional base stations will generate a carbon footprint 1.8-2.9x higher without sufficient spectrum. The additional network densification mentioned above would increase mobile network energy consumption in the cities by 1.8-2.9x, as well as in the manufacturing process. Importantly, such a high level of densification may not even be feasible for other reasons (such as too much interference, site availability, restrictive electromagnetic field rules). This can be avoided through the timely availability of the right spectrum.



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. This would create significant cost-savings in network roll-out and drive affordable connectivity in areas where other broadband solutions are not economically viable (e.g., where fibre is not widely available or remains limited to bigger cities).

WRC-23 is a crucial opportunity for mid-bands

With WRC-23 approaching, positive engagement on mid-band solutions for IMT will provide vital support to the harmonisation of spectrum and give clear technical guidance for regulators. Coordinated regional decisions will lead to a WRC which enables the future of 5G and supports wider broadband take-up by increasing capacity and reducing costs.

Section 1:

How much spectrum is needed in major cities between 2025 and 2030?

Delivering reliable high-speed mobile broadband services is a particular challenge in densely populated areas such as major cities. The large number of people in relatively small areas can easily over-burden the capacity of mobile networks. As a result, mobile networks' spectrum requirements are typically higher in these urban settings.

Coleago analysed how much spectrum is needed to meet key ITU targets for 5G (IMT- 2020) in 36 cities around the world in the 2025-2030 timeframe. At this time, 5G take-up is expected to be significantly higher than today. The analysis calculates how much spectrum is needed to reliably deliver 100 Mbps download speeds and 50 Mbps upload speeds to end users.

The Coleago analysis found that the amount of spectrum needed depended on a number of factors. These included:

- Population density (excluding temporary population);
- Predicted amount of available spectrum by 2025;
- Geographical separation of base stations (inter-site distance);
- 5G technology used in every band, with MIMO upgrades and both outdoors small and macro cells;
- Percentage of high-band, indoor small cells and Wi-Fi offload; and
- Cellular network activity factor.

