

GSMA™

Intelligence

Spectrum Navigator Quarterly Research Series

Spectrum for Mobile, Q4 2020: Auctions, mmWave and sharing gain momentum

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This quarterly series leverages the GSMA Intelligence Spectrum Navigator tool to identify key trends and insights.

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Spectrum for 5G

Strong quarter for spectrum assignments in Europe

Five countries assigned 5G spectrum in Q4 2020, of which four were from Europe. There was also good progress in low bands, as three European countries awarded spectrum in the 700 MHz band. This is noteworthy because Europe is lagging in this particular band – more than half of the EU countries missed the EC deadline of assigning spectrum in 700 MHz band by the end of 2020.

mmWave is slowly getting more attention

Greece assigned 26 GHz spectrum, making it the fourth country in Europe and the 11th worldwide to award mmWave bands for 5G. Although some operators have indicated a lack of immediate interest in mmWave spectrum (e.g. Polish and Czech operators expressed no interest in 26 GHz spectrum before 2022), assignments of mmWave spectrum will grow as 5G rollouts and adoption gain momentum and mmWave gets more attention within the wider mobile ecosystem. Indeed, the recent iPhone 12 series launched in the US taps into mmWave spectrum, helping to drive traction for the use of this spectrum technology. At least five auctions in 2021 will include mmWave bands.

Spectrum for legacy networks

Lots of spectrum left in legacy bands

Spectrum for legacy network generations (2G, 3G and 4G) was awarded in eight countries in Q4 2020. It is interesting to see that six out of the eight countries obtained spectrum in the 1800 MHz and 2600 MHz bands (both important bands) for the first time. This is a significant time lag considering that the first auction for spectrum in the 2600 MHz band in Europe took place in 2007 (Norway). Delays in assignments affect both the timing of network rollouts and quality of service, as operators are required to refarm old spectrum or make use of the limited bandwidth available.

2100 MHz continues to be the most refarmed band for 5G

Six out of the 44 new 5G network launches in Q4 2020 were supported by spectrum in the 2100 MHz band. Because of delays in 'new' spectrum assignments for 5G, operators are refarming existing bands to support deployments. There are currently 16 confirmed 5G networks being supported by spectrum in the 2100 MHz band, making this the most commonly used legacy spectrum band for 5G.

Spectrum pricing

Significant 5G spectrum price variations

Prices paid by operators for 5G spectrum vary significantly by country due to a variety of factors. Recent developments in some large markets show that these differences are set to become even more extreme. Indian proposed reserve prices accounting for IND4.9 billion (\$65 million) per MHz of spectrum in the 3.5 GHz band are higher than most of the actual prices paid in other markets. And the US mid-band spectrum auction that started in December 2020 has exceeded all price predictions, which may affect the ability of operators to invest in upgrading mobile networks. For example, some US operators have announced they are seeking out funds to help with this spectrum acquisition.

4G spectrum price sets a new record

In Q4 2020, a new record was set for 4G spectrum price in the 2600 MHz band. Mobile operators in Egypt acquired long-awaited licences, having to pay \$1.17 billion for 80 MHz of spectrum. This is the equivalent of \$0.064 on a \$/MHz/pop/year (PPP) basis and represents a new record for spectrum in this frequency band. The scarcity of spectrum offered and high reserve prices are two factors that contributed to the high prices paid.

Spectrum regulation

Novel conditions continue to be imposed to cater for wider spectrum demand

Licence conditions set at the recent French auction imposed commitments on operators to provide customised solutions for vertical industry companies (i.e. slicing or tiered services by 2023) or to share/lease spectrum. In Germany, new assignments of mmWave spectrum will be based on a “use it or lose it” condition with reviews after one year. These recent developments reinforce the latest trend of variation and novelty in obligations attached to 5G spectrum licences. This means operators will face added pressure to comply with a variety of new or extended conditions

Local licensing continues to gather steam

In Q4 2020, Australia and Germany became the newest additions to the growing number of countries making spectrum available through local licences as opposed to on a national level (Japan and Hong Kong are other notable examples). Local licensing is seen as a way to support innovation in the wider mobile industry (as well as vertical industries) and enable new users to access spectrum in key bands through more localised licences.

New assignment models

Award models of new spectrum continue to be adjusted to aid longer-term goals

The French 5G auction adopted a new approach, which involved awarding a core chunk of the 3.5 GHz band to operators at a fixed price, auctioning the remainder. Mobile operators also had a mix of mandatory and optional obligations. This follows other recent shifts in award designs, such as the Austrian auction (aimed at securing network coverage) or the awards in the UAE and Qatar (where spectrum has been assigned with no upfront fee in return for coverage). These indicate that many more governments are now carefully considering wider economic goals rather than short-term monetary gains.

Assignments on a first-come, first-served basis in mmWave bands to gain traction

The German regulator has created an application process to allow the use of mmWave 5G spectrum on a first-come, first-served basis. Australia has adopted a similar approach. Because of its high bandwidth and low propagation characteristics, high-frequency spectrum will most likely be used, in the short term, in very localised deployments.

Other spectrum developments

Questions remain around the allocation of the 6 GHz band

Arguments have continued around licensed versus unlicensed use of the 6 GHz band. However, there was an important update to this in December. A set of regulators (in China, Egypt and Slovenia), together with mobile industry players and organisations (Telefónica, Ericsson, Huawei, Nokia, ETNO and the GSMA), delivered a public-facing joint statement centred around support for 6 GHz as a licensed band for 5G. While many markets still need to make their own decisions, this announcement is an important signal of what the industry is aligning towards.

