aetha

# Ensuring spectrum awards in Latin America align with digital connectivity ambitions

Report for Ericsson

1 October 2022

# Contents

# 1. Executive summary

## 1.1 Introduction

Aetha Consulting Limited (Aetha) has prepared this report for Ericsson to discuss how spectrum award processes – including the pricing of spectrum – can be designed to maximise digital connectivity and promote economic growth in Latin America, as well as to help achieve sustainability targets.

There remain many Latin American citizens without access to Internet connectivity (fixed or mobile), preventing them from accessing the Internet's vast information resources and the corresponding benefits. In light of this, policymakers in Latin American countries have set ambitious fibre and/or 5G deployment targets. However, achieving these targets will require significant investment from operators at a time when they face major financial pressures due to stagnating revenues and increasing capital expenditure. One major component of capital expenditure contributing to this increase is the cost of spectrum, including one-off spectrum fees, annual licence fees and indirect licence costs, all of which contribute to the Total Cost of Spectrum Ownership (TCSO).

Many spectrum awards are set to occur in Latin America in the coming years, providing an opportunity for policymakers to set spectrum licence terms which are aligned with their connectivity objectives. This includes the TCSO and its distribution between the three components outlined above – by setting spectrum prices which are affordable in the long term and consider the costs of extending connectivity, policymakers could ease financial pressure on operators and promote investment. In this report, we discuss best practices for spectrum award processes and spectrum pricing which, if followed, will enable policymakers to increase the likelihood of achieving their connectivity and sustainability objectives.

## 1.2 Importance of spectrum in bridging the digital divide

### 1.2.1 Status and importance of connectivity

The economic and societal importance of Internet connectivity cannot be over-emphasised, with several studies demonstrating a strong linkage between broadband take-up and GDP.[1] Connectivity is also vital for creating a sustainable society – for example, it enables a multitude of new Internet of Things (IoT) applications with the potential to increase the efficiency of manufacturing, farming and transportation processes, saving energy and reducing waste. Indeed, a resilient telecoms infrastructure is a key component of United Nations Sustainable Development Goal (SDG) 9[2].

**However, it is estimated that one-third of the population of Latin America remains unconnected to the Internet, leaving citizens without access to the vast amount of information, education, business productivity and entertainment resources that Internet connectivity provides.**[3]

As shown in Figure 1-1 below, GSMA Intelligence estimates that over one-third of the population of Latin America remained unconnected to the Internet in 2020, leaving citizens without access to the vast

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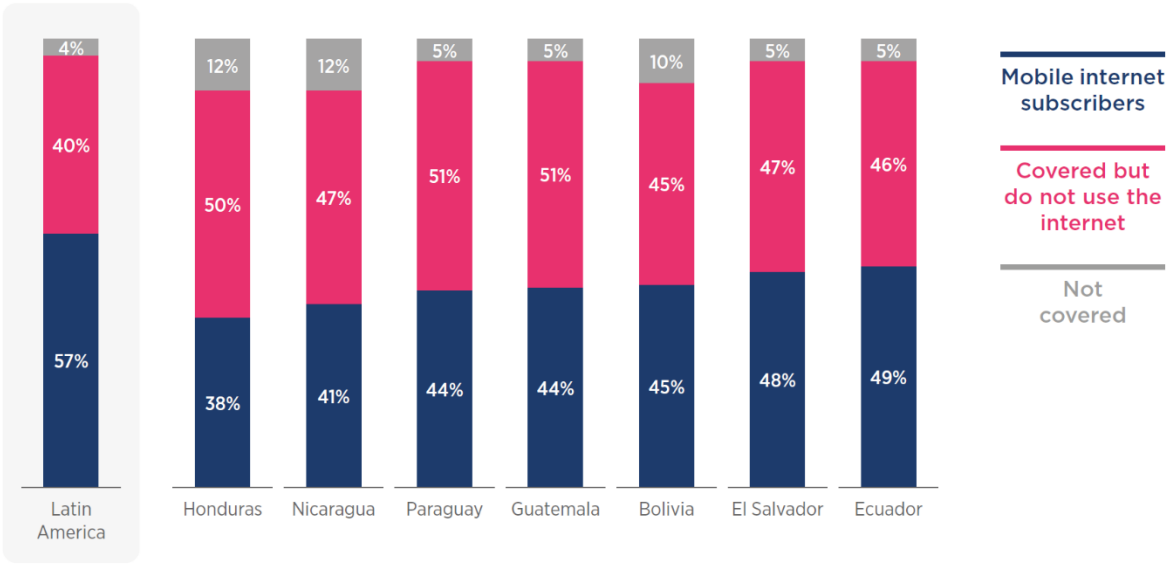
[1] See, for example, World Bank, '2009 Information and Communications for Development: Extending Reach and Increasing Impact', 2009 and International Telecommunications Union, 'The economic contribution of broadband, digitization and ICT regulation', 1918.

[2] See European Commission, 'Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: Next steps for a sustainable European future: European action for sustainability', COM(2016) 739 final, 22 November 2016 and United Nations General Assembly, 'Resolution adopted by the General Assembly on 25 September 2015: 70/1. Transforming our world: the 2030 Agenda for Sustainable Development', Reference A/RES/70/1, 21 October 2015.

[3] GSMA, 'The Mobile Economy: Latin America 2021', November 2021.

amount of information, education, business productivity and entertainment resources that Internet connectivity provides.

**Figure 1-1: Proportion of population in less connected Latin American countries who make use of the Mobile Internet, are covered by the Mobile Internet but do not make use of it and are not covered [Source: GSMA Intelligence[4]]**

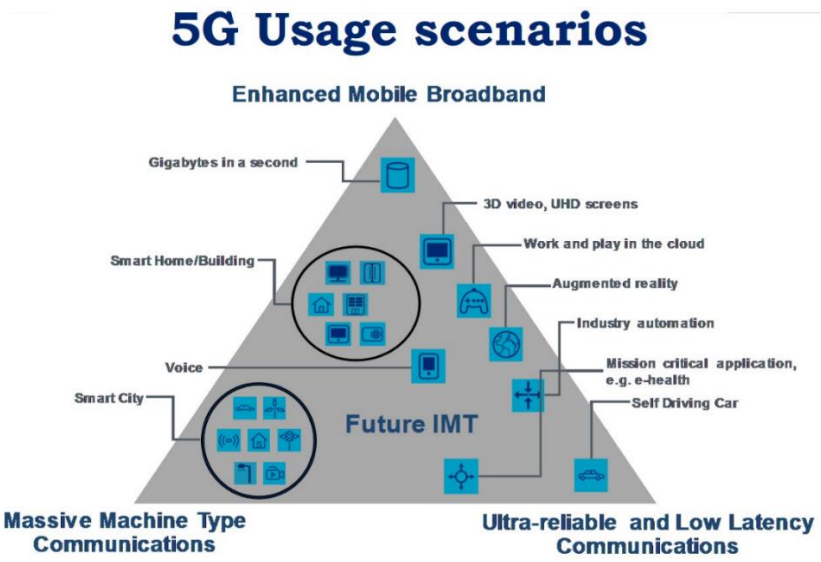



*Note: Totals may not add up due to rounding*

Mobile networks are key to providing connectivity, particularly in less populated areas. Therefore, ensuring widespread availability of mobile services (particularly 5G) is a priority. 5G deployment is enabling access to the resources above, increasing productivity and driving economic growth. As a result, 5G does not just provide an economic boost to the telecoms sector but to the entire economy. 5G improves upon 4G in three main areas: enhanced mobile broadband, ultra-reliable low-latency communication and massive machine-type communication, as shown in Figure 1-2.

[4] GSMA, 'The Mobile Economy: Latin America 2021', November 2021.

**Figure 1-2: The 5G triangle [Source: ITU[5]]**




The full benefits of connectivity can only be realised through universal access (i.e. universal connectivity to high-speed networks, including via 5G). Several countries have therefore set ambitious targets for fibre and/or 5G connectivity improvements, including Argentina, Brazil and Chile. In Brazil, 3.5GHz licensees are required to deploy 5G in 100% of municipalities by December 2029.[6] This mirrors targets in other parts of the world – e.g. the EU aims to have all populated areas covered with 5G by 2030[7].

To achieve these targets, considerable investments will need to be made by both the telecoms industry and governments, with public funding required to bridge the 'investment gap' where network deployment would otherwise be uneconomic.

### 1.2.2 Financial challenges facing mobile operators

The public funding required to meet connectivity targets depends on the industry's ability and economic incentive to fund network coverage expansion. However, operators are facing significant financial challenges due to necessary rises in capital expenditure and stagnating revenues. Mobile operators are currently making record investments in their networks due to:

- Investment in new 4G and 5G technology (radio access network and core network upgrades)
- The simultaneous operation of four generations of mobile technology (2G, 3G, 4G & 5G)
- Investment in new network architectures (e.g. small cells)
- The deployment of new sites to increase network coverage
- Spectrum acquisition costs.

However, this is occurring whilst mobile service revenues are flat lining (or even declining). The result is that operators' capital intensity (capital expenditure as a proportion of revenue) is increasing, as illustrated in Figure 1-3 below, and margins are decreasing. This is clearly unsustainable in the long term – if this trend continues, operators will increasingly become financially unviable and exit the market, as has occurred in Mexico where Telefónica returned its spectrum due to high annual licence fees.

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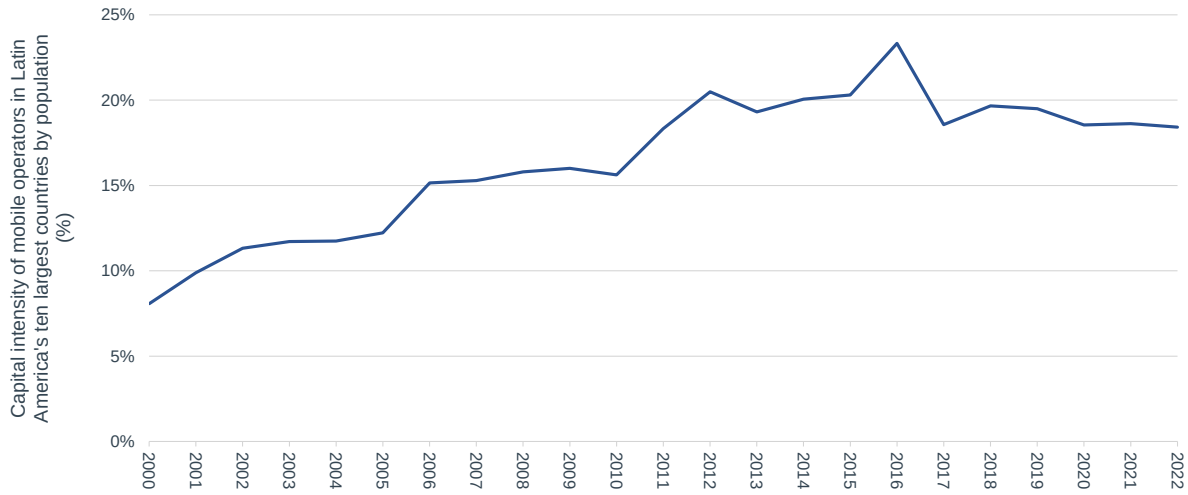
[5] ITU, 'Emerging Trends in 5G/IMT2020', September 2016.

[6] Anatel, 'Bidding No. 1/2021-SOR/SPR/CD-ANATEL. Radio frequencies in the bands of 700MHz, 2.3GHz, 3.5GHz and 26GHz', 27 September 2021.

[7] European Commission, '2030 Digital Compass: The European Way for the Digital Decade', March 2021.

**Figure 1-3: Capital intensity of mobile operators in Latin America's ten largest countries by population (2000-2022) [Source: GSMA Intelligence[8]]**




### 1.2.3 Impact of upcoming spectrum assignments

One key area of capital expenditure is spectrum acquisition. Spectrum is a major area of investment for mobile operators and is sometimes described as the 'lifeblood' of a mobile network. As discussed in Section 1.3.1 below, spectrum can represent a considerable cost for mobile operators – up to 16% of recurring service revenues in some countries.

We highlight spectrum acquisition because the availability and price of spectrum are often under the direct control of regulators, in contrast to many of the other sources of financial pressure outlined above (e.g. revenue decline). It is therefore an area in which regulators can make a positive contribution towards easing operators' financial challenges, potentially increasing the investment they are able to make in other areas (e.g. 5G deployment) and reducing the investment gap.

Operators require a portfolio of low-, mid- and high-band spectrum to support high-speeds to customers, provide sufficient network capacity and enable network coverage to be provided to less populated areas in the most cost-effective way. Sufficient low frequency spectrum (below 1GHz) is needed to provide mobile services to areas (less populated areas, deep indoor areas) which higher frequency signals cannot reach. Looking forward, to continue offering competitive services in line with customer requirements, operators will need to both acquire new spectrum (bands) and renew their existing spectrum holdings under reasonable conditions.

New spectrum is required to deploy the latest technologies and extend network capacity to keep up with traffic growth, especially as mobile data traffic is expected to grow faster than the global average in Latin America.[9] Whilst 5G can notionally be deployed using existing licensed mobile bands, to provide a real step change from 4G performance and unlock the full benefits of 5G, 5G needs to deployed by operators using a mix of low-band spectrum (e.g. 700MHz or 600MHz) for a coverage layer and a large contiguous block of mid-band spectrum (e.g. 100MHz from the 3.5GHz band) to offer high speeds across a wide area, supplemented with mmWave spectrum (e.g. 26GHz band) to provide sufficient capacity in very busy areas (e.g. transport interchanges, sports/entertainment arenas etc).

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[8] Source for capital expenditure: GSMA Intelligence, 'Financial – Cost & Profitability. Total Capex', Accessed 17 May 2022. Source for revenue: GSMA Intelligence, 'Financial – Revenue (Mobile)', Accessed 6 June 2022.

[9] Ericsson, 'Ericsson Mobility Report: Mobile data traffic outlook', November 2021.

In the future, additional mid-band spectrum (e.g. upper 6GHz band) will be required to support traffic growth in city areas. GSMA Intelligence estimates that mid-band spectrum will generate around 63% of the total GDP uplift generated by 5G[10]. Additional low-band spectrum (e.g. 600MHz) will be needed to provide extra capacity in deep indoor and more rural areas that cannot be reached by mid-band spectrum and additional mmWave spectrum (e.g. 40GHz band) may also be required.

At the same time, keeping access to existing spectrum is critical to ensure continuity for existing 2G, 3G & 4G networks. As the demand for 2G/3G/4G reduces, existing spectrum assets can also be refarmed to be used for newer technologies such as 5G

Whilst spectrum availability is vital for supporting both new and existing connectivity services, many Latin American countries have only made limited amounts of spectrum available to operators. For example, the average quantity of licensed mobile spectrum in Latin American countries was 490MHz in November 2020.[11] In comparison, the UK had licensed 925MHz as of this date (excl. mmWave), whilst the USA had licensed 832MHz[12] – both have since licensed additional spectrum. As discussed above, it important that regulators in each country make appropriate amounts of low-band, mid-band and high-band spectrum available – it is not just simply the total amount of spectrum that is made available that matters – a portfolio of spectrum types is key.

In response to this, a large number of spectrum assignment processes are now scheduled to take place in Latin American countries in the coming years, with a focus on 5G-suitable spectrum in, for example, the 700MHz and 3.5GHz bands. Figure 1-4 below shows details of the planned spectrum awards in Latin American countries of which we are aware, focussing on those expected to occur within the next two years (i.e. by year-end 2023). We have identified at least 15 spectrum awards that are scheduled to occur by year-end 2023, including seven 700MHz and 3.5GHz awards, in additional to several awards of spectrum in the AWS, 2.3GHz and mmWave bands, amongst others.

[10] GSMA Intelligence, 'The Socio-Economic Benefits of Mid-Band 5G Services', February 2022.

[11] GSMA, '5G and the 3.3-3.8GHz Range in Latin America', November 2020.

[12] Analysys Mason, 'Comparison of total mobile spectrum in different markets', June 2020.

**Figure 1-4: Upcoming spectrum awards in Latin America [Source: GSA[13]]**

| | Bands | Date |
|---|---|---|
| **Argentina** | 700MHz, AWS, PCS | 2023 |
| **Brazil** | 26GHz | 2022/2023 |
| **Colombia** | 3.5GHz | 2022 |
| | 2.3GHz | 2022 |
| **Costa Rica** | 850MHz, 900MHz, 1400MHz, 3.5GHz, 26GHz, 40GHz | 2022 |
| | 700MHz, 2.3GHz, 3.5GHz, 26GHz, 28GHz | 2022/2023 |
| **Ecuador** | 700MHz, AWS, 2.5GHz, 3.5GHz | 2022 |
| **El Salvador** | 700MHz | 2022 |
| **Guatemala** | 700MHz | 2022 |
| **Guyana** | 700MHz, 3.5GHz | 2022 |
| **Honduras** | 700MHz, 3.5GHz | 2022 |
| **Mexico** | 600MHz, 850MHz, 1400MHz, 3.5GHz | 2022 |
| **Panama** | AWS | TBC |
| **Peru** | AWS-3, 2.3GHz | 2022 |
| **Uruguay** | 3.5GHz | 2022 |

It is important for mobile operators to have confidence that these spectrum assignment processes will enable them to acquire the new spectrum they require, as well as retain key existing spectrum, at a reasonable price. This will enable them to divert their energy and investments into deploying 5G and extend mobile network coverage, thus helping to widen connectivity to more citizens and improve the quality of existing services (e.g. higher speeds, lower latency). Only by doing so will each country be able to gain the full economic benefits from the use of 5G technology.

It is also important that existing spectrum is renewed following best practice principles. The loss of existing spectrum assets can be an existential threat to operators, as illustrated by the example of Tele2 in Norway which failed to re-acquire spectrum in the 900MHz band during an auction process in 2013, resulting in its exit from the Norwegian market. Due to the magnitude of these risks, a lack of information over how expiring spectrum licences will be re-assigned and the corresponding prices creates a huge amount of uncertainty, potentially impacting operators' ability/willingness to invest in its network.

[13] GSA, 'Spectrum Auctions Calendar', May 2022.