Activity Factor

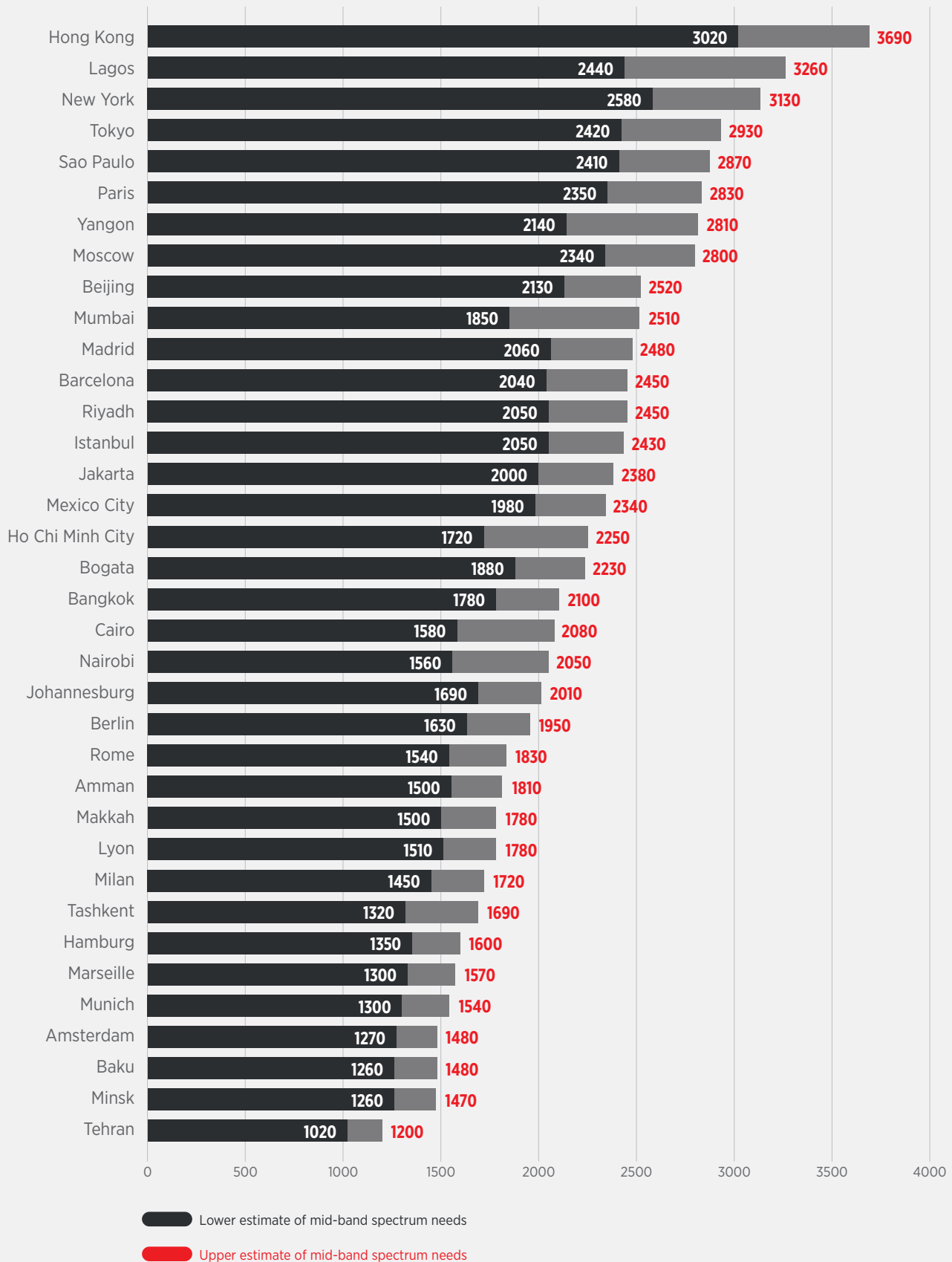
The activity factor is an assumption surrounding what percentage of human and machine connections require the 100 Mbps download and 50 Mbps upload connection at any one time during the busiest hours. This varies depending on 5G usage levels and is likely to be greater in higher-income markets initially, growing in time in every market, based on both mobile and FWA requirements.

Table 1 (below) shows, as a range, the total amount of spectrum that is predicted to be needed in each city based on assumptions for the network activity factor and high-band offload. It shows that additional spectrum is needed in every city and that, on average, a total of 2 GHz in mid-bands will be required. While the amount of additional spectrum is lower in some markets and/or less populated cities, it is important to note that the amount required is still far greater than what is currently planned for release. This begs the question: where are policymakers going to find the right amount of mid-band spectrum?

The activity factor is expected to rise over time and thus the projected amount of spectrum will rise as well. This is likely as 5G usage growth is driven by smart cities, including intelligent transport and connected video cameras, and by consumers and businesses for mobile use and for FWA.



Table 1:

Total mid-band spectrum needed for 5G in the 2025-2030 time frame



Cost of densification

If there is a shortfall in the amount of spectrum available, where possible, mobile operators will be required to densify their networks by deploying more small cells. However, this imposes additional costs, which are ultimately borne by mobile operators' customers. Such a densification may not even be feasible for other reasons (e.g., interference

scenario, site availability, restrictive electromagnetic field rules), while large numbers of cells will also increase the overall power consumption (see table 2) as well as having an aesthetical impact. Coleago calculated the environmental impacts for three cities assuming a conservative spectrum shortfall of 800-1000 MHz.

Table 2:

Financial and environmental costs in three cities with an 800-1000 MHz spectrum shortfall

City	# of additional small cells	Cost of additional cells over 10 years	Relative increase in total network costs	Increase in network power consumption
Paris	27,505	\$782mn	3x	1.8x
Mumbai	195,785	\$5bn	4.3x	2.9x
Mexico City	178,236	\$5.8bn	4.9x	2.5x

Densification alone will not solve the lack of spectrum and high levels of densification would not be physically possible in some of these cities.

On top of this, after a certain level of densification, interference between sites would also trigger the need for additional spectrum.