OnGo Alliance (formerly CBRS Alliance) goes global

A recent announcement from the OnGo Alliance (formerly the CBRS Alliance) indicates that it is expanding its mission to enable 3GPP technology solutions in other shared spectrum bands and on a more global scale. Although the OnGo Alliance already knows how to build the ecosystem while solving technical and policy issues, its expansion to other territories could bring new challenges.

Five things to watch for: 2021 and beyond

1

Spectrum sharing on the rise – Before the 5G era, there was no significant use of shared spectrum, with exclusive licensing having been the main mechanism so far. However, interest in spectrum sharing is growing as the wider mobile ecosystem explores new network models (including private networks) and use cases. This is likely to continue in 2021 and beyond, since more regulators have to consider spectrum-sharing requirements or conditions as part of their new 5G spectrum assignment models, to cater for vertical needs.

2

New momentum for spectrum auctions – In 2021, a mix of 4G and 5G spectrum bands will be assigned in a few major markets, giving operators the opportunity to renew existing licences or acquire new spectrum: South Africa will assign long-awaited spectrum for 4G, a major breakthrough considering that assignment plans started in 2011; Canada will have its first 5G auction to assign key spectrum in the 3.5 GHz band; the UK will conduct a second 5G auction, releasing additional much-needed C-band and the entire 700 MHz band; and in Latin America, Brazil, Chile and Peru will see their first major 5G assignments.

3

mmWave deployments will increase value of spectrum – Assignments of spectrum in mmWave bands are likely to gain momentum as 5G rollouts and adoption make progress and the mmWave ecosystem matures. Twelve countries have already released mmWave spectrum for 5G, which is particularly remarkable given that mmWave spectrum was only internationally allocated to mobile services at the recent World Radiocommunication Conference in November 2019 (WRC-19). Deployments in mmWave spectrum, coupled with device developments, will increase the value of this spectrum band.

4

Spectrum refarming will fuel 5G deployments in developing markets – As developing markets enter the 5G era, spectrum availability will become crucial for operators that wish to deploy 5G networks and launch 5G commercial services. If governments in these countries are slow to act, operators will be required to explore ways of refarming existing spectrum bands to support deployments of new 5G networks.

5

Network sunsets will accelerate – 2021 is expected to be the year with the most 2G and 3G network sunsets ever. The rollout of 5G networks has led operators and regulators to step up plans to switch off legacy networks and refarm 2G and 3G spectrum for 4G and 5G. This will also allow operators to shift frequencies towards more spectral-efficient networks. By reducing the number of technologies maintained, operators should be able to lower running costs significantly, rationalise device portfolios and simplify tariff structures.

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5G spectrum state of play

- Market update** – New spectrum specifically earmarked for 5G has been assigned in 38 countries. Some other countries are in the process of assigning spectrum, bringing the total to 52.

	No. of countries (as of 31 Dec 2020)	Previous quarter (Q4 2020)
Assigned	38	5
Of which assigned and more planned	13	N/A
Planned	14	N/A

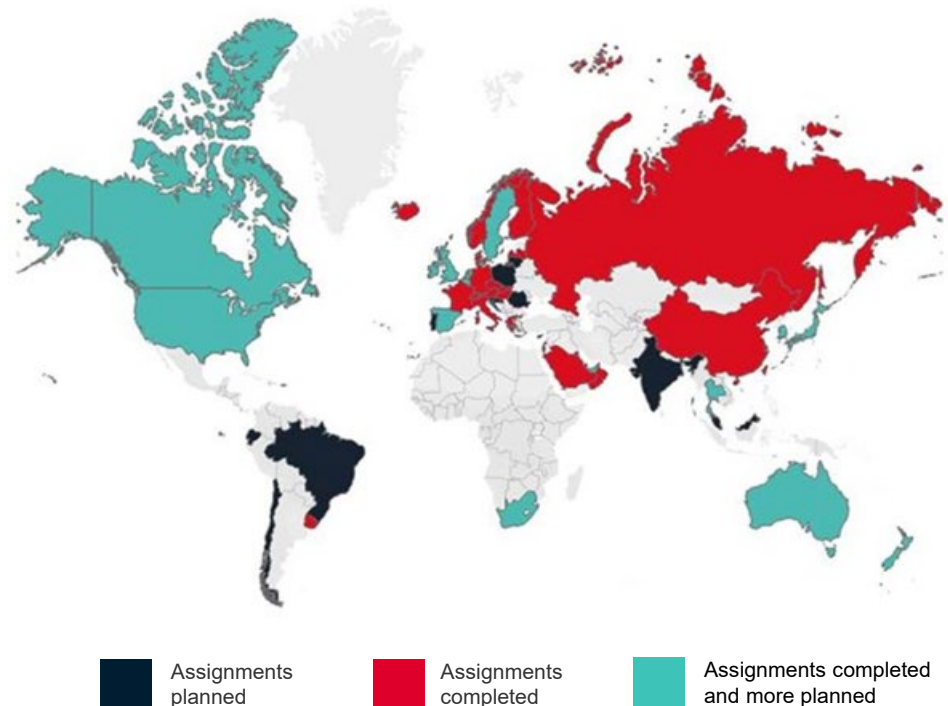
- Operator update** – 128 individual operators have received spectrum for 5G use across three key ranges of frequency bands. This is a 44% increase compared to 2019 despite challenges from Covid-19, a notable achievement.

	No. of operators (as of 31 Dec 2020)*	Previous quarter (Q4 2020)
Low band (<1 GHz)	48**	9
Mid-band (1–6 GHz)	99	12
High band (>6 GHz)	41**	5

* A range of operators have received spectrum for 5G in multiple bands.