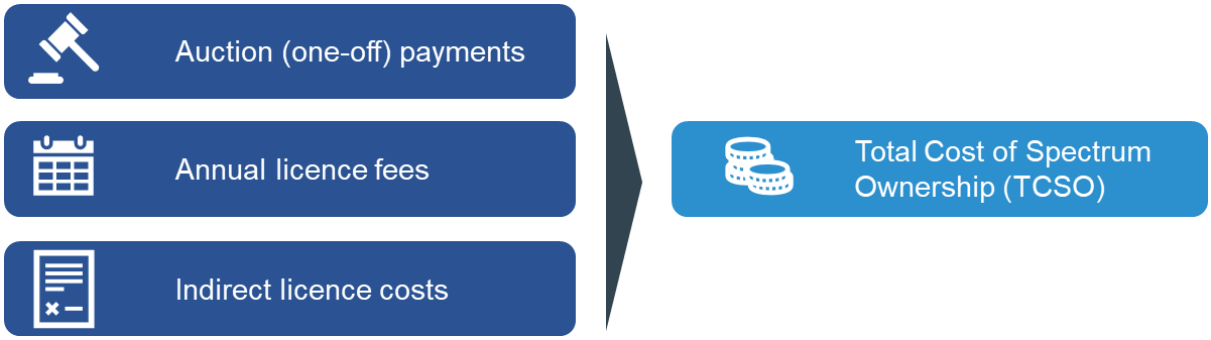
## 1.3 Best practices for spectrum pricing

**Spectrum pricing is one area in which regulators can make a positive contribution towards easing operators' financial challenges**, as highlighted above. **The availability and price of spectrum are often under the direct control of regulators**, in contrast to many of the other sources of financial pressure outlined above (e.g. revenue decline).

### 1.3.1 Total cost of spectrum ownership

For regulators to make positive decisions regarding spectrum pricing, it is important to consider all aspects of spectrum price; the Total Cost of Spectrum Ownership comprises several components:

**Figure 1-5: Components of the Total Cost of Spectrum Ownership**




- **Auction (one-off) payments**: The amount of money determined by the award process, typically expressed as a one-off lump sum (although staggered payments are increasingly common).
- **Annual licence fees**: Annual spectrum fees are charged to cover the cost of administering the spectrum and are typically determined outside the award process.
- **Indirect licence costs:** Licences can contain specific obligations, for example to extend network coverage. The costs of these obligations can be difficult to quantify as they depend on the operators' private cost structures and network rollout ambitions; however, they can be significant.

The TCSO to a mobile operator is the sum of these three components – if one is high, the others should be reduced to account for this. Operators will only acquire spectrum if their value for the spectrum is lower than the associated TCSO.

Spectrum is a pre-requisite for the provision of mobile services – operators cannot exist without it – and therefore the fees associated with it can, to some extent, be considered to be an additional form of taxation on the industry – a 'spectrum tax'. A typical way of assessing the magnitude of this spectrum tax is to evaluate the costs associated with spectrum as a percentage of operator revenues.

GSMA Intelligence has undertaken such an assessment on mobile spectrum prices in Colombia and Ecuador. Expenditure on spectrum in Colombia[14] was estimated to amount to around 6% of recurring revenues. For Ecuador, GSMA Intelligence found[15] that spectrum costs amounted to just over 16% of recurring revenue – the highest across the Latin America region despite the amount of spectrum assigned for mobile use in Ecuador (around 280MHz) being amongst the lowest in the region (the regional average was estimated to be around 490MHz, as shown in Figure 3-7 above).

[14] GSMA Intelligence, 'Effective spectrum pricing in Colombia, September 2021.

[15] GSMA Intelligence, 'Effective spectrum pricing in Ecuador', October 2021.

The main limitation of this calculation is that it does not take account of indirect licence costs (e.g. coverage obligations) since these are hard to quantify; however, it does provide a lower bound indication of the impact of spectrum costs on all mobile operators in each country.

A study on spectrum pricing by NERA[16], undertaken on behalf of the GSMA, found that median prices for capacity spectrum in Latin America are approximately 60% higher than prices paid in Europe. More generally, a study on the impact of spectrum pricing on consumers undertaken by the GSMA[17] also found that spectrum prices as a % of revenues were around three times higher in developing markets than in developed markets.

In summary, it can be seen that spectrum costs are a significant burden for operators, especially so in several Latin America countries, with costs being as high as 16% of recurring revenues just for the operators' existing spectrum holdings. In light of the large number of upcoming spectrum awards in Latin America, it is clear that the TCSO needs to be carefully considered by regulators in the region.

### 1.3.2 Risk and impact of high spectrum prices

One element to consider when renewing spectrum is spectrum pricing, including all components of the TCSO. High spectrum prices carry significant risks, having the potential to stymie investment and leave spectrum underutilised. **Therefore, it is essential that spectrum prices are set at a level which is affordable for operators in the long term and are aligned with policymakers' objectives**.

Operators are having to acquire new spectrum, as well as renew their existing spectrum holdings, to support traffic growth. At the same time, revenues are relatively static. Therefore, if spectrum continued to be awarded at the same price (per MHz), the overall spectrum cost (as a proportion of operator revenues) would increase. This is clearly unsustainable – as the amount of spectrum available increases, the unit price paid for spectrum (including all elements of the TCSO) has to decrease.

However, regulators often use the outcomes of historic auctions in the country as a basis for setting spectrum prices. This risks prices being set at excessive levels, potentially resulting in spectrum remaining unassigned (as has occurred in e.g. India, Thailand, Mexico, Romania). Even if the spectrum does sell, it may still be an inefficient outcome for the market that harms investment (e.g. Italy). For example, several studies have highlighted possible links between high spectrum prices and both reduced investment/network coverage and increased service prices:

- A study by NERA[18] found a modest correlation between higher prices for spectrum and both reduced network quality/availability (in terms of 3G/4G coverage, 4G subscribers and average speeds etc.), likely due to reduced network investment, and increased service prices. The results of this study were referenced within the GSMA's report on 'effective spectrum pricing'.[19]

- A report[20] produced by LS telcom, PolicyTracker and VVA for the European Commission suggested that there may be an inverse relationship between price paid for spectrum and network availability (i.e. higher auction prices are associated with lower 4G availability).

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[16] NERA Economic Consulting on behalf of GSMA, 'Effective Spectrum Pricing in Latin America: Policies to support better quality and more affordable move services', February 2018.

[17] GSMA, 'The impact of spectrum prices on consumers', September 2019.

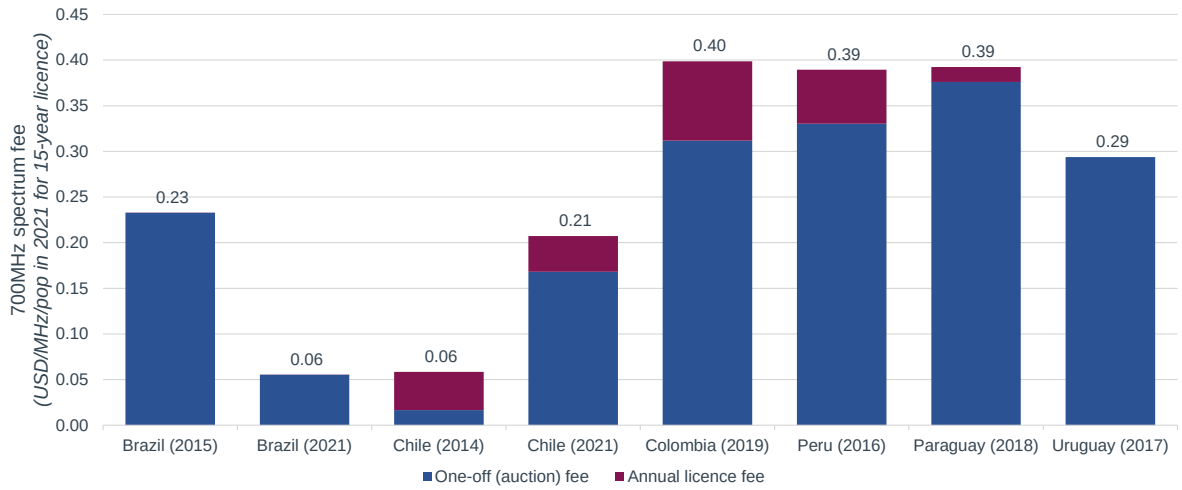
[18] NERA Economic Consulting, 'The Impact of High Spectrum Costs on Mobile Network Investment and Consumer Prices', May 2017.

[19] GSMA, 'Effective Spectrum Pricing: Supporting better quality and more affordable mobile services', February 2017.

[20] LS telcom, VVA and PolicyTracker for the European Commission Directorate General for Communication Networks, Content and Technology, 'Study on Spectrum Assignment in the European Union', October 2017.

The levels of annual licence fees varies considerably across countries. Figure 1-6 below shows 700MHz prices in several example Latin American countries/spectrum auctions, including the split of 700MHz spectrum prices between one-off and annual licence fees.

**Figure 1-6: 700MHz spectrum fees in Latin America separated into upfront (one-off) and annual licence fees [Source: Aetha]**




When using international benchmarks to set spectrum prices, account needs to be taken of both the annual fees and the reserve price/auction outcomes when comparing across countries. Importantly, **a country which has high annual fees cannot expect to gain the same levels of auction outcome price as a country which has a relatively low level of annual fees**.

Furthermore, **annual licence fees for spectrum are commonly set using formulas and parameters that are many years old. In some cases, the formulas and parameters are no longer appropriate**. For example:

- Formulas do not always differentiate between low and high frequencies (or have a cut-off at a relatively low level). A multiplier related to the frequency range needs to be included and this needs to reflect the frequency ranges that are currently being considered for assignment for mobile use.
- Formulas in several countries, including Mexico, include an income-related parameter. This is no longer appropriate because it will cause unit prices for spectrum to increase (e.g. with inflation) whilst the actual value of each MHz of spectrum to the operator is decreasing.
- Annual fees should not discourage network deployments – for example annual fees in some countries increase linearly with the number of base station on which the spectrum is deployed – creating a disincentive to widening service availability.

Finally, **we note that if policymakers' priority is to expand network coverage, it may be appropriate to consider accepting lower spectrum fees in return for operator commitments to expanding coverage.** There is a cost to expanding coverage that operators cannot be expected to bear alone, particularly in areas where deployment would not ordinarily be commercially viable. This is a key element of the TCSO and, therefore, if it is particularly high, other elements of the TCSO (i.e. one-off and/or annual fees) should be decreased accordingly – spectrum prices should always be set in consideration of the TCSO.

**In summary, high spectrum prices can have a detrimental effect on network investment and service prices. With the increasing amount of spectrum required by operators to meet customer needs, unit prices for spectrum must go down** – and therefore regulators should not continue to

adopt the approach of using outcomes of historic auctions in the country to set reserve prices for upcoming auctions.

## 1.4 Best practices for spectrum award processes

We have identified several areas of best practice for regulators when allocating spectrum:

- Timing of award process – Awarding spectrum at the appropriate time:
  - Spectrum should be made available at a time when it is needed to support service innovation (e.g. for deployment of new technologies) and capacity expansion of existing networks
  - The co-existence conditions for use of spectrum by IMT and any other legacy users should be clear, including clearance of incumbent uses where necessary prior to spectrum award (or, at a minimum, a clear timeline for its clearance should be defined)
  - Renewal processes ought to be commenced well in advance of licence expiry, in order to limit the degree of uncertainty faced by operators and protect investor confidence
- Spectrum availability – Ensuring sufficient spectrum is available for all operators:
  - Policymakers should seek to ensure that sufficient spectrum is made available in any given band to meet the needs of all operators in the market
  - Policymakers should avoid providing preferential access to local or industrial users unless the supply of spectrum is greater than the demand from mobile operators
- Objectives of process – Ensuring the priorities/objectives for the process are understood:
  - Regulators' priorities would be expected to include encouraging the growth and development of the mobile market, maintaining competition, and encouraging investment and innovation
  - Regulators' priorities would not be expected to include the maximisation of spectrum assignment revenue as this is likely to detract from investment in operators' networks
- Conditions of spectrum use – Specifying an appropriate licence duration:
  - Licences should be as long as possible, ideally indefinite, to provide certainty for investors by allowing a longer amortisation period and avoiding 'dead periods' at the end of licences. At a minimum, licences should have a duration of 20+ years
  - Ideally long spectrum durations should be coupled with allowing operators to trade spectrum, since the adoption of extended licences, particularly indefinite licences, has been shown to promote spectrum trading (e.g. in the UK & USA) and thereby increase the efficiency of spectrum use
- Design of award process – Selecting an appropriate award process:
  - Whilst auctions are increasingly the default approach for assigning mobile spectrum, and are a very useful tool, sometimes simple administrative award processes may be appropriate in cases where demand does not outstrip supply, and may involve either the equal distribution of spectrum in the band to all operators or, in the case of renewals, direct renewal of the existing holdings of each operator

    - Regulators may seek discussions with industry regarding how its priorities may be achieved through an administrative award process (e.g. in terms of expanding network coverage in exchange for reduced spectrum fees or rebalancing spectrum holdings between operators)

  - Auction processes are likely to be appropriate where demand for spectrum exceeds supply

    - Policymakers should focus on the objectives of the award process and not get distracted by auction dynamics – the aim should be to encourage competition and investment in the mobile market to meet connectivity objectives, not to create competition in the auction

  - Partial renewal is likely to be appropriate in cases where existing spectrum is being re-awarded and demand for spectrum exceeds supply, but there is a business/service continuity risk to existing licensees if they lose key spectrum

    - The guaranteed renewal of part of an operator's spectrum holdings would significantly de-risk the process by addressing concerns regarding business continuity and ensuring the future availability of existing technologies (e.g. 2G/3G)

    - Such an approach would only be appropriate in situations where the partial renewal is economically efficient and do not risk distorting competition in the mobile market

    - This approach is particularly important in the short-term where specific technologies (2G/3G) can only be deployed in particular frequency bands

- Auction best practices – Where an auction is required, adopting best practice approaches including:

  - Packaging spectrum appropriately:

    - Spectrum should be packaged in a way that makes efficient use of the spectrum (i.e. block sizes should not be too small) whilst enabling operators to acquire the spectrum they require (so not too large) and allowing them to compete over the marginal blocks.

  - Avoiding risky or complex auction formats/rules and ensuring transparency:

    - If an auction is deemed necessary, the auction design should take account of the risks and uncertainties that the mobile operators are facing in a competitive spectrum award process

    - To reduce the uncertainty faced by operators when seeking to acquire spectrum, we recommend using simple 'tried and tested' formats (e.g. SMRA, Clock) and avoiding the use of formats which yield highly uncertain outcomes (e.g. CCA)

    - The award process should be as transparent as possible, with the maximum possible amount of information being published that does not risk collusion between bidders – in this way, policymakers enable price discovery and maximise the chances of an efficient outcome

  - Ensuring that auctions do not unduly impact on natural evolution of the market:

    - Where auctions are deemed necessary, we recommend that the auction rules do not prevent natural market evolution (e.g. forcing a new entrant through a spectrum reservation)

  - Prioritising non-monetary objectives, such as coverage:

    - If expanding coverage is an objective, regulators should consider accepting lower spectrum fees in return for operator commitments to expanding mobile coverage/5G deployment etc.

- For example, Brazil auctioned spectrum in the 700MHz, 2.3GHz, 3.5GHz and 26GHz bands for a total of BRL47.2 billion in 2021. [21] Of this total however, BRL39.3 billion (83%) will not be paid as auction fees but instead as investments in extending coverage to underserved areas.

– Enabling reconfigurations of bands:

- Where necessary, the auction should include a process for the reconfiguration of spectrum holdings in the band to enable all operators to have contiguous holdings.

Overall, awarding spectrum using less complex/less risky auction designs, with the spectrum being appropriately packaged, made available on a timely basis and with licences of at least 20 years duration, will reduce the level of risk/uncertainty faced by the mobile operators in acquiring spectrum. This will release funding for strategic investments such as reducing the digital divide and deploying the latest technologies (e.g. 5G) which will, in turn, yield significant economic benefits for the country – the magnitude of these economic benefits is expected to be many multiples of any short-term revenue gains from holding an auction process which is designed to maximise revenues.

[21] Ministry of Economy, 'Biggest auction in the history of telecommunications in Brazil, 5G guarantees BRL 47.2 billion in investments', 8 November 2021.

# 2. Introduction

Aetha Consulting Limited (Aetha) has prepared this report for Ericsson to discuss how spectrum award processes – including the pricing of spectrum – can be designed to maximise digital connectivity and promote economic growth in Latin America, as well as to help achieve sustainability targets.

## 2.1 Background

It is estimated that around one-third of the population of Latin America remains unconnected to the Internet in 2020. These citizens do not have access to the vast amount of information, education, business productivity and entertainment resources that Internet connectivity provides.

Mobile networks are key to providing connectivity outside the most populated areas of each country. Furthermore, they will need to play a role (alongside satellite solutions) in providing connectivity to those communities and individuals that are currently outside the reach of Internet connectivity.

In addition to enabling universal connectivity to the Internet, 5G has the potential to transform processes and increase productivity across all industries. In view of its importance, governments have set ambitious targets for 5G deployment – e.g. 3.5GHz licensees in Brazil are required to deploy 5G in 100% of municipalities by December 2029.[22] This mirrors similar targets in other parts of the world – for example, the EU aims to have all populated areas covered with 5G by 2030[23].

The achievement of such targets will require considerable investment by both the telecoms industry and governments – with public funding required to close the 'investment gap' and bring connectivity to areas where network deployment would otherwise be uneconomic. The greater investment made by the telecoms industry, the smaller the investment gap.

A key factor impacting operators' ability to invest is certainty over the regulatory environment in which they operate – the greater the level of certainty, the greater the level of investor confidence and ultimately investment. In respect of mobile services, regulatory certainty over radio spectrum availability is critical.

Spectrum is a key input to mobile services – too little and mobile operators will incur additional costs to carry the traffic generated, for example, by smartphone applications. Mobile operators are not awash with funds at present – the investment climate is very tight – so any money spent on expanding network capacity which could have been saved through spectrum access reduces the funding available for network expansion. Furthermore, any money spent by operators on 'unnecessarily expensive' spectrum in auctions also reduces the available funds for network investment.

Mobile operators regularly invest in spectrum to deploy new technologies such as 5G and support traffic growth – both new and existing spectrum is required to continue offering existing services and launch new ones. However, operators face uncertainty over whether they will be able to acquire the spectrum they need and the price they will have to pay for it, particularly in complex auction processes. Until they have certainty on the spectrum award process, operators will be hesitant to further invest in networks as they seek to avoid inefficient investments if spectrum acquisitions do not occur as envisioned.

The cost of spectrum is not limited to auction payments, however. There are multiple additional costs associated with spectrum, including annual licence fees and indirect licence costs, all of which

[22] Anatel, 'Bidding No. 1/2021-SOR/SPR/CD-ANATEL. Radio frequencies in the bands of 700MHz, 2.3GHz, 3.5GHz and 26GHz', 27 September 2021.