Section 2:

How much mid-band spectrum is needed for Fixed Wireless Access?

5G delivers broadband FWA with fibre-like speeds, but at a fraction of the deployment cost. This can have a profound impact in areas with limited access to high-speed fibre.

Mid-band spectrum is well equipped to provide 5G FWA in population clusters such as towns and smaller urban areas, especially where other options are expensive or unavailable. Mid-bands complement lower bands (e.g. sub-1 GHz), which are useful for rural and remote areas where populations are more spread out, and mmWave bands, which can provide access in more densely populated areas with the very fastest 5G speeds.

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, Coleago 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 (see figure 1). They found a single 5G mid-band cell site could cover local population clusters of 540 households, which equate to a small town or village.

Coleago then applied these findings to assess the cost of extending broadband rollouts in India and Europe and compared these with the fibre alternatives. The model assumed a higher 'activity factor' (50% rather than 10-25%) to represent the heavier usage of FWA connections.

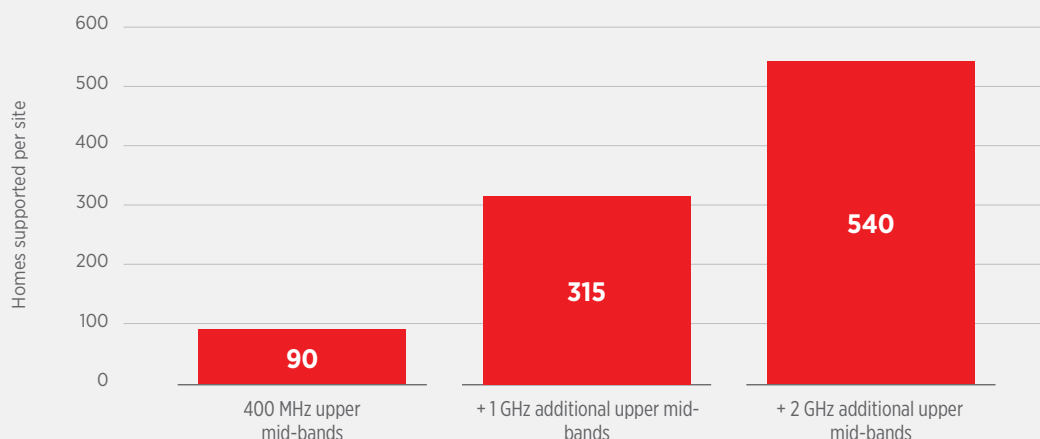
They found that meeting the proposed 5G spectrum needs in mid-bands allows a 5G cell site to support 3.5-6x more households when adding 1 GHz and 2 GHz to a standard 400 MHz upper mid-band spectrum baseline.

This dramatically improves the business case for these services and thus the ability to widen broadband access through affordable FWA 5G.

In India the cost of covering rural towns using 5G FWA was found to \$9.8bn less than using fibre. In Europe, the savings were €42bn.

Figure 1:

Number of households supported per mid-band cell site with different amounts of spectrum





Section 3:

MNOs can meet vertical needs with licensed mid-band spectrum

5G can have a profound impact on vertical sectors. It is designed to meet ambitious requirements in terms of speed, latency, security, and support for connected machines and sensors. Alongside small cells, network slicing, IoT, cloud computing, machine learning and robotics, the stage is set for what has been dubbed 'industry 4.0'.

However, network provision for vertical sectors spectrum needs to be carried out in a spectrally efficient way and set-asides for private networks can have a damaging effect. Limiting the amount of spectrum available to MNOs makes it harder to deliver on 5G targets and creates artificial scarcity,

leading to high auction prices. Higher auction prices are strongly linked to reduced network investment and thus slower rollouts, worse coverage and slower data speeds.²

Each vertical sector will generally have multiple different requirements including low latency, high throughput, long-battery life, localised coverage, wide area coverage, and others. However, these differing requirements need different spectrum and network resources. MNOs are well placed to support such diverse requirements due to their wider spectrum assets and broad expertise.