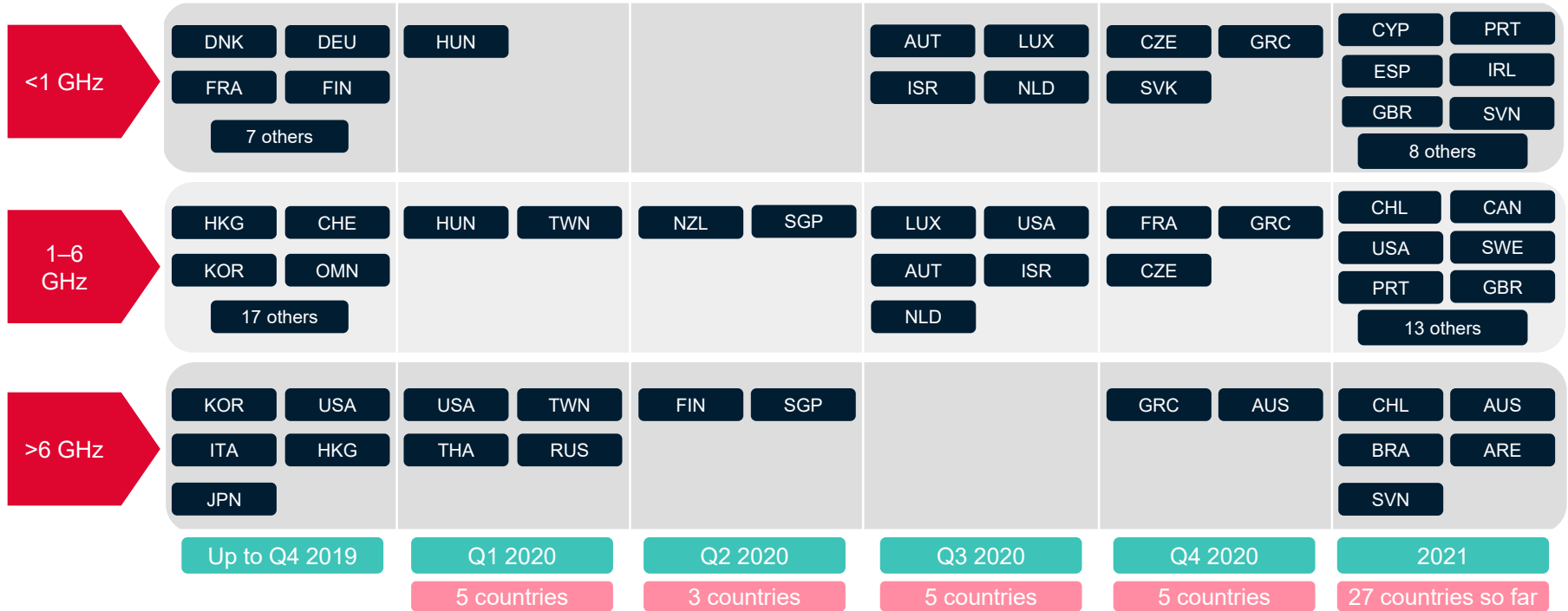
** Excluding US and Canadian regional operators/winners.

5G spectrum assignments



5G spectrum assignments pipeline

- Momentum is building** – After a slowdown in Q2 2020 (due to Covid-19 lockdowns), spectrum assignments accelerated in the second half of the year. In 2021, there will be new spectrum assignments across 27 countries, a significant increase compared to 2020. Other countries may make announcements throughout the year as 5G plans ramp up. Momentum will build, especially in Europe, where more 700 MHz band assignments are expected to take place. Largely confined to a few countries so far, mmWave will also gain traction in 2021 and beyond.



5G spectrum assignments in Q4 2020

- **Assignments gathering pace despite Covid-19 challenges** – Five auctions for 5G spectrum ended in Q4 2020, of which four were in Europe. Spectrum was assigned in the 700 MHz, 3.5 GHz and mmWave bands. Greece is now the fourth country in Europe to assign mmWave spectrum, after Italy, Russia and Finland. Assignments of the 700 MHz band in Europe are accelerating, as national governments are catching up on the missed European Commission (EC) deadline for 5G awards (December 2020).