[23] European Commission, '2030 Digital Compass: The European Way for the Digital Decade', March 2021.

contribute to the Total Cost of Spectrum Ownership (TCSO). All of these must be considered when determining spectrum prices, with the objective being to ensure that the total is not excessive. Only by doing so is it possible to avoid spectrum being 'unnecessarily expensive', thereby protecting operators' ability to fund network investments, including those associated with achieving connectivity targets.

Whilst optimising spectrum policy has always been important, with the introduction of 5G it becomes even more so because 5G will impact on every corner of society and the economy. Policymakers should be aware that the societal and economic benefits of universal 5G connectivity will compensate many times over for any short-term reductions in spectrum assignment revenue. Therefore, they should look to trade-off auction proceeds for greater investment in networks, including investments in expanding coverage and rolling-out new technologies/services. Over time, government income will, in any case, be maximised due to the resulting growth of the economy and consequent increases in tax revenue etc.

In this paper, we set out a series of recommendations for policymakers in relation to spectrum awards, both in terms of spectrum pricing and award format. We set out best practice approaches which will reduce the uncertainty facing mobile operators, meaning that their attention can be focused on expanding network coverage and deploying high-performance 5G services, unlocking the resulting economic and societal benefits.

We urge policymakers to consider our recommendations and signal intentions to adopt the suggested approaches to the mobile industry as early as possible, allowing the industry to have the confidence to make the required investments to achieve a rapid and complete roll-out of 5G.

## 2.2 Structure of this document

The remainder of this document is structured as follows:

- Section 3 further discusses the importance of spectrum in achieving universal connectivity and the challenges currently facing mobile operators, particularly with regards to the cost of spectrum
- Section 4 presents our recommendations with regards to spectrum pricing, in consideration of all components of the TCSO and the risks of policymakers setting excessive spectrum prices
- Section 5 presents our recommendations, based on best practices, in relation to spectrum awards
- Section 6 summarises the conclusions of our assessments.

# 3. Importance of spectrum in bridging the digital divide

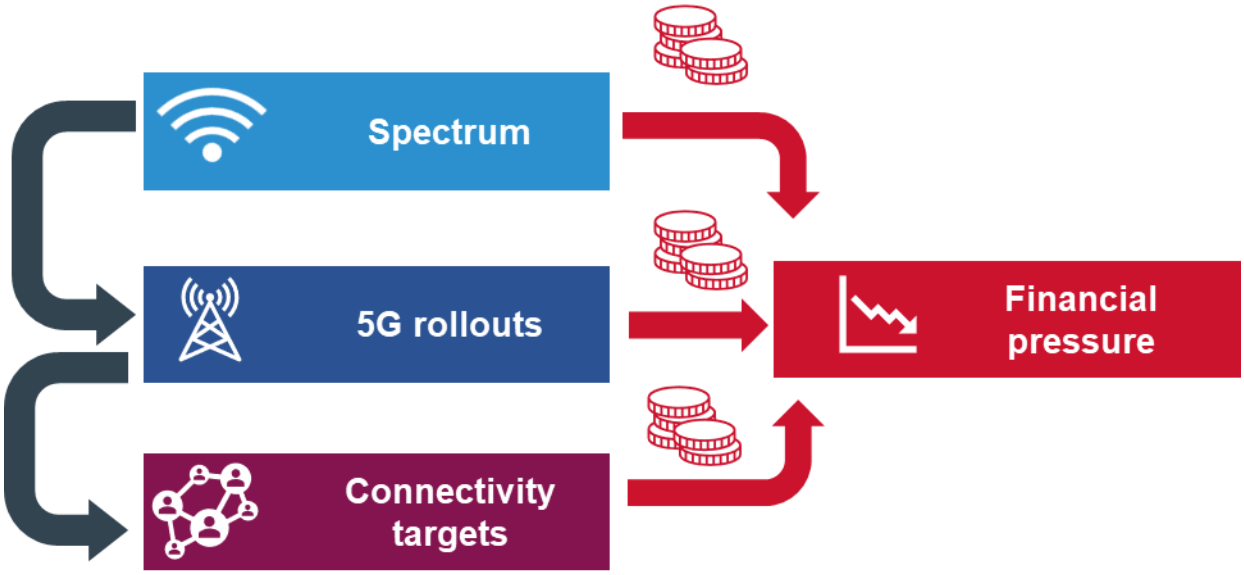
Policymakers worldwide have outlined ambitious connectivity targets, with the aim of facilitating productivity and sustainability improvements across the entire economy – the potential benefits are enormous. We discuss connectivity targets and current status of connectivity in Latin America, as well as the importance of achieving universal connectivity, in Section 3.1.

To achieve these targets, operators will need to further invest in 5G deployments, for which spectrum is a key input. Investments are required in acquiring spectrum and rolling out networks to achieve universal connectivity, all of which add to the financial pressures faced by operators, impacting their willingness and ability to invest. We discuss why it is financially challenging for mobile operators to make the necessary investments to achieve universal 5G coverage in Section 3.2.

One source of financial pressure is spectrum acquisition costs. Spectrum pricing lies within policymakers' control. Therefore, it is one means by which they may ease the pressure on operators, thus facilitating investments in universal connectivity. There are many planned spectrum awards in Latin America in the next few years. It is therefore important to understand the specific impact that they will have on operators' ability and willingness to invest, as well as the licence and award conditions which will need to be in place for them to contribute to meeting connectivity and sustainability targets. We discuss the importance and impact of upcoming spectrum award processes in Section 3.3.

This complex interaction and the specific role that spectrum plays in this context has been summarised in Figure 3-1 below – we will discuss each of the components in more detail in this chapter.

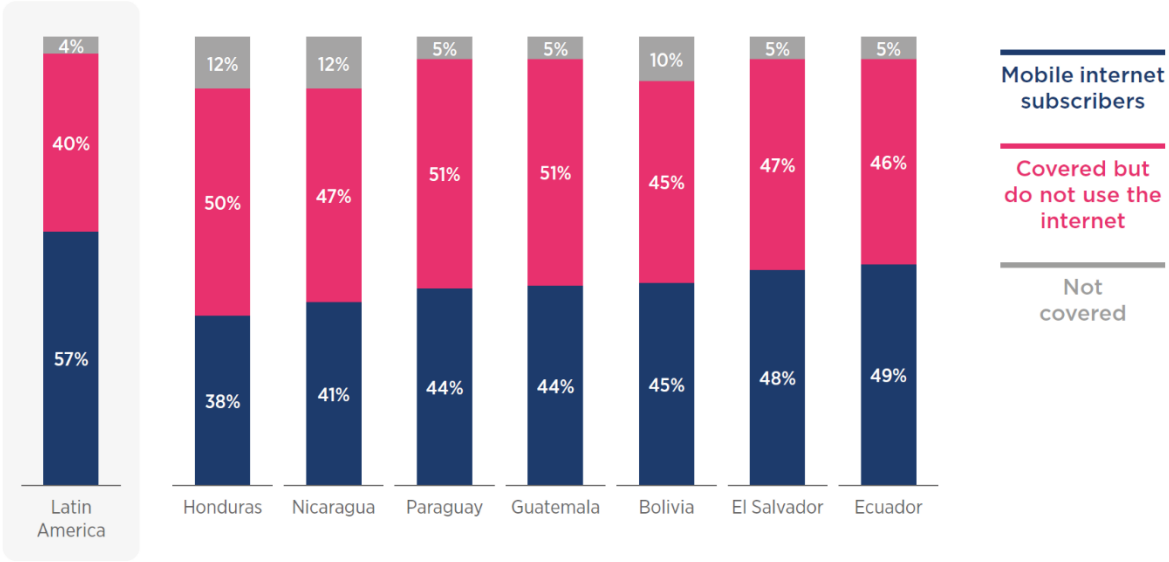
**Figure 3-1: The role of spectrum in achieving the connectivity targets and the factors contributing to the financial pressure on operators**




## 3.1 Status and importance of connectivity

As shown in Figure 3-2, GSMA Intelligence estimates that over one-third of the population of Latin America remained unconnected to the Internet in 2020. This means they lack access to the vast amount of information, education, business productivity and entertainment resources that almost all of the population of wealthier countries take for granted as part of their day-to-day lives.

**Figure 3-2: Proportion of population in less connected Latin American countries who make use of the Mobile Internet, are covered by the Mobile Internet but do not make use of it and are not covered [Source: GSMA Intelligence[24]]**




*Note: Totals may not add up due to rounding*

Mobile networks are key to providing connectivity outside the most populated areas of each country and will also need to play a role (alongside satellite solutions) in providing connectivity to those communities and individuals that are currently outside the reach of mobile networks. For those who are currently within the coverage of mobile networks but do not use the Internet, factors such as device availability/affordability and lack of digital skills/training need to be overcome.

The economic and societal importance of increasing connectivity cannot be over-emphasised. Several studies[25] have demonstrated a linkage between broadband take-up and GDP – whilst the exact level of impact can be debated (estimates range from a 0.1-0.2% increase in GDP for every 1% increase in broadband penetration), there is undoubtedly a strong linkage. Likewise, studies have also shown that improvements in broadband speeds for those already connected contribute to GDP growth[26].

5G deployment is further enabling access to key information, education and entertainment resources, as well as new business applications that will increase productivity and drive economic growth. 5G networks do not just provide an economic boost to the telecoms sector but to the whole economy.

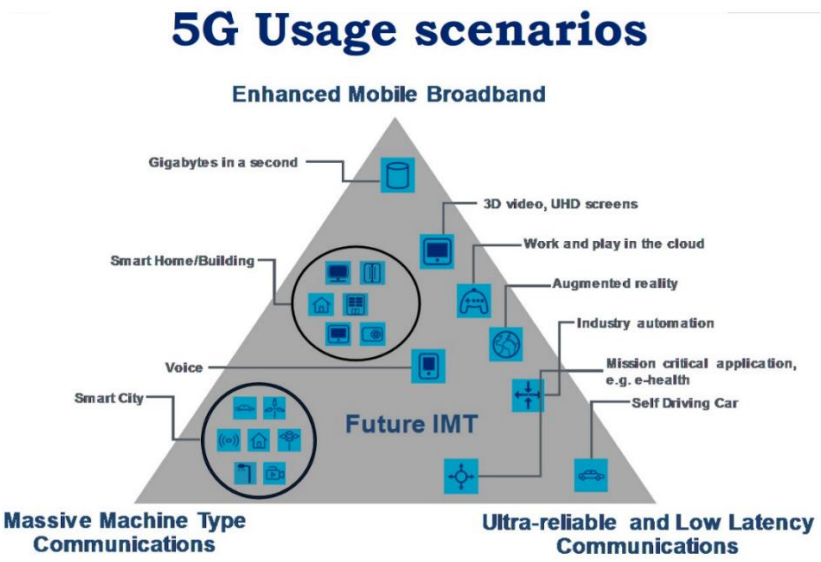
5G improves upon 4G in three main areas: enhanced mobile broadband, ultra-reliable low-latency communication and massive machine-type communication. These three components are known as the 5G triangle, as shown in Figure 3-3.

[24] GSMA, 'The Mobile Economy: Latin America 2021', November 2021.

[25] See, for example, World Bank, '2009 Information and Communications for Development: Extending Reach and Increasing Impact', 2009 and International Telecommunications Union, 'The economic contribution of broadband, digitization and ICT regulation', 1918.

[26] See, for example, Ericsson, Arthur D. Little and Chalmers University of Technology, 'Socioeconomic effects of broadband speed', 2013.

**Figure 3-3: The 5G triangle [Source: ITU[27]]**




- Enhanced mobile broadband refers to data speeds, which are expected to be around 20 times faster than for 4G. The actual speed of a 5G connection depends on the frequency of spectrum used. As the International Telecommunication Union (ITU) has defined[28], the total capacity for a single 5G mobile cell must be at least 20Gbps in download and 10Gbps in upstream. Furthermore, ITU has also defined the "per-user" speed for downloads as 100Mbps and uploads as 50Mbps. According to industry expectations, the mobile cell speed will increase up to 100Gbps in the future.

- Ultra-reliable low-latency communication is extremely important for time-critical applications like gaming. Low latency will also play an important role in many business applications – for example, in Automated-Guided Vehicles (AGV), manufacturing plants or warehouses. In current 5G deployments, latency of approximately 30ms is achieved, while some optimisations (e.g. operating in the edge cloud field) could realistically see a latency as low as 10ms. Latencies below 10ms are possible under lab conditions and the long-term target is to achieve 1ms, however this may be extremely challenging in reality.

- Massive machine type communication refers to support for the growing number of IoT devices that are all communicating with each other. Connection density is expected to be a major consideration for 5G that has never been as much of an issue for previous generations. Statistica, for example, predicts that the ratio of IoT connected devices per human on the planet will increase from the two per person today to ten per person by 2025.[29] For a future smart city with connected traffic lights, parking lots and meters (gas, water, power), the approximately 2000 active users per square kilometre envisaged in 4G is very different from the assumptions made in developing the IMT-2020 standard where 5G aims to support at least one million connections per square kilometre.[30]

As a consequence of these new capabilities, 5G is expected to impact on many different industries, driving new processes and productivity growth. Some examples include:

- Agriculture: Monitoring and control
- Education: New learning opportunities enabled by Augmented and Virtual Reality applications

[27] ITU, 'Emerging Trends in 5G/IMT2020', September 2016.

[28] ITU, 'Minimum requirements related to technical performance for IMT-2020 radio interface(s)', 22 February 2017.

[29] Statistica, 'Number of IoT connected devices worldwide 2019-2030', 19 October 2021.

[30] ITU, 'Key features and requirements of 5G/IMT-2020 networks', 14 February 2018.

- Health: Remote diagnosis, Telemedicine
- Logistics and transportation: Smart ports, autonomous connected vehicles
- Manufacturing: Automated robots and vehicles
- Public sector: Access to e-services
- Professional services: Improved remote workforce productivity.

Providing universal connectivity, particularly 5G connectivity, is also vital for creating a sustainable society – for example, it enables a multitude of new Internet of Things (IoT) applications with the potential to increase the efficiency of manufacturing, farming and transportation processes, saving energy and reducing waste. Indeed, a resilient telecoms infrastructure is a key component of United Nations Sustainable Development Goal (SDG) 9[31].

As illustrated above, the combination of access to huge amounts of data, analytics/computational power/artificial intelligence and connectivity (including bringing edge computing to mobile networks) has the potential to radically transform society and generate substantial economic growth. However, the full benefits can only be realised through universal access to these new services through high-speed networks, including 5G. For example, a government cannot move entirely to self-service provision via the Internet whilst a proportion of its citizens are unable to make use of such services due to a of lack connectivity, access to Internet-enabled devices and digital skills.

In order to address the lack of universal connectivity, individual governments in Latin America have set ambitious targets for connectivity improvement, including plans for both fibre and 5G roll-out:

- Argentina:
  - The Argentine government launched the 'Plan Conectar' (Connect Plan) in September 2020 with the intention to invest ARS37.9 billion in promoting universal access to ICT services.[32,33] The government secured a USD100 million loan from the Inter-American Development Bank to fund the initiative in October 2021.[34] The four-pronged approach consists of:
    - Investing ARS19.95 billion in the national satellite program, ARSAT.
    - Investing ARS13.2 billion to expand the national fibre optic and upgrade equipment for a tenfold increase in broadband capacity.
    - Investing ARS450 million to provide 80% coverage of digital terrestrial television (DTT).
    - Investing ARS4.3 billion in the National Data Centre run by ARSAT.
- Brazil:
  - The Brazilian government launched its Structural Plan for Telecommunications Networks (PERT) in 2019 and it is updated annually.[35] The plan seeks to (i) diagnose shortfalls in digital connectivity in Brazil, (ii) identify any competition concerns in telecoms markets, (iii) identify

[31] See European Commission, 'Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: Next steps for a sustainable European future: European action for sustainability', COM(2016) 739 final, 22 November 2016 and United Nations General Assembly, 'Resolution adopted by the General Assembly on 25 September 2015: 70/1. Transforming our world: the 2030 Agenda for Sustainable Development', Reference A/RES/70/1, 21 October 2015.

[32] Government of Argentina, 'The National Connectivity Plan "Connect" was presented', 16 September 2020.

[33] Pagina12, 'What does the Connect Plan consist of?', 26 May 2022.

[34] Inter-American Development Bank, 'Argentina to Increase Internet Access and Digitization of Remote Areas with IDB Support', 14 October 2021.

[35] Anatel, 'Structural Plan for Telecommunications Networks – PERT', 12 July 2021.

projects which aim to address these shortfalls, and (iv) identify funding for such projects. PERT was most recently updated in April 2021, and identified strategic projects including:

- Expansion of the fibre backhaul network to areas unserved by this infrastructure
- Expansion of 3G and 4G services to unserved areas
- Expansion of high-speed broadband access networks in areas with low average speeds.

It also identified sources of funding for these projects, including spectrum assignment revenues, licence obligations and the Fund for Universalisation of Telecommunications Services (FUST).

The FUST is particularly interesting. It was established by the Brazilian Government in 2001 to fund the provision of connectivity in areas where it would otherwise be uneconomic. The primary contribution to this fund is from operators, who are required to contribute 1% of gross operating revenue from telecoms services.[36] In total, ~BRL44 billion has been contributed to the FUST since its establishment, including BRL1.58 billion in 2021.[37] However, it has largely failed to release this funding for strategic connectivity projects. Nevertheless, changes to the FUST legislation in December 2020,[38] followed by a decree regulating the application of the new rules in March 2022[39] and the publication of the regulator's (Anatel's) 5-year plan for the use of the FUST in May 2022,[40] mean this funding should soon be released to aid investment in extending connectivity.

– Anatel completed an auction of 700MHz, 2.3GHz, 3.5GHz and 26GHz spectrum in 2021, raising BRL47.2 billion.[41] Coverage obligations were associated with the spectrum, including obligations for 3.5GHz licensees to meet the following requirements:

- All state capitals to be covered with 5G by July 2022
- All municipalities with > 100 000 people to be covered with 5G by July 2027
- 100% of municipalities with < 30 000 people to covered with 5G by December 2029.[42,43]

In order to meet these licence obligations, operators were offered discounts on their auction fees in exchange for infrastructure investments. We discuss this further in Section 5.2.6.

- Chile:

– The Chilean regulator, Subtel, awarded 700MHz, AWS, 3.5GHz and 26GHz spectrum in 2021.[44] Winning bidders were required to use the spectrum for high-speed mobile – the 700MHz and AWS bands are eligible for deployment with either LTE-Advanced (i.e. 4G) or 5G, whilst the 3.5GHz and 26GHz bands are eligible for 5G only. Furthermore, significant coverage obligations were associated with the spectrum, including requirements to provide 90% population coverage within two years and provide high-speed mobile services in 366 underserved areas within three

[36] Anatel, 'Fund for Universalization of Telecommunications Services – FUST', 10 May 2022.