² Read more about the impact of high spectrum prices at: <https://www.gsma.com/spectrum/resources/effective-spectrum-pricing/>

Section 4:

How to meet the demand

Meeting the 5G spectrum demand in the 2025-2030 time frame will be challenging and policymakers must already consider the best options for inclusion in their digital connectivity plans and spectrum roadmaps. Mid-bands, which offer a good mixture of coverage and capacity benefits, should be at the core of this effort.

The majority of the first commercial 5G networks are relying on spectrum within the 3.3-3.8 GHz range. Other bands which may be assigned to, or re-farmed by, operators for 5G include 1.5 GHz, 1.8 GHz, 2.1 GHz,

2.3 GHz and 2.6 GHz. These are still not available in all countries. More spectrum will be needed to maintain 5G quality of service and meet growing demand in the longer term (e.g., 3.3-4.2 GHz, 4.8 GHz and 6 GHz).

However, the number of options may be limited in some countries due to incumbent services or decision making that does not fully consider 5G needs (i.e parts of prime 5G spectrum set-aside).The demand for mid-band spectrum will be addressed from the following ranges:

Figure 2:

Lower Mid-Band Spectrum

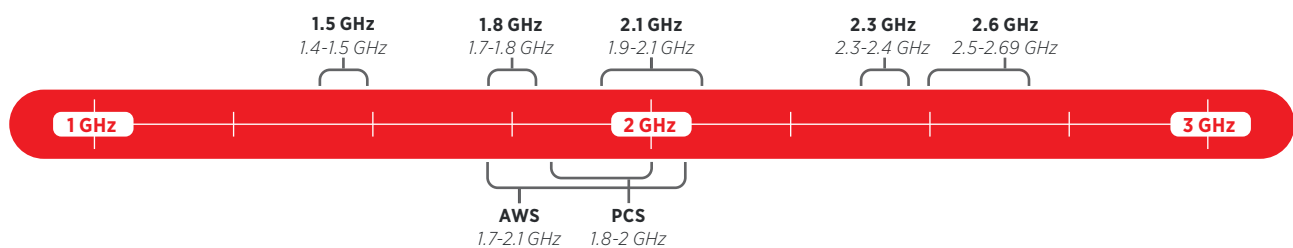
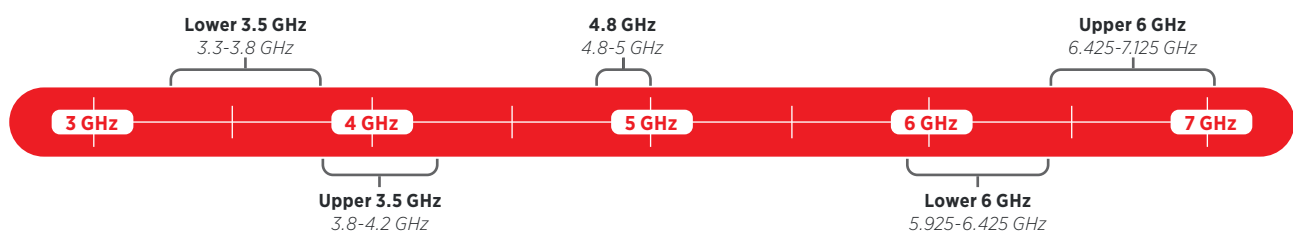


Figure 3:

Upper Mid-Band Spectrum



Lower mid-band spectrum

1.5 GHz	1427-1518 MHz
1.8 GHz	1710-1785 x 1805-1880 MHz
PCS	1850-1910 x 1930-1990 MHz
AWS	1710-1780 x 2110-2180 MHz
2.1 GHz	1920-1980 x 2110-2170 MHz
2.3 GHz	2300-2400 MHz
2.6 GHz	2500-2690 MHz

Upper mid-band spectrum

Lower 3.5 GHz	3.3-3.8 GHz
Upper 3.5 GHz	3.8-4.2 GHz
4.8 GHz	4.8-5 GHz
Lower 6 GHz	5.925-6.425 GHz
Upper 6 GHz	6.425-7.125 GHz



Section 5:

Conclusions and recommendations

The analysis shows a spectrum demand for, on average, a total of 2 GHz of mid-band spectrum will be required to support the growth of 5G in the 2025-2030 time frame. Specifically, it shows a requirement of 1320 MHz to 3630 MHz in high income countries, from 1020 MHz to 2870 MHz in upper middle income countries, and from 1320 MHz to 3020 MHz in lower middle income countries. Without it, there is a risk 5G networks in busier areas will not deliver on the goal of reliable 100 Mbps download speeds.