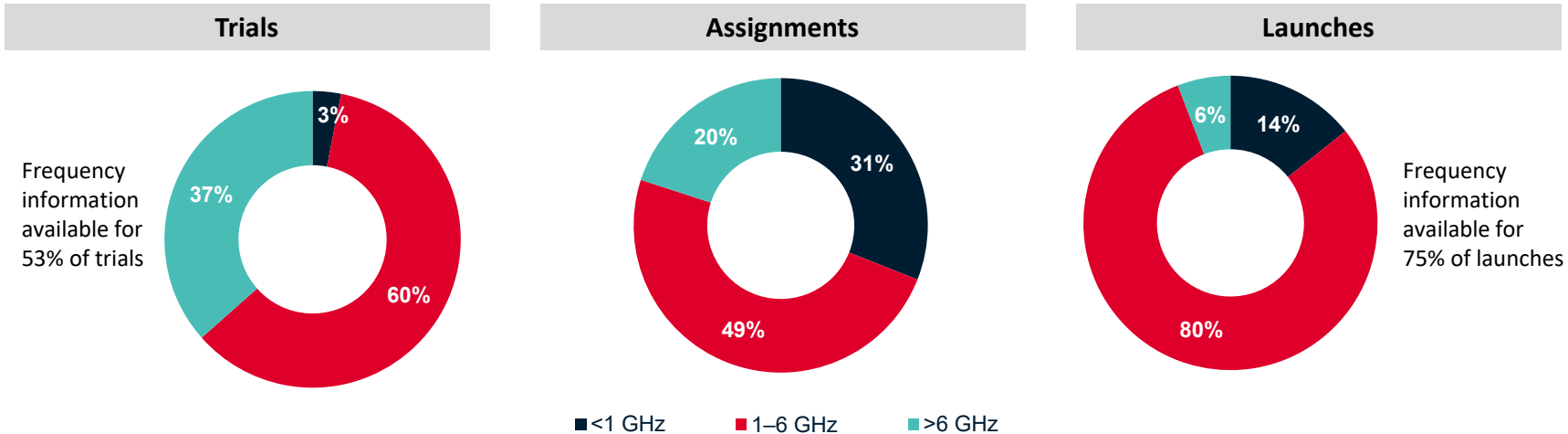
5G spectrum assignments in Q4 2020

Country	Date	Bands	Bandwidth	Upfront fees	\$/MHz/pop/year (PPP)	Number of winners
France	Oct 2020	3.5 GHz	310 MHz	\$3.3 billion	\$0.009	4 – Bouygues Telecom, Free Mobile, Orange, SFR
Czech	Nov 2020	700 MHz	60 MHz	\$178.4 million	\$0.033	5 – O2 (Telefónica), Vodafone, T-Mobile, CentroNet, Nordic Telecom
		3.5 GHz	200 MHz	\$71.8 million	\$0.005	
Slovakia	Nov 2020	700 MHz	60 MHz	\$116.5 million	\$0.031	3 – O2 (PPF), Slovak Telecom (Deutsche Telekom), Orange
Greece	Dec 2020	700 MHz	60 MHz	\$180.9 million	\$0.028	3 – Cosmote (OTE), Vodafone, Wind (Largo)
		3.5 GHz	390 MHz	\$117.5 million	\$0.003	
		26 GHz	1000 MHz	\$19.3 million	\$0.0002	
Australia	Dec 2020	26/28 GHz	Undisclosed	Undisclosed	N/A	15 – including Telstra and Optus

5G spectrum by band range

- **Trials** – 219 individual operators have conducted a total of 580 5G trials. Frequency information is available for 53% of these. The majority of trials have been conducted in mid-band spectrum (1–6 GHz). However, the overall number of trials in mmWave bands now exceeds 100, which shows the technology is reaching a more mature stage.
- **Assignments** – 128 individual operators across 38 markets have received 5G spectrum. Nearly half of the assignments were for mid-band spectrum. Of these, the vast majority were in the 3.5 GHz band. However, awards in 700 MHz picked up in the previous two quarters, especially in Europe.
- **Launches** – 145 individual operators have launched commercial 5G networks (mobile and/or FWA). The vast majority of 5G networks have been launched using mid-band spectrum. This comes as no surprise, as 3.5 GHz is the most frequently assigned band and it offers a better balance between coverage and capacity for current 5G use cases and deployment scenarios.

5G spectrum by band range



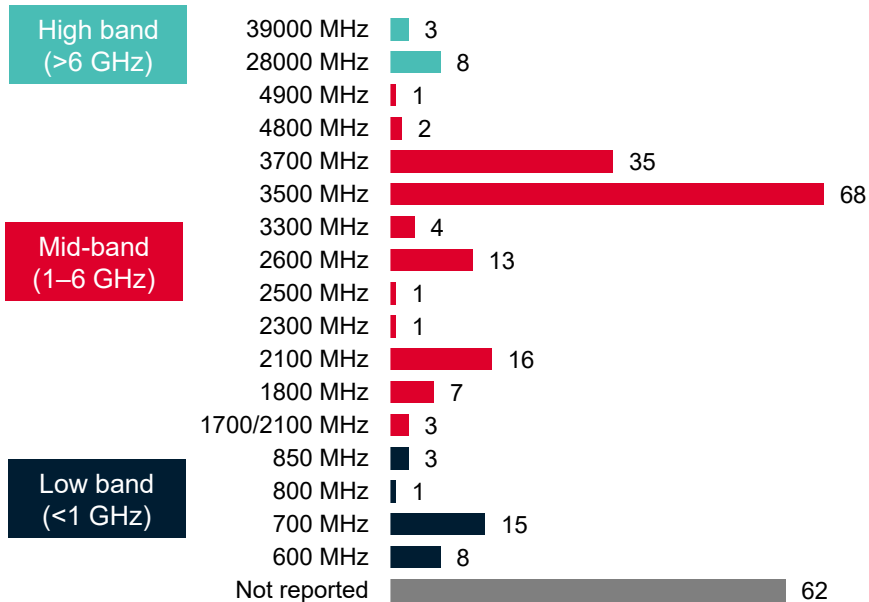
These figures refer to trials, assignments and launches, not to individual operators. A range of operators have trialled or launched their 5G networks on more than one frequency.