[37] BNAmericas, 'Is the longstanding stalemate over Brazil's Fust fund finally over?', 21 May 2022.

[38] Government of Brazil, 'Law No. 14,109, of December 16, 2020', 16 December 2020.

[39] Government of Brazil, 'Decree No. 11,004, of March 21, 2022', 21 March 2022.

[40] Government of Brazil, 'Judgement No. 184, of May 18, 2022', 18 May 2022.

[41] Ministry of Economy, 'Biggest auction in the history of telecommunications in Brazil, 5G guarantees BRL 47.2 billion in investments', 8 November 2021.

[42] Anatel, 'Bidding No. 1/2021-SOR/SPR/CD-ANATEL. Radio frequencies in the bands of 700MHz, 2.3GHz, 3.5GHz and 26GHz', 27 September 2021.

[43] Agência Brasil, 'In Brazil, 5G expected available in all capitals by July 2022', 3 December 2021.

[44] Subtel, 'Result of 5G public tenders (700MHz – AWS – 3.5GHz – 26GHz)', February 2021.

years. To meet these obligations, Subtel estimate that operators will need to deploy 5G on more than 9000 sites.[45]

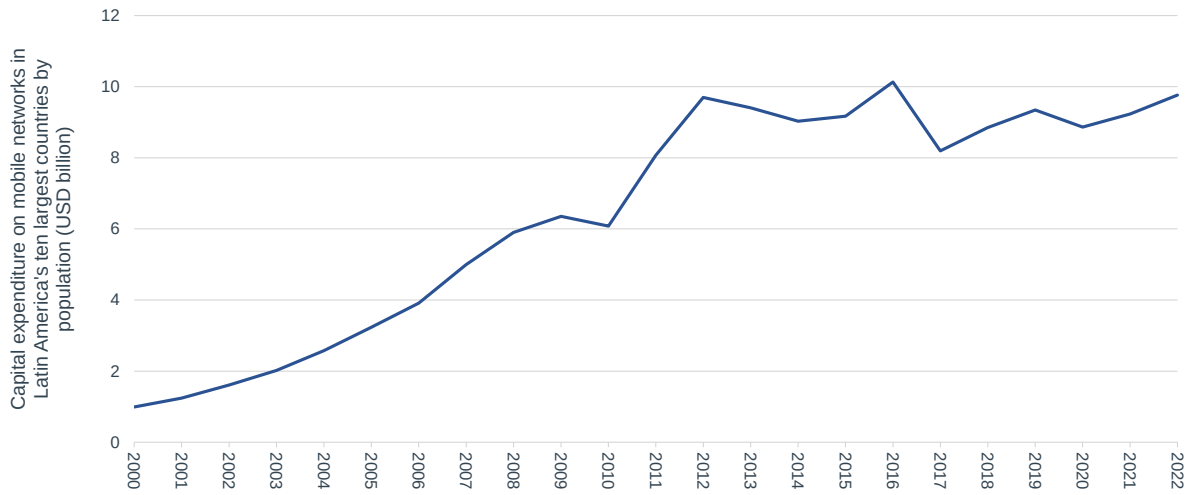
Other countries have announced similarly ambitious targets. For example, the European Commission (EC) has set out a clear ambition for all European households to be covered by a Gigabit network and all populated areas to be covered by 5G by 2030, as part of its Digital Decade[46].

## 3.2 Financial challenges facing mobile operators

Given the significant investment required in deploying networks in commercially unviable areas, connectivity targets can only be met through a combination of incentivising private investment to a maximum and leveraging public funding to bridge remaining coverage gaps. The funding required from the public (the so-called 'investment gap') depends on the extent to which the telecoms industry can fund network coverage expansion, including 5G deployments.

Mobile operators are making record investments in their networks at present - see, for example, the annual capital expenditure by operators in Latin America's ten largest countries in Figure 3-4 below.[47]

**Figure 3-4: Annual capital expenditure (excluding spectrum) on mobile networks in Latin America's ten largest countries by population [Source: GSMA Intelligence[48]]**




Such high levels of investment are arising as a consequence of:

- The requirement to **invest in new 4G and 5G technology** – including both radio access network (RAN) and core network upgrades (incl. virtualisation) to support low latency, network slicing etc.
- The requirement for operators to **operate four generations of mobile technology in parallel** – 2G, 3G 4G & 5G. Operators will seek to shut down 2G/3G networks in the coming 5-15 years, but short-term they will be needed to support users/devices (incl. M2M) which are 4G/5G incompatible.
- **Investing in new network architectures** – as mobile traffic grows, investments need to be made in deploying additional spectrum, plus moving to a small cell architecture in the densest areas.

[45] Subtel, '5G FAQ – Will the service only be available in Santiago?', 26 May 2022.

[46] European Commission, '2030 Digital Compass: The European Way for the Digital Decade', March 2021.

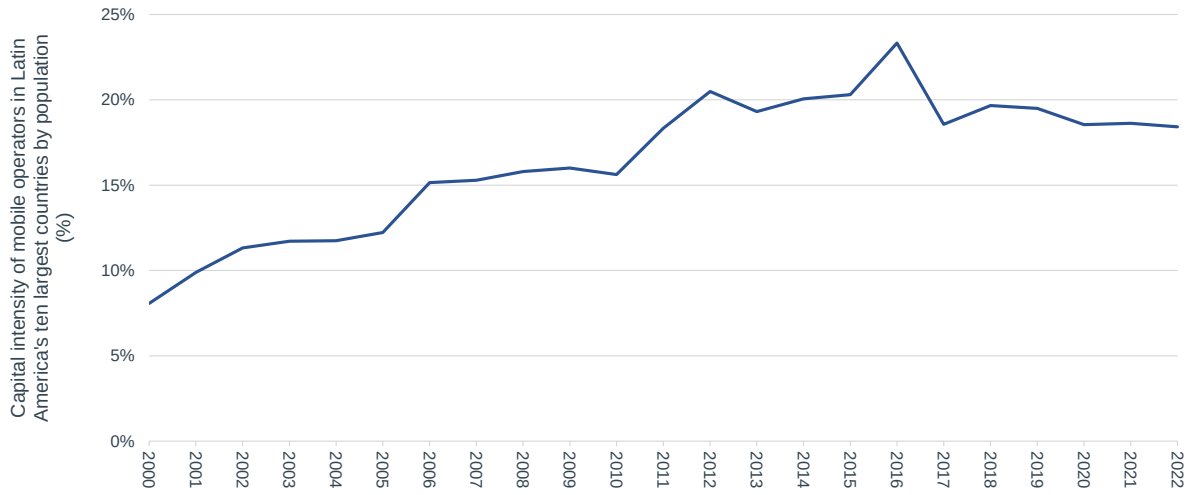
[47] These countries are Brazil, Mexico, Colombia, Argentina, Peru, Venezuela, Chile, Ecuador, Guatemala & Cuba.

[48] GSMA Intelligence, 'Financial – Cost & Profitability. Total Capex', Accessed 17 May 2022.

- **Deploying new sites to increase network coverage** – there are coverage gaps in operators' coverage footprints and investment in new sites is required to close these gaps. This is in addition to the additional sites that need to be deployed to extend network coverage in less populated areas.
- The cost of **spectrum acquisition** – This is a key expenditure, as we discuss further below.

This peak in capital expenditure is occurring at a time when operators' revenues are flat-lining (or even declining) – the surge in traffic has not translated into increased spending on mobile services. This is illustrated in Figure 3-5 below, which shows the capital intensity (capital expenditure as a proportion of revenue) of Latin American mobile operators from 2000-2022. Capital intensity has increased during this period and is now consistently at a level of ~20%. Similar observations have been made in other studies – e.g. the GSMA observed an increase in capital expenditure by Latin American operators from 2000-2022, combined with a decrease in Average Revenue Per User (ARPU).[49]

**Figure 3-5: Capital intensity of mobile operators in Latin America's ten largest countries by population (2000-2022) [Source: GSMA Intelligence[50]]**




The combination of these factors has meant that operators' margins have also reduced. For example, the development of mobile service revenue and operators' EBITDA (earnings before interest, tax, depreciation and amortisation) in Mexico from 2001-2016 is shown in Figure 3-6 below.

[49] GSMA, 'Taxing mobile connectivity in Latin America. A review of mobile sector taxation and its impact on digital inclusion' 2017.

[50] Source for capital expenditure: GSMA Intelligence, 'Financial – Cost & Profitability. Total Capex', Accessed 17 May 2022. Source for revenue: GSMA Intelligence, 'Financial – Revenue (Mobile)', Accessed 6 June 2022.

**Figure 3-6: Mobile service revenue and EBITDA in Mexico (2001-2016) [Source: Coleago Consulting[51]]**

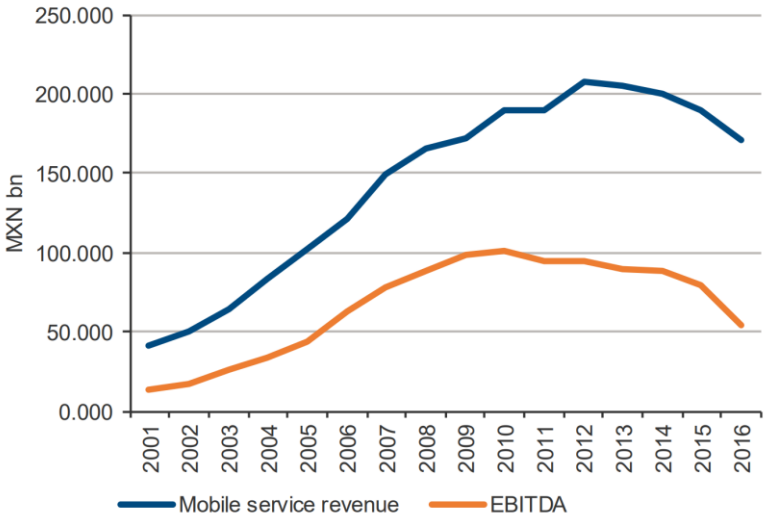



Figure 3-6 illustrates how Mexican operators' EBITDA margin (EBITDA as a proportion of revenue) decreased from ~45% in 2005 to ~30% in 2016, with total EBITDA falling from around 2010 onwards (and revenues from 2012 onwards). Such reductions are clearly unsustainable in the long term.

## 3.3 Impact of upcoming spectrum assignments

We outlined the key contributions to mobile operators record investments above, one of which is spectrum acquisition. Spectrum is a major area of investment for mobile operators and is sometimes described as the 'lifeblood' of a mobile network. As discussed in Section 4.1 below. spectrum can represent a considerable cost for mobile operators – up to 16% of recurring service revenues in some countries.

We highlight spectrum acquisition because the availability and price of spectrum are often under the direct control of regulators, in contrast to many of the other sources of financial pressure outlined above (e.g. revenue decline). It is therefore an area in which regulators can make a positive contribution towards easing operators' financial challenges, potentially increasing the investment they are able to make in other areas (e.g. 5G deployment) and reducing the investment gap.

Operators require a portfolio of low-, mid- and high-band spectrum to support high-speeds to customers, provide sufficient network capacity and enable network coverage to be provided to less populated areas in the most cost-effective way. Sufficient low frequency spectrum (below 1GHz) is needed to provide mobile services to areas (less populated areas, deep indoor areas) which higher frequency signals cannot reach. Looking forward, mobile operators in Latin America need to both acquire spectrum in new bands and seek to renew their existing spectrum holdings:

- **New spectrum** is required to enable capacity growth and the deployment of new services:
  - The award of 700MHz, AWS-3 and 2.5GHz spectrum is important to support capacity growth and, in the case of the 700MHz band, provide a low frequency coverage layer mobile services.
  - Full initial deployment of 5G (providing a real step-change to existing 4G performance) requires operators to utilise 700MHz (or 600MHz) spectrum (for a low frequency coverage layer), a large contiguous block (e.g. 100MHz) of mid-band spectrum e.g. in the 3.5GHz range (to offer high-

[51] Coleago Consulting, 'Supporting Mexican Digitisation', 24 June 2017.

speed services across a wide area) and 26/28GHz spectrum (to provide sufficient capacity in very busy areas (e.g. transport interchanges, sports/entertainment arenas etc)). Whilst 5G can notionally be provided using existing spectrum that has been assigned to mobile, this will not support the full performance/high-speed 5G services that are key to unlocking the wider economic and societal benefits that the technology brings.

  - In the future, additional mid-band spectrum (e.g. upper 6GHz band) will be required to support traffic growth in city areas. GSMA Intelligence estimates that mid-band spectrum will generate around 63% of the total GDP uplift generated by 5G[52]. Additional low-band spectrum (e.g. 600MHz) will be needed to provide extra capacity in deep indoor and more rural areas that cannot be reached by mid-band spectrum and additional mmWave spectrum (e.g. 40GHz band) may also be required.

- **Existing spectrum** is important for continuing to offer 2G, 3G and 4G services. Losing access to certain bands (e.g. 8500MHz, 1900MHz and AWS-1) could necessitate an operator shutting down services to part of its customer base (e.g. individuals who do not have compatible 4G devices). Over time, this spectrum can be refarmed for use by newer technologies (e.g. 5G) and will provide additional capacity to support traffic growth.

### The relevance and prevalence of new spectrum awards

Spectrum availability is key to enabling new technologies (e.g. 5G) and the innovative applications they enable. However, many Latin American countries have only made limited amounts of mobile spectrum available. For example, the GSMA analysed the spectrum assigned to mobile operators in Latin America in August 2017, finding that only Brazil had licensed a comparable quantity of spectrum to developed markets in Europe and North America (with the UK and USA used as comparators).[53] Whilst individual country positions have since changed, the conclusion remains the same –Latin American countries lag considerably behind in terms of spectrum availability, creating spectrum scarcity.

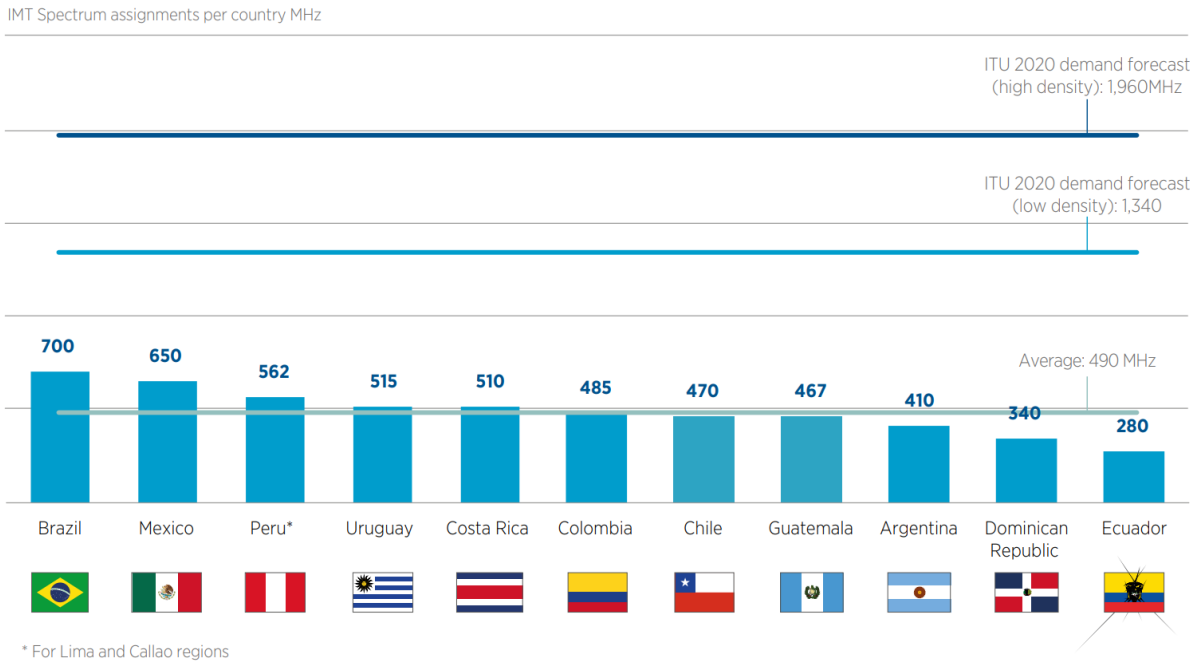
A more recent analysis by the GSMA, the results of which are shown in Figure 3-7 below, indicated that the average quantity of licensed mobile spectrum in Latin American countries was 490MHz as of November 2020. Furthermore, the country with the highest quantity of licensed spectrum, Brazil, had allocated only 700MHz of spectrum to mobile operators. In comparison, the UK had licensed a total of 925MHz as of this date (excl. mmWave), whilst the USA had licensed a total of 832MHz[54] – both have since licensed additional spectrum. The results of this analysis reinforce the point above – spectrum availability in Latin America is lagging significantly behind that in Europe and North America.

[52] GSMA Intelligence, 'The Socio-Economic Benefits of Mid-Band 5G Services', February 2022.

[53] GSMA, 'Effective Spectrum Pricing in Latin America, Policies to support better quality and more affordable mobile services', November 2017.

[54] Analysys Mason, 'Comparison of total mobile spectrum in different markets', June 2020.

**Figure 3-7: Spectrum licensed for IMT services in Latin America – November 2020 [Source: GSMA[55]]**




As discussed above, it important that regulators in each country make appropriate amounts of low-band, mid-band and high-band spectrum available – it is not just simply the total amount of spectrum that is made available that matters – a portfolio of spectrum types is key.

A large number of spectrum assignment processes are scheduled to take place in Latin America in the coming years, with a focus on 5G-suitable spectrum in, for example, the 700MHz and 3.5GHz bands. Figure 3-8 below shows details of the planned spectrum awards in Latin American countries of which we are aware, focussing on those expected to occur within the next two years (i.e. by year-end 2023).

[55] GSMA, '5G and the 3.3-3.8GHz Range in Latin America', November 2020.