Network densification alone will not be enough to compensate for this shortfall. The significant rise in number of cell sites will raise emissions and cost while reducing levels of 5G investment. In some urban areas, densification will not be possible due to interference issues and, therefore, additional spectrum will be needed despite the densification.

The use of 5G to provide FWA creates a stronger demand on capacity and spectrum, especially where widespread fibre rollouts are lower and unlikely to be a cost-effective means of achieving broadband targets. FWA can also be used in remote towns and smaller urban areas in higher-income markets, where the cost of fibre can be prohibitive.

This analysis of spectrum demand shows a strong business case that will lead to extensive deployments and benefit all sectors of society if the right amount of spectrum is made available.

Against this background there are a range of factors which regulators should consider. The GSMA highlights its principal policy considerations in greater detail in its 5G spectrum position paper³, but relevant recommendations are:

- 1. Carefully consider national 5G spectrum demands in the 2025-2030 timeframe, when 5G usage will be much higher, and plan to make 2 GHz of mid-band spectrum available.** Failure to do so will make it impractical to deliver on the full characteristics of 5G (IMT-2020).
- 2. Governments and regulators should support prime 5G mid-bands (e.g., 3.3-4.2 GHz, 4.8 GHz and 6 GHz), including on the international stage at WRC-23.** Major decisions will be made surrounding additional 5G spectrum in the coming years that will be pivotal in addressing the identified shortfall, while spectrum harmonisation remains important. Decisions on the future of the 6 GHz range should safeguard the band for 5G in advance of WRC-23.
- 3. Access to spectrum is required in a timely manner.** Policymakers should consult the mobile operators in planning their roadmap for low-, mid- and high-bands. Greater certainty for operators will allow them to undertake mid- and long-term investment planning when rolling out networks and deploying new services. This will mean that they can bring new technologies and use cases to market sooner.

³ See '5G Spectrum - GSMA Public Policy Position' on the GSMA's website

4. Failure to award sufficient spectrum capacity to operators through national licences risks inflating spectrum prices and harming investment in 5G. Insufficient spectrum clearing or excessive set-asides for vertical, local or shared usage can contribute to this.

There has already been a significant variation in the amount of 5G spectrum awarded and awards where spectrum is scarce are associated with higher prices. High spectrum prices have been shown to reduce network investment and thus produce lower coverage, slower rollouts and slower mobile broadband speeds.

5. Governments and regulators should make available mid-band spectrum under technology neutral licences to allow existing 3G and 4G spectrum to be upgraded for 5G services.

MNOs will make use of all existing resources to minimise the need for higher spectrum demand. However, not all 4G spectrum will be re-farmed by 2030 as 5G take up will not have reached 100%. Some mid-band spectrum will remain in use for 4G for in the mid-term.

6. Regulators should be mindful that spectrum is also needed for 5G in high-bands (e.g., mmWave) to support ultra-high speeds and very dense human/machine usage.

Some 5G use cases cannot be met in mid- and low-bands. This includes the fastest Gbps speeds and support of the ITU high traffic density target of 10 Mbps per square metre. Such traffic density may be needed in hotspots such as busy train stations. The analysis shows how spectrum needs for mid-band is supported by the use of high-bands.

7. Spectrum is also needed in low bands (i.e., below 1 GHz) to support wide-area capacity, indoor use and across urban, suburban and rural areas, as well as for IoT.

Lower bands are needed for rapid wide area mobile broadband rollouts including in rural areas where the digital divide is largest and deep inside buildings to support connected machines for IoT.



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