Source: GSMA Intelligence
Data correct to 31 December 2020

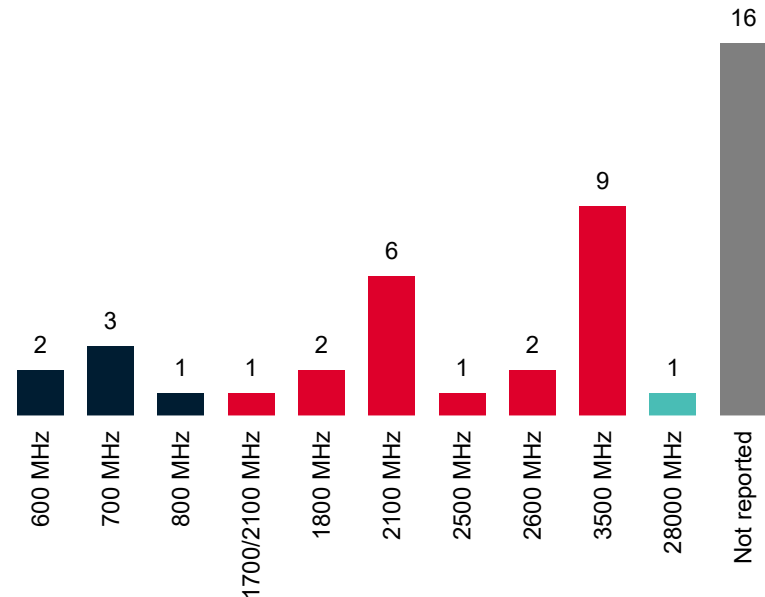
5G network launches by spectrum frequency

- 3.5 GHz band remains the main choice** – The 3.5 GHz band accounts for 36% of network launches (excluding frequencies not reported). However, as 5G spectrum has yet to be assigned in many markets, a number of operators are refarming existing bands for 5G deployments. So far, the 2100 MHz band appears to be the most refarmed legacy band, with 16 networks currently operating on this frequency.

5G network launches by spectrum frequency (up to Q4 2020)



5G network launches in Q4 2020



These figures refer to trials, assignments and launches, not to individual operators. A range of operators have trialled or launched their 5G networks on more than one frequency.

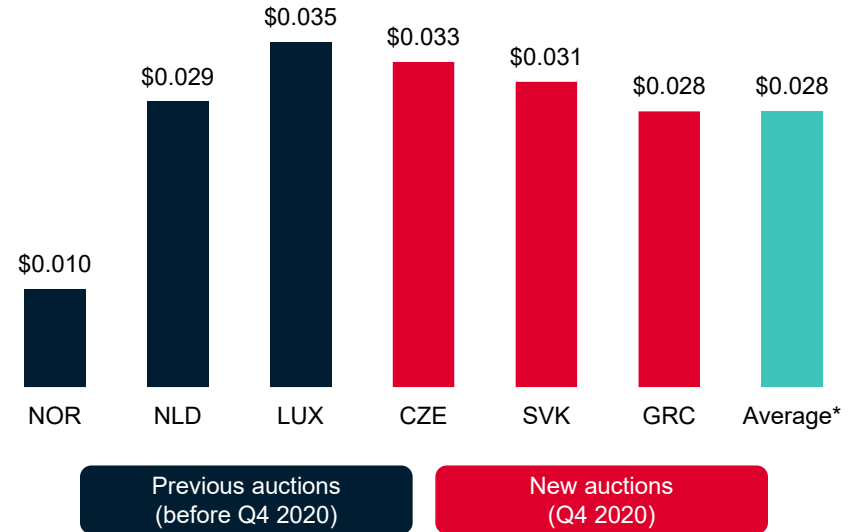
5G spectrum pricing: low band (<1 GHz)

- More countries on board** – As of 31 December 2020, a total of 19 countries have assigned spectrum in the 600 MHz and 700 MHz bands, earmarked for 5G. Although Europe as a region is leading the way in assigning 5G spectrum in low bands, progress within the EU-27 states has been slow, with 14 countries having missed the EC award deadline (December 2020).
- Price variations** – Analysis based on all the prices available for low-band 5G spectrum (pricing data is not available for some auctions) shows significant variation in the prices paid. This ranges from as low as \$0.003 (\$/MHz/pop/year (PPP)) in Iceland (2017) to as high as \$0.053 in Canada (2019), with an average of \$0.028.
- Understanding recent trends** – The most recent five auctions had a final price (\$/MHz/pop/year (PPP)) higher than the average of all 5G spectrum assignments for low band. But this was mostly due to high reserve prices. In fact, the final prices paid by winners have been, on average, only 2% higher than the reserve prices, confirming that reserve prices were set at high levels from the beginning.

5G spectrum pricing for low band (<1 GHz)

\$/MHz/pop/year (PPP)

Selected markets (previous six assignments)

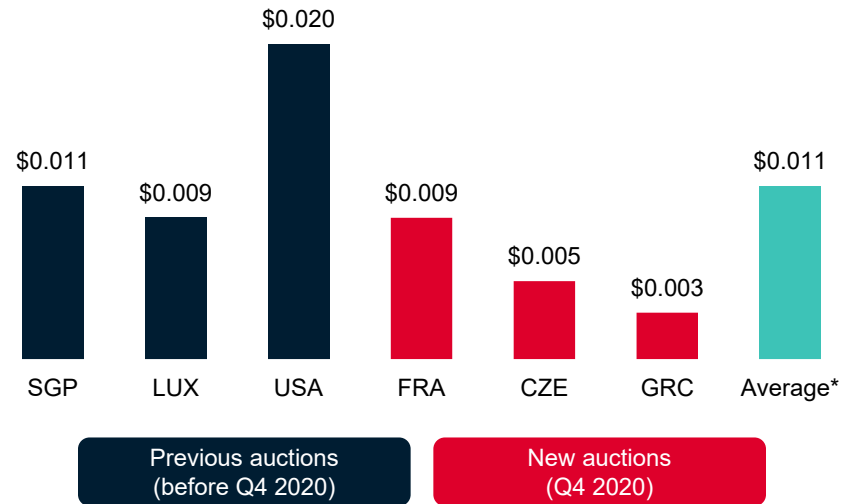


* Average of all 5G spectrum assignments for low band (<1 GHz). Calculated based on all prices available.