**Figure 3-8: Upcoming spectrum awards in Latin America [Source: GSA[56]]**

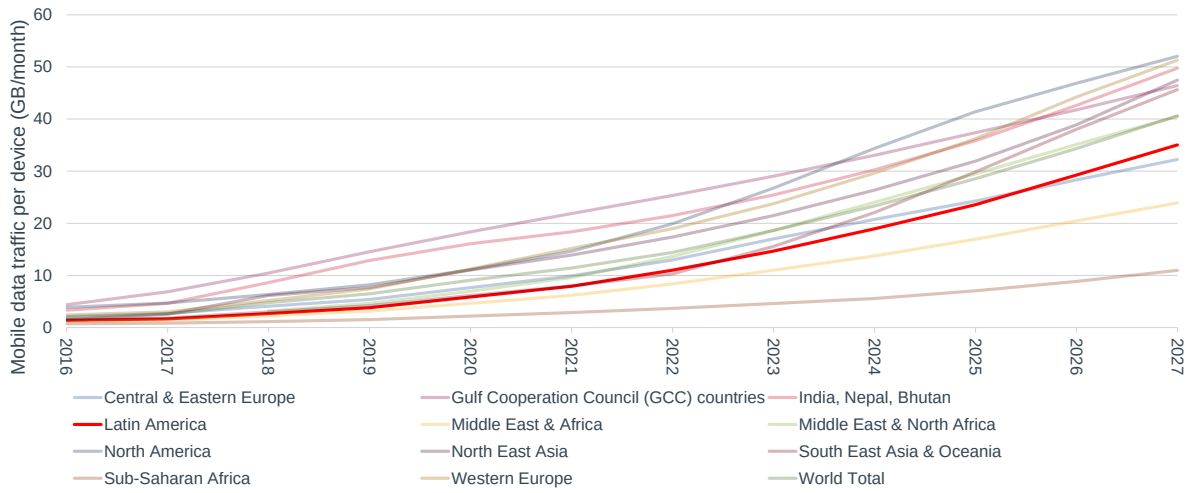
| | Bands | Date |
|---|---|---|
| **Argentina** | 700MHz, AWS, PCS | 2023 |
| **Brazil** | 26GHz | 2022/2023 |
| **Colombia** | 3.5GHz | 2022 |
| | 2.3GHz | 2022 |
| **Costa Rica** | 850MHz, 900MHz, 1400MHz, 3.5GHz, 26GHz, 40GHz | 2022 |
| | 700MHz, 2.3GHz, 3.5GHz, 26GHz, 28GHz | 2022/2023 |
| **Ecuador** | 700MHz, AWS, 2.5GHz, 3.5GHz | 2022 |
| **El Salvador** | 700MHz | 2022 |
| **Guatemala** | 700MHz | 2022 |
| **Guyana** | 700MHz, 3.5GHz | 2022 |
| **Honduras** | 700MHz, 3.5GHz | 2022 |
| **Mexico** | 600MHz, 850MHz, 1400MHz, 3.5GHz | 2022 |
| **Panama** | AWS | TBC |
| **Peru** | AWS-3, 2.3GHz | 2022 |
| **Uruguay** | 3.5GHz | 2022 |

Having access to this additional spectrum is critical for mobile operators. As discussed above, operators require a portfolio of low-, mid- and high-band spectrum in order for the full benefits of 5G to be realised. In particular, a large contiguous block of mid-band spectrum (e.g. 100MHz of 3.5GHz spectrum) is required for operators to be able to offer 'Real 5G' speeds to their customers.

Spectrum is also required more generally to support forecast traffic growth – as shown in Figure 3-9 below, data traffic is expected to grow faster than the global average in Latin America with a Compound Annual Growth Rate (CAGR) from 2021-2027 of 28% compared to a global average of 24%. This forecast is made in view of the role of mobile connections as the primary means of Internet access for many citizens in the region.

[56] GSA, 'Spectrum Auctions Calendar', May 2022.

**Figure 3-9: Forecast growth in mobile data traffic per smartphone (GB per month) [Source: Ericsson[57]]**




If new spectrum is not made available to a mobile operator in a timely manner, it will not be able to offer new services at the same quality as other operators in the market, potentially undermining its competitive position. As a result, the operator may suffer a market share fall and revenue decrease relative to its competitors. This in turn will mean that the operator has even less ability to invest in its network, exacerbating the problem. Furthermore, the operator will face higher costs in supporting forecast data traffic growth – for example, it will have to deploy additional base station sites (at high cost) instead of deploying new spectrum bands on its existing sites (at a lower cost). Finally, the additional costs faced by the operator due to lack of access to spectrum will lead to increased prices for customers, affecting the operator's competitive position once again – it is a vicious cycle.

## The relevance of spectrum renewals to mobile operators

In the case of spectrum that is expiring, the lack of availability of spectrum in any particular band could have a major impact on mobile operators. For example, lacking access to 850MHz spectrum could mean an operator cannot offer nationwide 2G or/and 3G services – this would not just impact users of 2G/3G-only devices, but also users of 4G devices that are not VoLTE capable. The loss of PCS and AWS-1 spectrum would result in a loss of 3G and 4G (and sometimes 2G) network capacity. Loss of a combination of bands would be even more disastrous.

The following case studies for Norway and Thailand vividly highlight the potential risks associated with adverse outcomes from renewal processes for key spectrum bands.

[57] Ericsson, 'Ericsson Mobility Report: Mobile data traffic outlook', November 2021.

## Case Studies – Risks from spectrum renewal processes

### Norway – Poor auction design leads to market exit by Tele2

**Background:** Tele2, the third-largest operator in Norway, held a licence for 2×5.1MHz of spectrum in the 900MHz band prior to Norway's 4G multi-band spectrum auction in 2013. Within the auction, which adopted a first price, sealed bid format, Tele2 was unsuccessful in acquiring any spectrum, which was acquired by other incumbents (Telenor & TeliaSonera) and an entrant (Telco Data).[58]

The auction design, which the regulator communicated as being driven by a desire to maximise revenues, was a one-shot first price, sealed bid auction forcing operators to make risky bids. Tele2 ultimately placed too low a bid and was left without low-frequency spectrum, which is vital for providing widespread voice and data coverage. Tele2 ultimately decided that it was unable to compete effectively in the market without this spectrum and entered into a merger agreement with TeliaSonera which was approved in October 2015, resulting in its exit from the market.[59]

**Key learnings:** The one-shot auction design forced operators to place risky bids on key spectrum assets and forced an existing operator to exit the market, harming the market and competition.

### Thailand – New entrant outbids incumbent operator and creates 2G continuity risk

**Background:** In 2015, Thailand hosted a multi-band auction including a renewal of 2×20MHz in the 900MHz band, previously licensed to AIS.[60,61] There were four bidders in the auction – however, only two were successful in acquiring spectrum: True Move (the third-largest operator) and Jasmine (a new entrant). Neither of the two largest operators (AIS, dtac) acquired 900MHz spectrum, despite the spectrum being essential to AIS's (2G) network. The bidding was highly competitive – at the time, it was reported that final prices were the highest ever per MHz paid for 900MHz spectrum.[62]

Whilst it had access to other bands (1800MHz / 2.1GHz), the loss of its 900MHz spectrum created a significant business risk to AIS as it faced significant gaps in its network coverage (built on 900MHz) and had about 400,000 devices relying solely on 900MHz.[63] Ultimately, there was no impact on the market, purely as a result of Jasmine defaulting on its payments and AIS re-acquiring the 900MHz spectrum in a subsequent auction.[64]

**Key learnings**: By placing all of AIS's 900MHz assets up for auction, the largest operator in the market was faced with an enormous business continuity risk, placing the service of millions of customers at risk. This situation stimulated excessive bidding, driving prices beyond rational levels and resulted in one of the winning bidders defaulting on its payments.

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[58] Tele2, 'Tele2 AB: Tele2 Norway does not obtain frequencies in the Norwegian spectrum auction', 6 December 2013.

[59] Norwegian Competition Authority, 'The Norwegian Competition Authority clears the acquisition of Tele2 by TeliaSonera, subject to conditions',21 October 2015.

[60] Telegeography, 'Jasmine, True win 900MHz licences in USD4.2bn auction', 21 December 2015.

[61] Telegeography, 'NBTC confirms 900MHz, 1800MHz auction by September 2015', 17 November 2014.

[62] Developing Telecoms, 'True and Jasmine win Thai 4G licences with record bids', 22 December 2015.

[63] Telegeography, 'AIS wins month leeway to migrate 900MHz users', 17 March 2016.

[64] Telegeography, 'AIS wins uncontested 900MHz re-auction at USD2.11bn', 31 May 2016.

## The importance of upcoming spectrum awards to mobile operators

Fundamentally, because spectrum is so critical to operators, a lack of information about how it will be assigned and the price that will need to be creates a huge amount of uncertainty and risk for an operator:

- It is not certain that the operator will be able to gain access to the portfolio of spectrum required to deploy a new technology such as 5G. This may in turn delay deployment/investment in the new technology until the operator has certainty that it will have the portfolio of low- and mid-band (and ultimately high-band) spectrum that it requires to offer a competitive 5G service.
- If the operator needs to pay a high price for spectrum, it will limit the funding available for network investments – including deploying new base station sites for coverage expansion and accelerating 5G technology deployment across its network footprint. Therefore, funds cannot be invested in advance of spectrum award processes, just in case they are needed to acquire spectrum holdings.
- In the case of spectrum renewal, it is not clear whether the operator will maintain access to any individual spectrum band. This may require a major reconfiguration of the network and/or result in the loss of customers, thereby impacting on the operator's revenue and profitability and the cash remaining (if any) for investment in network expansion. Consequently, making large investments in network expansion is incompatible with operators waiting to undertake spectrum renewal.
- In the last few years of existing spectrum licences operators will be reluctant to invest in new technologies using the spectrum in question because there is always a risk that they may not be able to reacquire the spectrum – essentially this creates a 'dead' period towards the end of licences when investment in the relevant spectrum band(s) ceases.

For all the above reasons, it is important for mobile operators to have confidence that spectrum award processes will enable them to acquire the new spectrum they require, as well as retain key existing spectrum, at a reasonable price. This way, they can divert their energy and investments into deploying 5G and extending mobile network coverage, thus helping to widen connectivity to more citizens and improve the quality of existing services (e.g. higher speeds, lower latency), enabling each country to gain the full economic benefits from the use of 5G technology. In the following sections of this report we discuss how policymakers can help to provide mobile operators with this level of confidence.

# 4. Best practices for spectrum pricing

One of the key contributions to mobile operators' record investments is spectrum acquisition, as alluded to in Section 3.3. Given this, and the fact that spectrum availability and pricing are often under the direct control of regulators, it is an area in which regulators can make a positive contribution towards easing operators' financial challenges. By easing the financial burden of spectrum acquisition, regulators can increase the investment operators are able to make in other areas (e.g. 5G deployment), reduce the investment gap, and thereby increase the likelihood of connectivity and sustainability targets being met.

If one is to lessen the financial burden of acquiring spectrum, it is essential to firstly understand the Total Cost of Spectrum Ownership (Section 4.1). Furthermore, it is essential to understand the risks and impacts of high spectrum prices and adopt best practice approaches to spectrum pricing (Section 4.2). Ultimately, mobile operators are having to acquire additional spectrum to support high traffic growth at a time when revenues are static or declining – therefore, if spectrum were to continue to be awarded at the same unit price (per MHz), the overall spectrum cost (as a proportion of revenue) would increase. This is unsustainable and therefore the unit price of spectrum must decrease.

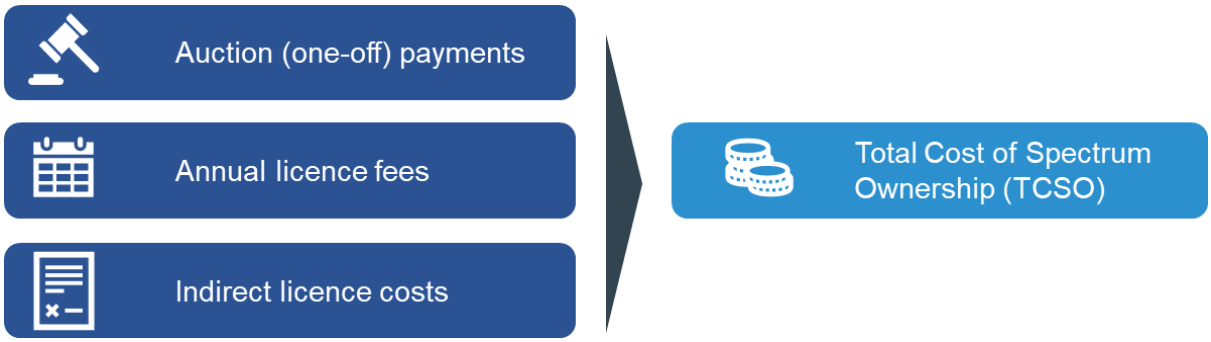
## 4.1 Total cost of spectrum ownership

We highlighted in Section 3.3 that operators require a portfolio of low-, mid- and high-band spectrum. In future, operators will require both new spectrum and continued access to existing spectrum in order to be able to offer a complete set of mobile services (2G, 3G, 4G & 5G).

However, the financial burden of spectrum acquisition is a key component of the financial challenges facing operators. Furthermore, the availability and price of spectrum are often under the direct control of regulators. Spectrum pricing is therefore an area in which regulators can make a positive contribution towards easing operators' financial challenges, as highlighted above.

For regulators to make positive decisions regarding spectrum pricing, it is important to consider all aspects of spectrum price; the Total Cost of Spectrum Ownership comprises several components:

**Figure 4-1: Components of the Total Cost of Spectrum Ownership**




- **Auction (one-off) payments**: The amount of money determined by the award process, typically expressed as a one-off lump sum (although staggered payments are increasingly common).
- **Annual licence fees**: Annual spectrum fees are charged to cover the cost of administering the spectrum and are typically determined outside the award process.
- **Indirect licence costs:** Licences can contain specific obligations, for example to extend network coverage. The costs of these obligations can be difficult to quantify as they depend on the operators' private cost structures and network rollout ambitions; however, they can be significant.

The total cost of spectrum to a mobile operator is the sum of the three components. Therefore, a mobile operator will only seek to acquire spectrum if the TCSO is lower than the value of the spectrum to the mobile operator (e.g. in terms of network cost savings, additional revenue generating opportunities etc).

Consequently, the true 'reserve price' in an auction is the sum of the published reserve price, annual licence fees and any indirect licence costs. Again, if this sum is higher than the value of the spectrum to the operator, then the operator will not be interested in acquiring the spectrum in an auction, no matter how low the published 'reserve price' appears to be. Therefore, policymakers must consider the cost of annual fees and licence obligations when determining auction reserve prices – if the cost of one component is high (e.g. a coverage obligation), the others should be reduced to account for this.

Unsurprisingly, given the importance of spectrum to mobile operators, their expenditure on spectrum is considerable. One way to evaluate the impact of spectrum costs on mobile operators is to consider these costs as a percentage of revenues. Here, the cost of spectrum considers all mobile spectrum licences currently in use by the operator, not just those most recently awarded. It considers both upfront payments (translated into an annualised amount) and any annual fees associated with each licence. The resulting annualised spectrum cost for each operator can then be divided by the operator's annual mobile service revenue. A similar calculation can be undertaken at a country level by summing the spectrum costs of all of the operators and dividing by the total mobile service revenues in the country.

GSMA Intelligence has undertaken such an assessment on mobile spectrum prices in Colombia and Ecuador. Expenditure on spectrum in Colombia[65] was estimated to amount to around 6% of recurring revenues. For Ecuador, GSMA Intelligence found[66] that spectrum costs amounted to just over 16% of recurring revenue – the highest across the Latin America region despite the amount of spectrum assigned for mobile use in Ecuador (around 280MHz) being amongst the lowest in the region (the regional average was estimated to be around 490MHz, as shown in Figure 3-7 above).

The main limitation of this calculation is that it does not take account of indirect licence costs (e.g. coverage obligations) since these are hard to quantify; however, it does provide a lower bound indication of the impact of spectrum costs on all mobile operators in each country.

A study on spectrum pricing by NERA[67], undertaken on behalf of the GSMA, found that median prices for capacity spectrum in Latin America are approximately 60% higher than prices paid in Europe. More generally, a study on the impact of spectrum pricing on consumers undertaken by the GSMA[68] also found that spectrum prices as a % of revenues were around three times higher in developing markets than in developed markets.

Spectrum is a pre-requisite for the provision of mobile services – operators cannot exist without it – and therefore the fees associated with it can, to some extent, be considered to be an additional form of taxation on the industry – a 'spectrum tax'.

This is particularly true of ongoing spectrum costs; specifically, annual licence fees and one-off fees for previously assigned spectrum, such as that available in renewal processes. This spectrum is required for continuity of services and, over time, will be refarmed to the latest more spectrally efficient technologies; however, the spectrum on its own does not directly enable the provision of all new products/services or open up new revenue streams. Therefore any costs associated with this spectrum may reasonably be considered to be a form of additional taxation on mobile operators. This 'spectrum

[65] GSMA Intelligence, 'Effective spectrum pricing in Colombia, September 2021.

[66] GSMA Intelligence, 'Effective spectrum pricing in Ecuador', October 2021.

[67] NERA Economic Consulting on behalf of GSMA, 'Effective Spectrum Pricing in Latin America: Policies to support better quality and more affordable move services', February 2018.

[68] GSMA, 'The impact of spectrum prices on consumers', September 2019.

tax' is in addition to many other telecoms sector specific taxes and fees – a GSMA study[69] identified that sector-specific taxes account for one-fifth of all tax payments made by the telecoms industry on average across Latin America.

In summary, it can be seen that spectrum costs are a significant burden for operators, especially so in several Latin America countries, with costs being as high as 16% of recurring revenues just for the operators' existing spectrum holdings. In light of the large number of upcoming spectrum awards in Latin America, it is clear that the TCSO needs to be carefully considered by regulators in the region.

## 4.2 Risk and impact of high spectrum prices

In this section, we discuss the risks and impacts of high spectrum prices, as well as highlighting some actions that policymakers might take to address these risks. As highlighted previously, mobile operators are having to both acquire new spectrum and renew their existing spectrum holdings to provide services to customers and support high traffic growth (typically 30%-50% network traffic growth each year). At the same time, revenues are relatively static or declining. Therefore, if spectrum were to continue to be awarded at the same unit price (per MHz), the overall spectrum cost (as a proportion of operator revenues) would increase considerably.

Such a situation would be unsustainable – effectively, as the amount of spectrum held by an operator increases, the unit price paid by the operator for spectrum has to decrease. However, regulators often use the outcomes of historic auctions in the country as a basis for setting spectrum prices, including reserve prices for auctions. This is likely to result in excessive spectrum prices being set, carrying significant risks such as spectrum remaining unassigned.

There are many examples of spectrum going unassigned in auctions as a result of the effective reserve prices being set too high. This can arise from different components of the TCSO – not just the reserve price for the auction itself. For example:

- High annual fees have resulted in spectrum remaining unassigned in Mexico and Romania
- An onerous emergency services obligation resulted in spectrum remaining unassigned in the USA
- High auction reserve prices in India and Thailand have resulted in spectrum remaining unassigned.

In all cases, the failure to assign spectrum is indicative of regulators failing to recognise (i) the need for unit spectrum prices to reduce over time in order for the telecoms industry to be sustainable, and (ii) the need to consider all aspects of the TCSO (auction payments, annual licence fees and indirect licence costs) when setting auction reserve prices.

To address this issue and ensure that spectrum prices remain affordable in the long term, it is essential for policymakers to consider all components of the TCSO across operators' entire spectrum portfolio when awarding spectrum. The overall objective should be to ensure that the spectrum tax (i.e. TCSO as a proportion of revenue) is set at a manageable level – it certainly should not exceed 10%, and the overall benefits to the economy are likely to be higher if it is lower. Only by keeping the spectrum tax at a manageable level is it possible to avoid the problems highlighted in the case studies below.

[69] GSMA, 'Taxing mobile connectivity in Latin America: A review of mobile sector taxation and its impact on digital inclusion', 2017.

## Case studies – The negative impact of annual fees on spectrum auctions

### Romania – High annual fees leading repeatedly to unsold spectrum

**Background:** 2.6GHz FDD spectrum has remained unassigned in Romania through two auction processes (2012 and 2021) due to very high reserve prices.[70,71,72] In the 2012 auction, spectrum also remained unassigned in the 800MHz band for the same reason.[73] This has been primarily due to high annual fees, resulting in the TCSO being in excess of operators' valuations.

**Key learnings:** The ultimate impact of this has been spectrum remaining unassigned for many years, denying both operators and consumers from the potential benefits associated with it. This is clearly an inefficient outcome and could be solved easily be reducing annual spectrum fees.

### Mexico – High annual fees leading to spectrum being unassigned and even returned

**Background:** Large amounts of AWS and PCS spectrum remain unassigned in Mexico. As an example, in the 2021 auction for 800MHz, AWS, PCS and 2.5GHz spectrum, only 3 of the 41 lots were sold. The result was attributed to high annual fees by the regulator, IFT, which has previously submitted proposals for adjusted annual licence fees to the Mexican government. [74]

Mexican operators have even returned spectrum due to the high annual spectrum fees. Telefónica relinquished its 800MHz, PCS and 2.5GHz frequencies, reportedly generating USD104 million in savings. Having returned its spectrum, it now provides services as a virtual operator using AT&T's network, having signed an access agreement with AT&T in 2019.[75]

**Key learnings:** High annual fees have left large amounts of spectrum unsold and have forced an operator to shut down its network. This is an inefficient outcome which is widely accepted to have negatively impacted consumers through reduced quality of service etc.

[70] ANCOM, 'Results of the spectrum auction for mobile electronic communications', 24 September 2014.

[71] ANCOM, 'Task book for the organisation of the competitive selection procedure in view of granting some radio frequency right in 800MHz, 2600MHz and 3400-3600MHz', September 2021.

[72] ANCOM, 'This year's auction for spectrum allocation has been completed', 23 November 2021.

[73] GSMA, 'Effective Spectrum Pricing in Europe: Policies to support better quality and more affordable mobile services, September 2017.

[74] Telecoms.com, 'Mexican regulator blames high prices for spectrum auction failure', 8 October 2021.

[75] Telegeography, 'Telefonica generates EUR95m from returned Mexican spectrum, report says', 28 February 2020.

## Case studies – The impact of high reserve prices and costly obligations on auctions

### Thailand – Historic spectrum pricing leads to unsold spectrum

**Background:** As previously highlighted, the 2015 Thai 900/1800MHz auction resulted in Jasmine (a new entrant) defaulting on its payment. but contributing to competitive bidding leading to very high prices.[76] In 2018, a further auction for 1800MHz only sold two of the nine available lots.[77] The primary reason for this were the reserve prices, set based on prices from the 2015 auction.[78]

**Key learnings:** With more spectrum available in the market, there was no interest in acquiring spectrum at high prices. By setting the wrong reserve price, the regulator contributed to there being unsold spectrum – a situation that was repeated in an auction of 850MHz spectrum in 2018.[79]

### India – High reserve prices lead to unsold spectrum

**Background:** India has repeatedly failed to assign spectrum, including in the 700MHz band, due to the setting of very high reserve prices.[80] It first attempted to award spectrum in the 700MHz band in 2016; however, all spectrum remained unassigned.[81] In total, more than 50% of the available spectrum in this auction (which included other bands) remained unsold. A second auction was held in 2021; however, all 700MHz spectrum again remained unassigned, as well as spectrum in the 2.1GHz and 2.5GHz bands (in total, ~70% of the available spectrum remained unassigned in 2021).

**Key learnings:** The primary reason for spectrum remaining unassigned has been high reserve prices, combined with the heavy debt burden on the industry resulting from previous high-price auctions. The result is that large quantities of spectrum remain unassigned, despite operators expressing clear interest, holding back 4G deployments and impacting the quality of service.

### USA – Emergency service obligation leads to unsold spectrum

**Background:** The 2008 700MHz auction included one 2×5MHz lot (D Block) requiring the winning bidder to deploy a national public safety communications network via a public/private partnership. As all bids received in the auction did not exceed the reserve price, the lot remained unsold. [82]

**Key learnings:** This is an example of where onerous licence obligations (a key element of the TCSO) resulted in spectrum remaining unassigned – bidders considered that the cost of addressing this obligation made acquiring it at the specified reserve price unjustifiable.

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[76] Mobile World Live, 'Thailand's AIS, True pay $1.1B each to win 1.8GHz licences', 13 November 2015.

[77] Telegeography, 'NBTC's 1800MHz auction concludes with just two blocks sold', 20 August 2018.

[78] NERA Economic Consulting, 'Spectrum Auction Risks Leaving Thailand Stranded in a Mobile Data Slow Lane', 15 December 2017.

[79] Telegeography, 'AIS, DTAC submit bids for 1800MHz spectrum; 850MHz auction cancelled', 9 August 2018.

[80] European 5G Observatory, 'Spectrum auction raised 778 billion INR (9 billion EUR) in India, but 700MHz spectrum was left unsold for second time', 18 March 2021.

[81] Telegeography, 'Spectrum auction nets USD9.9bn despite conservative bidding', 7 October 2016.

[82] FCC, 'Auction 73: 700MHz Band', 18 March 2008.

Even in cases where the reserve prices in an auction have not been so high that the spectrum remained unassigned, high prices are unlikely to represent an efficient market outcome and can be considered to be a revenue (tax) raising exercise for the government.

**Case study: Italy – Spectrum packaging results in high prices**

**Background:** Italy assigned 200MHz of 3.5GHz spectrum in 2018. The auction was successful in terms of assigning spectrum; however, operators were forced to compete strongly for the spectrum, resulting in prices much higher than in other European countries.[83] There were two main reasons:

- Firstly, a relatively small quantity of spectrum was made available. 200MHz equates to 50MHz per operator in Italy, far below the 80-100MHz that operators typically target.
- Secondly, rather than awarding the spectrum in equal-sized lots which would allow all operators to acquire a meaningful quantity, the band was split into two 80MHz lots and two 20MHz lots. This meant that at least two operators would acquire 40MHz or less, effectively forcing an outcome that would create 'winners' (those acquiring ≥80MHz) and 'losers' (those acquiring ≤40MHz).

**Key learnings:** The high prices in this auction are likely to have negatively impacted upon 5G deployment in Italy, as a greater proportion of operators' budgets had to be diverted towards spectrum acquisition and away from network investment. Therefore, it could be argued that this auction failed to meet its objectives, despite the successful assignment of all spectrum.

A study undertaken by NERA[84] on a possible link between spectrum fees and service prices also examined whether there could be a link between spectrum fees and network investment. This study considered network investment in terms of the coverage of 3G and 4G networks, average speeds and the proportion of subscribers on 4G networks, finding a modest correlation between higher prices for spectrum and lower levels of network investment. The results of this study were referenced within the GSMA's report on 'effective spectrum pricing'.[85]

A report produced by LS telcom, PolicyTracker and VVA for the Directorate General for Communications Networks, Content and Technology of the European Commission[86] included an analysis of the relationship between auction prices and network coverage, comparing OpenSignal data on 4G availability with auction prices. The results suggested that there may be an inverse relationship between price paid for spectrum and network availability (i.e. higher auction prices are associated with lower 4G availability).

One counter-argument that is sometimes made regarding the impact of high spectrum prices (particularly from competitive auction processes) on network investment is that the intensity of competition in the auction resulting in high auction prices will translate into operators maximising their network investments in order to secure the high returns that are required to justify the prices paid for the spectrum. In considering this issue, it is important to consider the different types of investments that are made:

[83] European 5G Observatory, 'Italian 5G spectrum auction', 15 October 2018.

[84] NERA Economic Consulting, 'The Impact of High Spectrum Costs on Mobile Network Investment and Consumer Prices', May 2017.

[85] GSMA, 'Effective Spectrum Pricing: Supporting better quality and more affordable mobile services', February 2017.

[86] LS telcom, VVA and PolicyTracker for the European Commission Directorate General for Communication Networks, Content and Technology, 'Study on Spectrum Assignment in the European Union', October 2017.

- Investments that are made for commercial reasons i.e. to help maximise an operator's revenues and profit – such as the rapid deployment of 5G in the biggest cities. Here it is possible that this argument may apply although it would be expected that the operator's business case would include the profit-maximising investment/network deployment strategy, independently of the amount paid for spectrum.

- Investments that are made for wider societal reasons e.g. extending network coverage that on a strict commercial basis are uneconomic for the operator to provide coverage. This is the type of network investment that we are discussing in this report and clearly if an operator is forced to spend more money on spectrum, less money will inevitably be available for such network coverage expansion.

A further argument is that network investment can in some cases be seen to increase in cases where operators have not acquired spectrum due to high prices or acquired less spectrum that they would have targeted in advance of an auction. Here it is important to distinguish between efficient network investment and inefficient network investment. Specifically if an operator does not acquire spectrum in an auction, it may actually be forced to spend more money on its network in order to deploy new network sites to support the levels of traffic generated by the operator's customers. However this is not efficient investment – the more efficient investment would be to deploy additional equipment on existing sites to use new frequency bands as this would be considerably lower cost than deploying new sites. In this report we are concerned with maximising efficient investments by network operators – not inefficient investments.

On the topic of the link between high spectrum prices and the prices of mobile services to consumers, in a competitive market with high fixed costs/barriers to entry such as telecoms, market prices typically seek to recover marginal costs and fixed costs[87]. Consequently, if the costs of inputs such as spectrum, site rental, staff salaries etc are higher, then ultimately market prices will reflect these higher costs since they need to be recovered by the operator. Consequently if spectrum fees are higher, then over time, the underlying price of mobile services will also be higher - and if spectrum fees are lower, then the underlying price of mobile service should be lower.

In summary, high spectrum prices can have a detrimental effect on network investment. With the increasing amount of spectrum required by operators to meet customer needs, unit prices for spectrum must go down. Therefore, regulators should not continue to adopt the approach of using previous auction price outcomes to set reserve prices for upcoming auctions – otherwise, these auctions are going to result in spectrum remaining unassigned with hugely detrimental impacts on the operation of the mobile market, the prices of mobile services and levels of network investment by mobile operators. Instead, spectrum prices should be set in consideration of all components of the TCSO, with the overall objective of keeping the spectrum tax at a manageable level (<10%).

### Consideration of the TCSO when comparing and setting spectrum prices

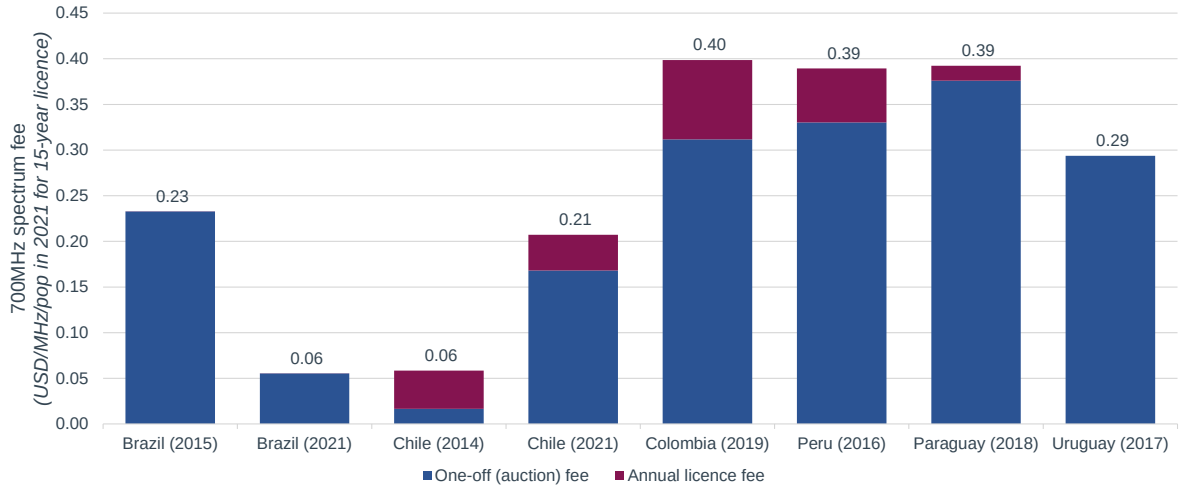
Spectrum pricing decisions should be made in consideration of all aspects of the TCSO, including auction payments, annual licence fees and indirect licence costs (i.e. the costs of meeting licence obligations), as operators' investment decisions will be dependent on the sum of these components.

Countries have very different levels of spectrum fees; in particular, annual licence fees. This is illustrated in Figure 4-2 below, which shows 700MHz prices in several example Latin American countries/spectrum auctions, including the split of 700MHz spectrum prices between one-off and annual licence fees.

[87] See, for example, Harald Gruber, 'The Economics of Mobile Telecommunications', 2005.

Importantly, a country which has high annual fees cannot expect to gain the same levels of auction outcome price as a country which has a relatively low level of annual fees.

**Figure 4-2: 700MHz spectrum fees in Latin America separated into upfront (one-off) and annual licence fees [Source: Aetha]**




When using international benchmarks to set spectrum prices, account needs to be taken of both the annual fees and the reserve price/auction outcomes when comparing across countries. Furthermore, account should also be taken of the cost of meeting obligations, though, as discussed in Section 4.1, this can be difficult to do quantitatively since these costs are often unknown.

A price benchmark (auction outcome/reserve price plus annual fees) in a country where the licence obligations are onerous should therefore be excluded from a benchmarking exercise – or the additional obligations taken account of when reaching a qualitative conclusion regarding the price of the spectrum.

Ultimately, if expanding network coverage is the key policy objective, regulators should consider accepting lower spectrum fees in return for operator commitments to expanding mobile coverage/5G deployment – we discuss this further within Section 5.2.6, outlining the benefits of doing so in terms of maximising investment and connectivity.

Finally, reserve prices should typically be set to be low but non-trivial, in consideration of all components of the TCSO, thereby letting the market determine an efficient allocation of spectrum and the corresponding market price of the spectrum.

### Review of annual fees formula and parameters

The formulas and parameters used for setting annual fees for spectrum have in many countries been set many years ago. Whilst they were often appropriate at the time, in some cases the parameters used in the formulas are no longer appropriate and require modification. For example:

- Formulas do not always differentiate between low and high frequencies (or have a cut-off at a relatively low level). The same price per MHz cannot be charged for e.g. 700MHz spectrum (where an operator may have 2×15MHz) as for 2.5GHz spectrum (where an operator may have 100MHz) or 26GHz spectrum (where an operator may have 800MHz). A multiplier related to the frequency range needs to be included which reflects the frequencies currently used for mobile services.

  - Singapore charges an annual licence fee of SGD7700 per 5MHz (or part thereof) for exclusive use of spectrum for public mobile radio services, regardless of frequency.[88] This means the same annual licence fees are payable for both 700MHz and mmWave spectrum, for example. This is clearly inappropriate, given the material differences in the value of the spectrum to operators as a result of their differing coverage characteristics.

- Use of an income related parameter – for example, a labour price, income or inflation parameter in the formula. Such a parameter will automatically cause unit prices for spectrum to increase (e.g. with wage inflation) – this is the opposite direction to the change in the actual value of each MHz of spectrum to the operator. Such a parameter should no longer be incorporated in the formula.

  - The Mexican regulator, IFT, charges an inflation-indexed annual licence fee for spectrum.[89] However, since revenues have historically not increased with inflation, the annual fee per MHz as a proportion of revenue has increased with time. Furthermore, the quantity of available spectrum has also increased, meaning the total annual licence fee as a proportion of revenue (i.e. the spectrum tax) has increased even more materially, placing financial pressure on operators. This has a potentially detrimental impact on investment, which is further impacted by the uncertainty regarding inflation and therefore future spectrum fees.

- Annual fees should not discourage network deployments – for example annual fees in some countries increase linearly with the number of base station on which the spectrum is deployed – creating a disincentive to widening service availability.

[88] IMDA, 'Spectrum Management Handbook', February 2022.

[89] Coleago Consulting, 'Supporting Mexican digitisation', 24 June 2017.

# 5. Best practices for spectrum award processes

Spectrum award processes pose significant risks to mobile operators, especially if a large quantity of spectrum (potentially including key existing spectrum holdings) is awarded through a single process. However, policymakers can contribute to minimising any unnecessary risks from the award process.

In this section, we discuss the key questions facing policymakers when awarding spectrum (Section 5.1) before presenting our recommendations based on international best practices (Section 5.2). These recommendations are made in the context of ensuring that the TCSO is manageable for mobile operators. Finally, we detail the benefits of awarding spectrum in line with best practice (Section 5.3).

## 5.1 Key questions facing regulators

Developing a best practice spectrum award remains a challenging task, despite the large number of awards that have taken place worldwide over the last 10 – 20 years, including in Latin America. An ever-changing technology environment, a growing number of available bands and changing market structures all contribute to there not being a 'one-size-fits-all' solution.