5G spectrum pricing: mid-band (3.5 GHz band)

- **The leading spectrum band range** – Most progress in awarding 5G spectrum has been made in mid-band spectrum. As of 31 December 2020, a total of 30 countries have assigned 5G spectrum in mid-bands.
- **3.5 GHz emerges as key band** – Out of the 38 countries that awarded 5G frequencies, 29 have assigned spectrum in the 3.5 GHz band, making this a critical band for 5G.
- **Price variations** – Variation in the price paid for the 3.5 GHz band is driven by the amount of spectrum made available and auction design. The highest prices (\$/MHz/pop/year (PPP)) paid for spectrum in the 3.5 GHz band have been in Taiwan (\$0.071), Italy (\$0.027) and South Korea (\$0.024). The small amount of spectrum being awarded in Italy and the disparity in lot sizes created artificial scarcity and pressure to win the two wider 80 MHz lots. In Taiwan, only 270 MHz of spectrum has been made available, meaning only two out of five operators could get the largest 100 MHz lots of spectrum.
- **Recent trends** – The CBRS spectrum auction in the US (August 2020) had a price (\$0.020) almost double the overall average C-band spectrum price (\$0.011). Despite the licence conditions (power limits, tiered access and protection for incumbent users) and the limited amount available (70 MHz), the price reflects the high demand for mid-band spectrum and the potential for private networks and 5G.

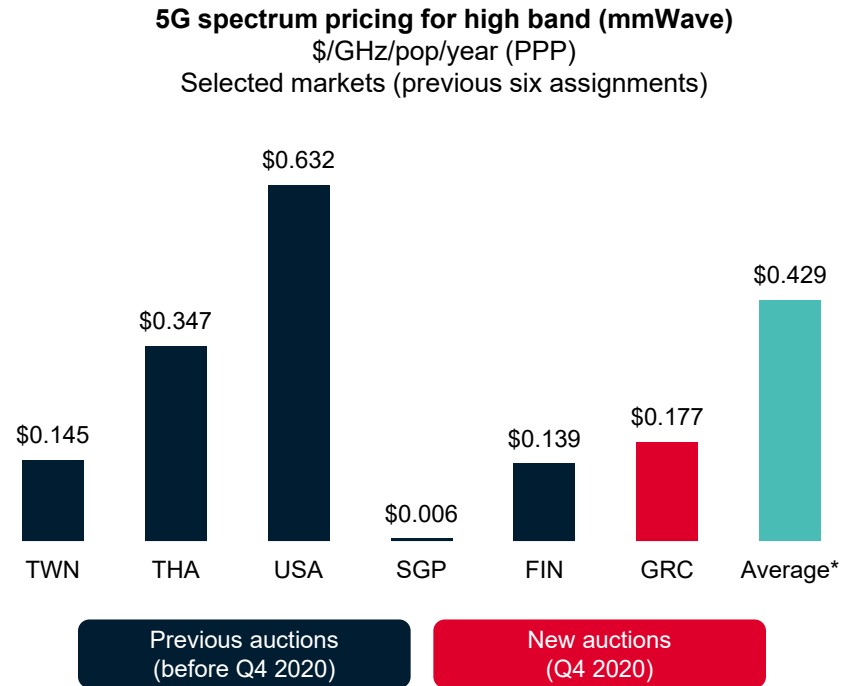
5G spectrum pricing for mid-band (3.5 GHz)
\$/MHz/pop/year (PPP)
Selected markets (previous six assignments)



* Average of all 5G spectrum assignments for mid-band (3.5 GHz). Calculated based on all prices available.

5G spectrum pricing: high band (>6 GHz)

- mmWave lags behind other bands** – In terms of 5G spectrum awards, progress in mmWave has been slower than other bands. As of 31 December 2020, only 12 countries had assigned spectrum in high bands. This is partly because this spectrum has only been allocated for IMT following WRC-19 (November 2019).
- Price variations** – Up to Q4 2020, prices for mmWave spectrum were available for 11 assignments in nine markets. There is significant variation in prices paid for spectrum. High reserve prices, overall amount of spectrum available and licence conditions are some of the factors that explain the high prices paid. Out of the 11 assignments analysed, the highest prices (\$/GHz/pop/year (PPP)) have been in South Korea in 2018 (\$1.177), the US in 2019 (\$1.008) and Thailand in 2020 (\$0.347). The prices paid in South Korea and Thailand can be explained by high reserve prices: in South Korea, high reserve prices are a historical trend; in Thailand, spectrum was sold at only 6% above the reserve. In the US, at the time of the mmWave auctions, no mid-band spectrum was available, making mmWave the only ‘new’ 5G spectrum on offer. Meanwhile, Singapore offered mmWave spectrum through a beauty contest with only 15% weightage on the offer upfront price, with operators ending up paying the lowest upfront fees (\$0.006).



* Average of all 5G spectrum assignments for high band (>6 GHz). Calculated based on all prices available.

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Spectrum for legacy networks: assignments pipeline

- **New assignments** – Assignments in Q4 2020 comprised both ‘new’ spectrum and previously assigned frequencies that came up for renewal. In a bid to increase competition, there has been a growing trend in recent years of regulators re-auctioning spectrum, as opposed to extending licences coming up for renewal. It seems that this trend will continue in 2021. Most of the new licences issued are either 4G or technology neutral, making this spectrum suitable for deployments of any network generation, including 5G.



Split of renewals versus new assignments applies only for historical data.

Spectrum assignments: previous quarter (Q4 2020)

- Q4 was the busiest quarter in 2020** – Eight countries assigned spectrum in Q4 2020. ‘New’ spectrum was assigned in Egypt, Mauritania, Sri Lanka, Trinidad and Tobago, Slovakia and Zambia, while assignments in Austria and Greece were for spectrum licences coming up for renewal. Of particular note is the award of spectrum in the 2600 MHz band in Egypt for the first time, with a total price of \$0.064 (\$/MHz/pop/year (PPP)), making this the most expensive assignment of spectrum in the 2600 MHz band.