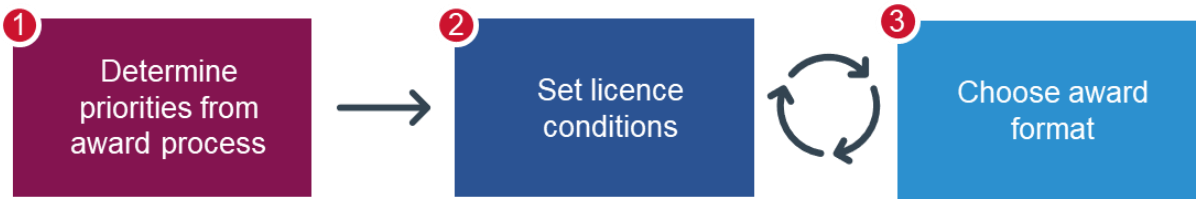
The first question to consider when awarding spectrum is that of **timing**. The appropriate timing of spectrum award processes will vary; however, it is important that it occurs in a timely manner so as to minimise the uncertainty faced by operators but not before there is demand for the spectrum from mobile operators and a well-developed equipment/device ecosystem supporting the spectrum's use.

The second question is that of **spectrum availability**. Where possible, policymakers should aim to maximise the quantity of available spectrum, ensuring there is sufficient for all operators in the market.

Once the subject and timing of the award process has been determined, there are three key questions that policymakers should answer when awarding spectrum – as illustrated in Figure 5-1 below:

1. ***What are the priorities for the award process?*** Without a clear target to achieve, it is impossible to design the right process.
2. ***Which licence conditions to attach to spectrum?*** Licence conditions cover a wide range of topics (technology restrictions, coverage obligations, licence duration etc.) and have a significant impact on the value of the spectrum that is awarded. Therefore, they need to be carefully defined.
3. ***Which type of award process is most suitable?*** Whilst auctions are the most common format, there are a variety of award mechanisms available to policymakers to award spectrum.

**Figure 5-1: Key questions facing policymakers ahead of spectrum awards**




In the remainder of this section, we discuss these key questions in more detail, noting that the choice of award process can be an iterative process, interlinked with the choice of licence conditions. In each case, we also outline our recommendations, based on international best practice. With respect to the question of setting the right licence conditions, we focus in particular on the question of licence duration.

## 5.2 Recommended best practice approach to spectrum awards

In this section, we outline our recommendations for conducting spectrum award processes based on international best practices. We do so in the context of the key questions highlighted in Section 5.1. Specifically, we provide detailed recommendations and examples of good/bad practice with regards to:

- **Timing of award process** (Section 5.2.1): Spectrum should be awarded as soon as possible once there is proven demand from mobile operators, and it has been cleared of incumbent use.
- **Spectrum availability** (Section 5.2.2): Sufficient spectrum should be assigned to meet the needs of all operators, avoiding preferential access for local/industrial users unless there is excess supply.
- **Objectives of process** (Section 5.2.3): The objectives of the spectrum award process and relative priorities should be clearly defined prior to its commencement.
- **Conditions of spectrum use** (Section 5.2.4):
  - **Longer licence durations:** Longer, ideally indefinite, licence durations provide certainty for operators when making network investments, as well as allowing a longer amortisation period.
- **Design of award process** (Section 5.2.5):
  - **Administrative spectrum award:** Administrative spectrum award processes may be appropriate in cases where demand does not outstrip supply.
  - **Auction:** Auctions are likely to be appropriate where demand for spectrum exceeds supply.
  - **Partial renewal:** Where existing spectrum is being re-awarded and demand for spectrum exceeds supply but existing licensees face business continuity risks if they lose spectrum, policymakers should consider guaranteeing renewal for part of operators' holdings in key bands.
- **Auction best practices** (Section 5.2.6): To be adopted in situations where an auction is necessary.

### 5.2.1 Timing of award process

One issue facing regulators is when to undertake spectrum award processes. Spectrum bands should be made available at a time when they are likely to be needed by the market – for example, for the deployment of new technologies such as 5G and for capacity expansion of existing networks (e.g. 4G).

At this point, spectrum should typically be awarded as soon as possible. However, prior to this, the co-existence conditions for use of spectrum by IMT and any other legacy users need to be defined and, in some cases, spectrum needs to be cleared of incumbent uses. The band clearance process can cause delays, resulting in the loss of economic value as these incumbent uses of spectrum typically generate considerably lower levels of economic or societal benefit. Regulators should look for means of accelerating such band clearance processes, where they are required.

At the same time, spectrum should not be unassigned unduly early – for example, if it is going to take some years for the spectrum to be cleared and there is considerable uncertainty over when a band will be cleared, or there is a lack of supporting equipment ecosystem (network equipment and/or consumer devices) and lack of clarity over when the equipment ecosystem is likely to develop. Nonetheless, in some cases regulators signalling the expected time of release of spectrum in the future can be very helpful for industry development as this itself can stimulate the development of the equipment ecosystem.

Band clearance is particularly important for low frequency (sub-1GHz) spectrum, as highlighted by the case studies of Brazil and Singapore below. This includes the 600MHz and 700MHz bands where television broadcasting in neighbouring countries can be a barrier to using the spectrum for mobile services. In Latin America, interfering high-power television transmissions from neighbouring countries may not cover too much of the area/affect too much of the population of the larger countries, but it may still be an issue for smaller countries or countries with large cities/population centres near the border.

## Case studies – Clearing sub-1GHz spectrum of incumbent use

### Brazil – money from 700MHz auction is used to fund TV's digital switchover

**Background:** Brazil first auctioned 700MHz spectrum in 2014, awarding four 2×10MHz lots (three nationwide, one regional) for a total of BRL5.22 billion – this left two further lots of regional spectrum unassigned.[90] However, in addition to the stated auction price, winning bidders were required to pay for the 700MHz spectrum to be cleared of incumbent broadcasting use, including the installation of filters to mitigate interference etc. The cost of this obligation was estimated at BRL3.60 billion[91], with the money to be paid to an entity called EAD that would manage the clearing process.[92]

**Key learnings:** There are positive aspects of this approach – for example, the principle of using proceeds from the spectrum award to fund migration of incumbent users from the band. However, the implementation was flawed. There was a lack of clarity regarding (i) the cost of clearing the band (and hence the amount to be paid by operators) and (ii) the timeline for spectrum availability. This created uncertainty for operators, impacting their ability to invest in the spectrum and corresponding network deployments, ultimately leading to some spectrum remaining unassigned.

### Singapore – 700MHz spectrum awarded several years before it is usable for IMT

**Background:** IMDA, the Singaporean regulator, awarded 700MHz spectrum in April 2017.[93] However, the licences were not to start immediately due to ongoing use of the spectrum for analogue TV services.[94] At the time of the auction, the 700MHz licences were planned to start on 1 January 2018, subject to the switch-off of analogue broadcasting services in Singapore by year-end 2017. However, the spectrum is still not in use several years later (as of May 2022). This is despite analogue TV switch-off having been completed on 1 January 2019.[95] The reason that licences have yet to start is interference from analogue broadcasting services in neighbouring countries, particularly Indonesia.[96]

**Key learnings:** Whilst timely allocation of spectrum is encouraged, there must be certainty that it is going to be cleared of incumbent use (except in cases where the intention is for the band to be shared). Otherwise, this creates uncertainty for operators – it is difficult for operators to efficiently plan network deployments if they are unsure when spectrum will be available.

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[90] Organization of American States, 'Auction of the 700 MHz in Brazil', 12 February 2015.

[91] Anatel, 'Public Notice 002/2014 – SOR/SPR/CD – Anatel. Notice 700MHz Responses to Requests for Clarification', 2014.

[92] Anatel, 'The 700MHz auction in Brazil', 2014.

[93] IMDA, '700 MHz Spectrum Rights (2016), 900 MHz Spectrum Rights (2016), 2.3 GHz Spectrum Rights (2016) and 2.5 GHz Spectrum Rights (2016) Auction ("2016 Spectrum Auction")', 26 May 2017.

[94] IDA Singapore, 'Auction of 700 MHz spectrum rights (2016), 900 MHz spectrum rights (2016), 2.3 GHz spectrum rights (2016) and 2.5 GHz spectrum rights (2016). Information memorandum', 29 April 2016.

[95] IMDA, 'Digital TV', 23 May 2022.

[96] GSMA, 'Securing the digital dividend across the entire ASEAN. A report on the status of the implementation of the APT700 band for ATRC', August 2018.

In respect of spectrum that is reaching the end of its existing licence period and is due to be renewed, uncertainty regarding future spectrum availability is damaging for investor confidence. This uncertainty increases the closer that one gets to the end of their licence period as, if spectrum were not to be renewed, the scope to recover one's investment prior to licence expiry reduces (i.e. the risk is higher).

It is therefore imperative that renewal processes are commenced in advance of licence expiry, limiting the degree of uncertainty faced by operators and protecting investor confidence. The optimum timing is situation dependent; however, it is advisable for renewal processes to be completed at least 1-2 years prior to licence expiry. This has a secondary benefit of allowing operators to plan for any spectrum redistribution or other changes to licence terms that are deemed necessary during the renewal process.

### 5.2.2 Spectrum availability

An additional issue that requires consideration prior spectrum awards is that of spectrum availability. The priority for regulators should be to ensure that sufficient spectrum is made available in any given band to meet the needs of all operators in the market, in light of the vast numbers of customers that they serve and the magnitude of the resulting economic benefits of using the spectrum.

Specifically, regulators should avoid giving any preferential access to local or industrial users unless the supply of spectrum is greater than the demand from mobile operators or unless there are constraints that prevent the spectrum being used for high power deployment. Such 'set-asides' where mobile operators are excluded from being able to acquire/use the spectrum reduce the spectrum available to mobile operators, resulting in a loss of economic benefits. In cases where a competitive auction process is used, it can result in high spectrum prices, risking taking funds away from being used on network investments.

### 5.2.3 Objectives of process

Once the available spectrum has been determined, the first key step for policymakers is to determine their main objective(s) for the spectrum award process. In all cases, it is essential for the objectives and priorities to be well understood prior to the spectrum award process – this information is required to make informed decisions regarding other aspects of the process (e.g. award format, licence conditions).

The objectives of the spectrum award process vary depending on the situation, but commonly include:

- Creating incentives to ensure the technically and economically efficient use of spectrum
- Encouraging investment in the widespread deployment of innovative new technologies and services
- Ensuring that the award process is transparent and non-discriminatory
- Protecting competition in the mobile market, both at the retail and infrastructure level
- Ensuring a fair return for a valuable public resource
- Maximising the quality of mobile services received by consumers (network speeds and coverage)
- Minimising retail prices for mobile services.

We would expect regulators' priorities to include encouraging the growth and development of the mobile market, (including expanding network coverage), maintaining (or increasing) competition between operators, and encouraging investment and innovation.

Conversely, we would not expect maximising spectrum assignment revenues to be a priority – in the European Union, Best Practice 24 of the European Connectivity Toolbox[97] specifically states that "Member States should avoid revenue maximization".

[97] European Union Connectivity Special Group, 'Common Union Toolbox for Connectivity', March 2021.

Although we understand that there is sometimes pressure from government to secure a minimum amount of revenue – we would expect the regulator to prioritise the long-term economic benefits of having a functioning mobile market and maximising service availability/connectivity over short-term government revenues. We observe that other services providing connectivity in hard to reach places (e.g. satellite) pay considerably lower (and in some cases zero) spectrum fees, partially in recognition of the key societal role that they play – this principle should be extended to mobile service providers.

We also note that improved connectivity has the potential to elicit significant economic benefits, increasing the productivity and profitability of businesses across many industries. This is likely to translate into increased tax revenues for governments – therefore, lower spectrum fees may, in the long term, translate into increased government revenue.

### 5.2.4 Conditions of spectrum use

A key question is which licence conditions to attach to the spectrum. As highlighted in Section 5.1, licence conditions cover a wide range of topics (technology restrictions, coverage obligations, licence duration etc.) and have a significant impact on the value of the spectrum that is awarded, meaning they need to be carefully defined when awarding spectrum. The most significant consideration when awarding spectrum is the duration of new/renewed licences and, therefore, we focus on this issue here. However, all licence conditions must be carefully considered for successful assignment to occur.

#### Longer licence durations

Regulators sometimes consider offering shorter licences (e.g. 10 years) in view of the difficulty in accurately forecasting technological and market developments beyond this. Furthermore, in the case of renewals, regulators can sometimes be tempted to offer short ‘extensions’ to existing licences (e.g. 5 years), particularly in cases where the renewal process is administrative. However, in both cases it is important that licence durations are sufficiently long to encourage investment.

Operators investing in the deployment of new radios and antennas for a particular frequency band will require time to recover this investment and a longer amortisation period can enhance an operator’s balance sheet. A 5-year licence does not provide sufficient time to do so and, therefore, such a short period should not be used unless there are particularly strong spectrum management reasons why it is appropriate (e.g. to align expiry with other licences in the band).

However, even with longer licence durations, one of the main issues with a finite duration licence is that it creates a ‘dead period’ at the end of the licence where no network investment is likely to take place (unless there is a very high likelihood of renewal). These ‘dead periods’ arise due to the uncertainty for operators over whether they will regain access to the spectrum following licence expiry, especially if a competitive award process is likely. This risk means that little investment in using the spectrum (e.g. deploying a new technology) is made towards the end of its licence period – this is not the most efficient use of spectrum that regulators aim for.

Indefinite spectrum licences overcome this problem. Few countries have adopted such an approach – mainly the USA (even in the USA, licensees are subject to “substantial service” requirements). The UK has also adopted perpetual licences for certain mobile frequency bands where spectrum has been auctioned with an initial minimum term (typically 20 years) for which a fixed price is paid, after which licences are renewed annually. Japan is another example of a country making use of indefinite spectrum licences. We provide further details of these examples in the case studies below.

## Case studies – Countries providing long-term spectrum certainty

### USA – Initial term with indefinite extension

**Background:** The American regulator, the FCC, has awarded renewable spectrum licences in many bands, including PCS, WCS, 700MHz, AWS and 3.5GHz.[98,99] Licences are awarded with an initial term which is typically either 10 or 15 years. However, there is a presumption of renewal, other than in exceptional circumstances.

**Key learnings:** This right of renewal means the spectrum licences are effectively of indefinite duration, providing operators with greater certainty regarding their future spectrum holdings and thereby promoting investment.

### United Kingdom – Initial term with indefinite extension

**Background:** For certain frequency bands, the United Kingdom regulator, Ofcom, has awarded spectrum licences of indefinite length with a fixed initial licence period during which the licence cannot be revoked other than in exceptional circumstances (e.g. if the terms of the licence have been breached). For example, in the UK's multi-band spectrum auction in 2021, all licences were awarded with an initial term of 20 years. After this initial term, the licences are renewed annually on payment of the annual licence fee, however Ofcom has the right to revoke the licence for spectrum management reasons, provided it gives operators at least five years' notice.[100] Essentially, the licences effectively become indefinite in duration. The same indefinite licence durations apply in other spectrum bands, including the 800MHz, 2.1GHz and 2.6GHz bands etc.[101]

**Key learnings:** Awarding licences of indefinite duration provides operators with greater certainty regarding their future spectrum holdings and thereby promotes investment. Ofcom does however face the challenge of setting the appropriate annual fee for the spectrum after the initial minimum term is over.

### Japan – Base-station licences with indefinite renewal option

**Background:** In the 2019 5G award already discussed above, the award conditions did not specify a specific licence duration as spectrum licences are granted for individual base stations with a duration of 5 years.[102] However, as these licences are renewable, they effectively become indefinite in duration.

**Key learnings:** Whilst this approach raises concerns in terms of its complexity, it provides more certainty regarding future spectrum availability, encouraging investment.

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[98] FCC, 'Report and Order – Promoting Investment in the 3550-3700MHz Band', 24 October 2018.

[99] FCC, 'Public Notice – Auction of Flexible-Use Service Licenses in the 3.45-3.55 GHz Band for Next-Generation Wireless Services; Notice and Filing Requirements, Minimum Opening Bids, Upfront Payments, and Other Procedures for Auction 110; Bidding to Begin October 5, 2021', 9 June 2021.

A further benefit of indefinite licences is that they increase liquidity by promoting spectrum trading. There is extensive spectrum trading in the USA, partially for historical reasons due to the award of licences on a localised basis but also because of the inherent value of indefinite use of the asset. The UK is the only European market where any major mobile spectrum trades have taken place and these trades of 1400MHz and 2.6GHz spectrum may not have occurred if the licence durations had been fixed.

**Case study: Spectrum trading in the UK and USA**

**Background:** One potential impact of indefinite licences is in spectrum trading – i.e. the market migrating spectrum to the party which can make most efficient use of it, without the direct involvement of regulators. It has been allowed in many countries for a number of years; however, there are relatively few examples of successful spectrum trades. The UK and USA buck this trend. For example, the UK has seen trades in the 1400MHz (Qualcomm to Vodafone/Three)[103] and 2.6GHz bands (EE to O2)[104], whilst the USA has seen many trades, including in the AWS band (AT&T to T-Mobile)[105].

**Key learnings:** Whilst it is not the only enabling factor, the certainty provided by the award of indefinite spectrum licences will have contributed to the success of these spectrum trades – it is unlikely that such transactions would have occurred in their absence.

We recommend that, where possible, policymakers adopt indefinite licence periods to provide maximum certainty to operators regarding future spectrum availability. Regulators can be concerned that issuing indefinite spectrum licences could potentially make it difficult to change the nature of use of the spectrum in the event that a new use arises. Whilst service and technology neutrality can help, sometimes the underlying conditions of use of the licence (e.g. power transmission rights/characteristics) can prevent other types of use. Even with indefinite duration licences, regulators retain the rights to terminate spectrum usage rights for spectrum management reasons and changes of use that could not be facilitated by the market alone can be facilitated by the regulator – this is not prevented by the existence of indefinite rights of use. For example, in the USA spectrum used for the provision of commercial broadcast television services in the 600-800MHz range have been repurposes for use for mobile services (creating the 600MHz and 700MHz bands) and spectrum used for satellite services (for the provision of space to Earth communications) has again been repurposed for terrestrial mobile use (3.7-4.0GHz range – the so-called 'C-band').

Nonetheless, recognising that some regulators may still not be open to indefinite licences, we recommend adopting a minimum licence period of 20 years to ensure that operators can generate sufficient returns from any investments – this has already occurred, for example, in Brazil, as highlighted below. Typically, such a duration will allow two cycles of equipment investment.

[100]Ofcom, 'Award of the 700MHz and 3.6-3.8GHz spectrum bands – Information Memorandum', 13 March 2020.

[101]ECO, 'ECO Report 03. The licensing of "Mobile Bands" in CEPT', 9 March 2022.

[102]APT, 'APT report on information of mobile operators' frequencies, technologies and license durations in Asia-Pacific countries', April 2021.

[103]Ofcom, 'Trade of frequencies in the 1452-1492 MHz band from Qualcomm UK Spectrum Ltd to Vodafone Limited and Hutchison 3G UK Limited', 22 September 2015.