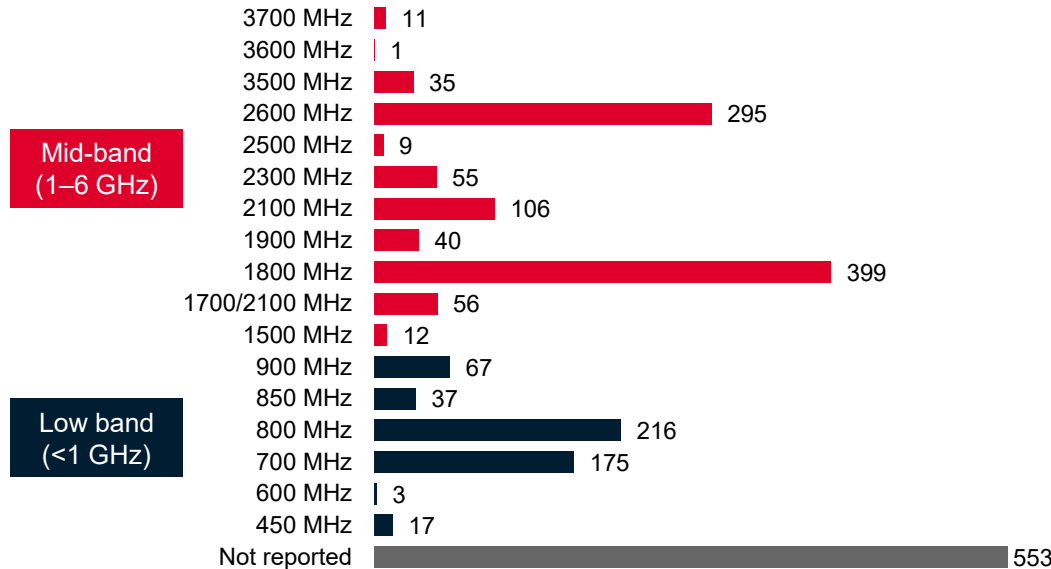
Spectrum assignments for previous network generations in Q4 2020

Country	Date	Bands	Bandwidth	Upfront fees	\$/MHz/pop/year (PPP)	Number of winners
Trinidad and Tobago	Oct 2020	700 MHz	20 MHz	Not available	N/A	1 - Digicel
Egypt	Oct 2020	2600 MHz	80 MHz	\$1,170 million	\$0.064	3 – Etisalat, Vodafone, We
Sri Lanka	Oct 2020	850 MHz	Not available	Not available	N/A	1 – Airtel (Bharti Airtel)
Mauritania	Nov 2020	1800 MHz	Not available	\$4.0 million	N/A	3 – Mauritel, Chinguitel, Mattel
Austria	Nov 2020	2100 MHz	120 MHz	Not available	N/A	3 - A1 Telecom, T-Mobile, 3
Slovakia	Nov 2020	900 MHz 1800 MHz	8 MHz 18 MHz	\$1.0 million \$2.0 million	\$0.008 \$0.007	3 – O2 (Telefónica), Swan Telecom, T-Mobile
Greece	Dec 2020	2100 MHz	120 MHz	\$126.2 million	\$0.010	3 – Cosmote, Vodafone, WIND
Zambia	Dec 2020	800 MHz	20 MHz	\$12.5 million	\$0.013	1 – Airtel

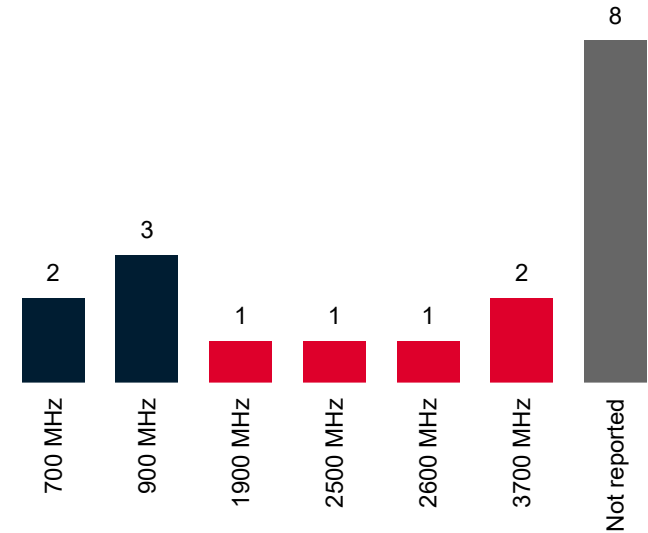
4G network launches by spectrum frequency

- **Don't forget 4G** – A total of 718 individual operators, accounting for 79% of global mobile operators, have launched commercial 4G services (mobile and/or FWA) as of 31 December 2020. The most common spectrum bands used to support 4G network launches are 1800 MHz and 2600 MHz, with nearly half of networks being launched using these bands. The majority of 4G launches in the second half of 2020 have been secondary launches, with operators focusing on improving coverage and network quality, either with advanced 4G launches or launches in additional frequency bands.

4G network launches by spectrum frequency (up to Q4 2020)



4G network launches in H2 2020



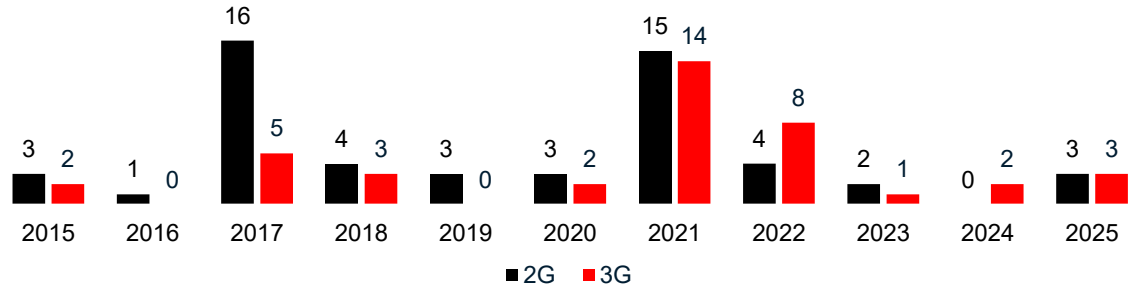
These figures refer to launches, not to individual operators. A range of operators have launched their 4G networks on more than one frequency.

Network sunsets

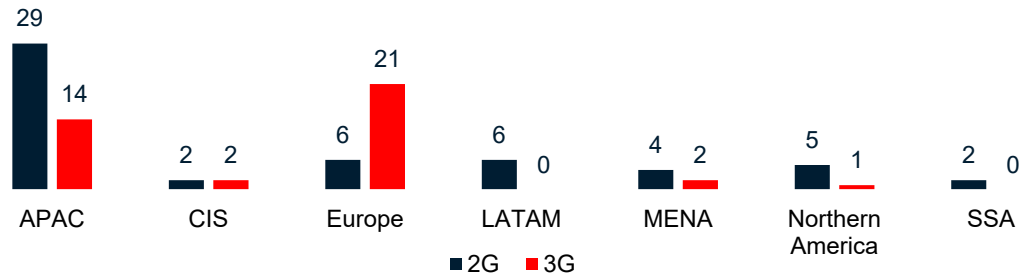
- On the rise** – In the past six years, a total of 42 networks have been shut down, of which 30 were 2G networks and 12 were 3G networks. The pace of shutdowns is likely to accelerate as operators seek to optimise their network operations and costs and refarm the spectrum for 4G and 5G. Based on operators’ announced plans, at least 52 networks will be shut down between 2021 and 2025, of which 24 will be 2G networks and 28 will be 3G networks.

- Regional variations** – The majority of sunsets in Asia Pacific will be 2G networks. Europe will have switched off significantly more 3G networks than 2G networks by the end of 2025. Taiwan is currently the only market where all operators have shut down both their 2G and 3G networks.

2G and 3G network sunsets (2015–2025)



Split by region – completed and planned sunsets (2015–2025)



Count of generation shutdowns as opposed to technology migration within the same generation of technologies. WiMAX network sunsets not included. Data for 2021–2025 estimated based on operators’ announced plans for shutdowns.

- Spectrum refarming is widespread** – In the second half of 2020, a range of operators shared updates on their spectrum refarming plans. The 2100 MHz band had the most transitions, with 11 operators refarming spectrum for either 4G or 5G networks. The refarming activity of spectrum used for legacy networks (3G or 4G) for 5G is driven by two factors: the absence of 5G mid-band assignments (e.g. in Denmark and Poland) and the need for additional capacity (e.g. in Hong Kong and Germany).

Spectrum refarming announcements (H2 2020)

Operator	Country	Frequency	Previous technology	Current technology	Status
TIM (Telecom Italia)	Brazil	2100 MHz	3G	4G	In progress
3 (CK Hutchison)	Denmark	700/1800 MHz	4G	5G	In progress
O2 (Telefónica)	Germany	900/2100 MHz	3G	5G	Planned
3 (CK Hutchison)	Hong Kong, SAR China	2100 MHz	3G	5G	In progress
Airtel (Bharti Airtel)	India	900/2100 MHz	2G/3G	4G	In progress
Vi	India	2100 MHz	3G	4G	In progress
Telia	Lithuania	2100 MHz	3G	4G	In progress
DiGi	Malaysia	2100 MHz	3G	4G	In progress
All operators	Poland	2100 MHz	3G	5G	Planned
Tele2 (Rostelecom)	Russia	1800 MHz	2G	4G	In progress
All operators	Ukraine	900 MHz	2G/3G	4G	In progress

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Our spectrum data

- Ongoing tracking of operators' spectrum assignments, licence duration and obligations
- Granular data covering 200 countries and 1,120 operators worldwide, from 1980 to today, updated regularly
- Basis for understanding future spectrum availability and plans
- Supports device pricing strategies (when combined with our device database)
- Helps identify market trends and opportunities driven by 5G

Spectrum Navigator

- User-friendly and comprehensive spectrum dashboard
- Custom search for spectrum assigned by frequency band
- Granular split by region, country and operator
- Dedicated section on current and future auctioning plans, including disruptions to auctions in times of Covid-19
- Data tables that allow quick understanding of key market questions on licence duration and obligations

How do I get access?

Talk to our Analyst

We would be keen to understand how our spectrum tool and data address your needs and requirements: schedule a demo with our industry expert to find out more. Please email info@gsmainelligence.com for more information.

Talk to your Account Manager

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- [5G and economic growth: an assessment of GDP impacts in Canada](#)
- [How spectrum will shape the outlook for 5G in Russia](#)
- [Effective Spectrum Pricing in Africa](#)
- [The Impacts of mmWave 5G in India](#)
- [The impact of spectrum prices on consumers](#)
- [Is 2020 the year for mmWave?](#)
- [US 5G market gets an infusion of mid-band spectrum](#)

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