[104]Telecompaper, 'Ofcom formally approves spectrum transfer from EE to O2', 5 November 2020.

[105]Fierce Wireless, 'FCC approves AT&T's AWS spectrum transfer to T-Mobile', 26 April 2012.

**Case study: Renewable spectrum licences in Brazil**

**Background:** Anatel, the Brazilian regulator, adopted several positive measures in its 2.3GHz, 3.5GHz and 26GHz auction in 2021, including offering discounts on spectrum fees in exchange for coverage commitments. Prior to this, it updated Brazilian telecoms laws in 2019 to extend licence terms to 20 years and introduce a presumption of renewal for spectrum licences, as well as to introduce a secondary spectrum market.[106]

**Key learnings:** The extension of licence durations and introduction of presumed rights of renewal, provides operators with certainty regarding spectrum availability. This is likely to translate into increased investor confidence, to the benefit of both operators and consumers.

This recommendation is consistent with third-party regulations regarding licence duration. For example, the European Electronic Communications Code (EECC) requires policymakers to provide "regulatory predictability" over a period of at least 20 years, with spectrum licences to be awarded with a minimum duration of at least 15 years (or longer, as required to provide the regulatory predictability).[107]

Extended licence durations should also be coupled with allowing operators to trade spectrum, as this will increase the efficiency of spectrum use.

### 5.2.5 Design of award process

Once the licence conditions have been defined, the next step is to assess the appropriate format to use to achieve the award's priorities within the stated timeline.

Regulators have historically relied on a variety of different award formats to make spectrum available:

- **Administrative spectrum awards**: Historically, spectrum licences have been awarded via simple administrative processes, particularly where demand for spectrum is equal to or less than supply.
- **Auctions**: Spectrum auctions are the most commonly used mechanism to award spectrum and typically award spectrum to the bidder that is prepared to pay most for the spectrum. Auctions have been used for many spectrum awards in Latin America over the last 10 years, including more than five in the last year alone (e.g. in Brazil, Chile, Mexico & Peru).
- **Partial renewal**: Partial renewal is a hybrid administrative/auction process, within which existing licensees are guaranteed renewal for part of their spectrum to ensure service continuity whilst allowing competition for remaining spectrum. This award format is only relevant in the context of previously assigned spectrum.
- **Beauty contests**: Historically, spectrum has at times been awarded through beauty contests, where bidders have to signal their plans with respecting to meeting a number of qualitative scoring criteria set by the regulator (in line with its priorities).

[106] GSMA, 'Brazil multi-band auction: one of the largest in mobile history', 22 December 2021.

[107] See Article 49(2) of European Union, 'Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code', 17 December 2018, sets out that "Where Member States grant individual rights of use for radio spectrum for which harmonised conditions have been set by technical implementing measures in accordance with Decision No 676/2002/EC in order to enable its use for wireless broadband electronic communications services ('wireless broadband services') for a limited period, they shall ensure regulatory predictability for the holders of the rights over a period of at least 20 years regarding conditions for investment in infrastructure which relies on the use of such radio spectrum, taking account of the requirements referred to in paragraph 1 of this Article."

Within this section, we will focus on administrative spectrum awards, auctions and partial renewal processes. We will not discuss beauty contests in detail. This is because beauty contests are subject to subjective scoring by individuals and lack transparency – they have therefore stopped being used in most countries (Japan being a notable exception, as discussed in a case study below).

We also exclude discussion of national wholesale networks here. In these processes, spectrum is awarded to a national infrastructure provider with the intention of setting up a common network that all mobile operators can use. Whilst several countries have announced plans for national wholesale networks in recent years, they have so far struggled to gain significant traction – with the Mexican wholesale operator going bankrupt and plans for a South African network being shelved.

#### 5.2.5.1 Administrative spectrum award

One option is to award spectrum directly via an administrative process. This may be appropriate in cases where demand does not outstrip supply. If demand is unclear, an industry consultation could be undertaken to understand this, allowing an informed decision to be made with regard to the award type. The primary benefit of this approach is that it provides certainty to those seeking spectrum access and avoids some of the risk/uncertainty raised by competitive award procedures.

Once a decision has been made to pursue an administrative spectrum award process, it is necessary to consider the details of the process. The exact nature of administrative spectrum award processes differs between countries and bands, depending on the demand for spectrum and whether it has previously been licensed for mobile use.

One option is for the spectrum to be split equally between all those wishing to acquire spectrum (typically mobile operators). Another is for spectrum to be split based on the demand expressed by stakeholders in the aforementioned consultation process. However, if the spectrum award is for previously licensed spectrum (i.e. it is a spectrum renewal), it may instead be appropriate for a simple renewal/extension of existing spectrum holdings to occur.

In this case, all current licensees would retain their existing spectrum under the same licence terms, often with no significant upfront fees (but possibly with annual licence fees). However, this would only be appropriate in situations where there is no excess demand, there is no possibility of the renewal creating an artificial barrier to market entry, and the regulator's objectives in terms of coverage and competition will continue to be satisfied under the current licence conditions

Policymakers also need to consider the conditions to attach to spectrum licences, given their objectives – doing so is part of the iterative award design process we outlined at the beginning of this section. If improving coverage/availability of services is a priority, the regulator could enter discussions with licensees with regards to how its objectives might be achieved (whilst acknowledging that operators will incur costs). For example, it could work with industry to agree commitments to expand network coverage in exchange for lower spectrum fees – this would likely yield much greater long-term benefits for the economy than higher spectrum fees, a point which has been highlighted by the GSMA which estimates that 5G will benefit the global economy by >USD960 billion annually by 2030.[108] Such an approach has been pursued in both France and Japan, as highlighted in the case studies below.

If competition in the mobile market is a concern, the regulator could work with operators to identify an appropriate rebalancing of spectrum holdings, particularly during spectrum renewal processes. An industry-driven solution is likely to be a simpler way of achieving such rebalancing of spectrum holdings than conducting an auction. We highlight the examples of Mexico and France below, within which spectrum has been renewed administratively and, in the case of Mexico, had technology restrictions

[108]GSMA, 'The Mobile Economy 2022', 28 February 2022.

removed, in exchange for industry agreements to redistribute spectrum (plus coverage commitments, in the case of France) – these processes provided certainty to existing licensees whilst continuing to promote competition through spectrum redistribution.

**Case studies – Different administrative spectrum award processes**

**Mexico – Licence renewal and technology neutrality in exchange for redistribution**

**Background:** In 2019, the Mexican regulator, IFT, renewed the 3.5GHz licences of AT&T, Axtel and Telmex for 20 years, in exchange for redistribution of the spectrum – each operator retained 50MHz of contiguous spectrum.[109] Following this, Telmex transferred its spectrum to Telcel[110], which acquired an additional 50MHz from Axtel[111]. Telcel then engaged with IFT to have the WiMAX technology restrictions removed, enabling 5G use, in exchange for annual licence fees of MXN900 million. [112,113]

**Key learnings:** Renewing spectrum licences provided certainty for operators whilst allowing redistribution of the spectrum to achieve contiguity, in line with the regulators objective of ensuring efficient use of spectrum. Relaxing technology restrictions enabled this spectrum to be used for 5G.

**France – Industry solution exchanging coverage commitments for auction fees**

**Background:** In 2018, the French regulator, ARCEP, engaged industry to sign a "New Deal for Mobile" when 900MHz, 1800MHz and 2.1GHz spectrum was up for renewal. Whilst technically an auction, the process effectively included a renewal at zero upfront cost in exchange for operators' agreeing to invest in coverage and redistribute 900MHz and 2.1GHz spectrum equally between all operators.[114, 115] The operators' committed to a ~EUR3bn investment to improve rural coverage, achieve ubiquitous 4G coverage, and improve transport corridor coverage and indoor services.

**Key learnings:** With licences expiring at various points in 2021, 2022 and 2024, starting the renewal process in 2018 provided operators with certainty and created a platform for investment, further enabled by ARCEP's decision to waive auction fees in exchange for coverage commitments.

**Japan – Beauty contest rewarding commitments in 5G**

**Background:** Japan typically awards spectrum via administrative processes. The 2019 award for 3.6-4.1GHz, 4.5-4.6GHz and 28GHz spectrum was a beauty contest, with criteria including 5G investment, 5G launch date, 5G coverage (using the awarded bands) and MVNO customers. [116,117]

**Key learnings:** The process traded off revenue generation against 5G coverage commitments. However, concerns remain around transparency – whilst this award type appears to work in Japan, beauty contests place a strong obligation on decision makers to score as objectively as possible.

#### 5.2.5.2 Auction

In those situations where the demand for spectrum is likely to exceed the supply, then a competitive award process such as an auction is typically appropriate. Adopting such an approach has multiple benefits, including increased transparency in the award process with allocation decisions being made

[109]Telegeography, 'AT&T, Axtel, Telmex renew 3.5GHz rights, report says', 22 October 2019.

[110]Telegeography, 'Telmex transfers 3.5GHz spectrum to Telcel ahead of 5G push', 14 April 2020.

based on objective criteria. Furthermore, auctions do not typically discriminate between existing licensees and potential new entrants, although there are exceptions to this.

Overall, whilst auctions present their own difficulties, they do address many of the concerns associated with administrative spectrum awards (e.g. in terms of transparency). However, the auction design should take account of the risks and uncertainties that operators face in competitive spectrum awards.

We make detailed suggestions on ways the auction process can be adapted accordingly in the following section (Section 5.2.6). However, we firstly discuss some of the key considerations to be made herein.

Firstly, we note that in situations where the key policy objective is extending network coverage, the award process can be designed to take account of this – e.g. by associating coverage obligations with specific lots or by offering spectrum price discounts in exchange for coverage commitments. An example is Chile, which typically adopts a two-stage process – an administrative stage focussed on non-financial criteria (e.g. coverage), followed by an auction. We discuss this further below, whilst additional examples of best practice with regards to prioritising coverage are provided in Section 5.2.6.

**Case study: Two-stage spectrum award process prioritises coverage in Chile**

**Background:** Article 13C of Chile's General Telecommunications Law stipulates that spectrum must be awarded to the applicant whose "project" provides the best technical conditions to ensure "optimal transmission or excellent service".[118] In other words, the primary criteria for spectrum assignment are non-financial, with achieving widespread coverage of high-quality telecoms services being the priority. Only if two applicants cannot be separated based on technical criteria alone is there an auction.

**Key learnings:** Chile effectively adopts a two-stage spectrum award process – an administrative stage focussed on non-financial criteria, followed by an auction (if necessary). This means that non-financial objectives such as coverage are always prioritised over auction revenue etc.

In addition, it is important that policymakers focus on the main objectives of the award process and do not get distracted by auction dynamics. We have observed situations in which policymakers are concerned about a possible lack of competition in an auction and adjust the spectrum packages, competition rules (e.g. spectrum caps) and/or detailed bidding rules to create artificial competition – for example, we note the case of Italy's 3.5GHz auction, details of which were provided in Section 4.2.

However, rarely (if ever) is a competitive auction the objective of the regulator – instead, the principal objectives of the regulator are encouraging competition and investment in the downstream mobile

[111]Telegeography, 'Telcel acquires 50MHz block of 3.5GHz spectrum from Axtel', 3 July 2020.

[112]Telegeography, 'IFT authorises Telcel to offer 5G services; promises 'largest 5G network in LatAm'', 11 February 2022.

[113]IFT, 'The IFT Plenary approves modifying 18 Telcel concession titles to offer 5G services. (Communication 8/2022)', 9 February 2022.

[114]ARCEP, 'Mobile coverage. New Deal Mobile. Implementation of new mobile coverage targets: Launch of the frequency reallocation procedure, and writing new obligations into operators' licences', 2 August 2018.

[115]ARCEP, '900MHz, 1800MHz and 2.1GHz bands: ARCEP opens a public consultation on the terms and methods for reallocating longstanding mobile telephony frequencies', 5 April 2018.

[116]Communication Infrastructure Bureau, 'Certification of a plan to open a specific base station for the introduction of the 5th generation mobile communication system (5G) (Overview)', April 2019.

[117]Communication Infrastructure Bureau, 'Examination results related to the approval of the establishment plan of a specific base station for the introduction of the 5th generation mobile communication system', April 2019.

[118]Government of Chile, 'General Telecommunications Law. Article 13 C', 14 June 2022.

market. Whether or not an auction is competitive should not be relevant provided the objectives of the award process are met – but this can sometimes be forgotten.

#### 5.2.5.3 Partial renewal for expiring spectrum licences

Competitive award processes (i.e. auctions) are typically appropriate in situations where demand for spectrum exceeds supply, as highlighted above. However, there are complicating factors where existing spectrum is being re-awarded. Therefore, in such cases the use of a partial renewal format should be considered – partial renewal is hybrid process in which part of the spectrum is awarded via administrative renewal whilst the remaining spectrum is awarded via a competitive award process.

One of the biggest risks faced by operators in spectrum renewal processes concerns business continuity. Without access to certain spectrum, an operator may not be able to continue supporting a given technology (e.g. 2G). The vast majority of this risk could be removed by offering existing licensees guaranteed renewal of part of their spectrum holdings in a band (e.g. 2×5MHz of 900MHz spectrum), ensuring a sufficient amount of spectrum is available to ensure they can continue to offer services to customers. The remaining spectrum could then be made available in a competitive award process (e.g. using a tried-and-tested auction format).

Such an approach would only be appropriate where the partial renewal is economically efficient and does not risk distorting competition in the mobile market. An example is provided in the following case study of Belgium – by providing a certain amount of spectrum to all existing licensees prior to the auction, operators were guaranteed to be able to continue operating existing 2G/3G/4G networks.

**Case study: Belgium reserves spectrum in existing spectrum bands for incumbent operators**

**Background:** BIPT, the Belgian regulator, is planning a multi-band spectrum auction for June 2022, within which it has reserved 2×5MHz of 900MHz, 2×15MHz of 1800MHz, and 2×10MHz of 2.1GHz spectrum for existing licence holders.[119]

**Key learnings:** This is an example of a partial renewal because each incumbent operator will be guaranteed access to a minimum quantity of spectrum at a fixed price. It therefore provides operators with a degree of certainty regarding future spectrum availability, removing much of the risk whilst still allowing the most efficient spectrum allocation to be determined via auction. This is good practice; however, there are other aspects of this auction process which do not necessarily correspond with best practice (e.g. the process has been delayed several times, potentially impacting 5G deployment).

Partial renewal is primarily relevant in the short-term where we have mobile technologies (such as 2G and 3G) that can only be deployed in specific frequency bands. Once operators have multiple bands in lo, mid and high-band spectrum and, over time, as all mobile technologies can be deployed across multiple bands, the level of risk faced by an operator in respect of an individual band is significantly lower and a partial renewal may not be so relevant. The exception to this may be the case where an operator is facing the renewal of a large number of frequency bands at the same time that represent a large portfolio of its spectrum holdings – in such a case the operator may be facing very high levels of risk and uncertainty and partial renewal could be a solution to this.

[119] BIPT, 'Procedure for the granting of rights of use for the 700 MHz, 900 MHz, 1400 MHz, 1800 MHz, 2100 MHz and 3600 MHz frequency bands – Information Memorandum – Version 1', 14 January 2022.

### 5.2.6 Auction best practices

We outlined the situations in which competitive spectrum award processes (i.e. auctions) would be appropriate within Section 5.2.5 above. In this section, we outline a series of best practices that should be adopted by policymakers if a spectrum auction is deemed necessary. These are:

- **Spectrum packaging:** Spectrum should be packaged to make efficient use of it whilst enabling operators to acquire the spectrum they require and allowing competition for marginal lots.
- **Avoiding risky or complex auction formats/rules:** To reduce the uncertainty faced by operators, the use of any unduly risky or complex auction formats should be avoided. Instead, we recommend use of simple 'tried and tested' simple formats (e.g. SMRA, Clock).
- **Ensuring the auction does not unduly impact on natural evolution of the market:** Policymakers should avoid auction rules which aim to 'force' changes to the market structure (e.g. spectrum reservations).
- **Prioritising non-monetary objectives, such as coverage:** If expanding connectivity is an objective, regulators should consider lowering spectrum fees in return for coverage commitments.
- **Reconfiguration:** If necessary, the auction should include a process for the reconfiguration of spectrum holdings in the band to enable all operators to have contiguous holdings.

In the rest of this section, we provide detailed best practice recommendations on each of the topics above, as well as providing examples of good and bad practice internationally.

#### Spectrum packaging

The spectrum to be assigned should be packaged in a way that both makes efficient use of the spectrum (i.e. block sizes should not be too small) whilst at the same time enabling operators to acquire the spectrum that require (so not too large) and allowing the operators to compete over the marginal blocks. The optimum block size for each band will depend on the amount of spectrum available which typically increases as the frequency range increases.

The risks of inappropriate spectrum packaging are highlighted by the example of Italy's 3.5GHz auction in 2018, a case of which was presented in Section 4.2. In this case, the spectrum packaging, combined with spectrum scarcity, forced an outcome which would create 'winners' (those acquiring ≥80MHz) and 'losers' (those acquiring ≤40MHz), with there guaranteed to be at least two 'losers'. The result was high spectrum prices which are likely to have negatively impacted upon 5G deployment in Italy as a greater proportion of operators' budgets had to be diverted towards spectrum acquisition.

#### Avoiding risky or complex auction formats/rules and ensuring transparency

To further reduce the risk/uncertainty faced by operators in relation to existing spectrum, we recommend that regulators avoid use of any unduly risky or complex auction formats. We recommend use of simple 'tried and tested' formats and avoid use of formats which can yield highly uncertain outcomes.

Examples of the main auction formats used include:

- First price, sealed bid auctions: Each bidder submits a sealed, one-off bid for each lot/category. The winner is the bidder who submits the highest bid, and it is required to pay the price it bid.
- Simultaneous multi-round ascending auctions (SMRAs): In each round, the auctioneer defines a minimum bid for each lot/category, which is higher than the previous highest bid (or, in the first round, the reserve price). Bidders are then invited to submit bids for each lot/category, with the

provisional winner for each lot being the bidder who submits the highest bid. This continues until there are no new bids on any lots in a round, with the spectrum being sold to whoever submitted the highest bid. All successful bidders must pay the price they bid in the final round.

- Clock auctions: The auctioneer sets the price for each lot/category in each round, with the price increasing from one round to the next – this is known as the 'clock price'. In each round, bidders are required to indicate the quantity of spectrum they wish to acquire in each category at the clock price, with the auction continuing until demand is less than or equal to supply. All successful bidders must pay the final clock price for the spectrum.

- Combinatorial clock auctions (CCAs): A more complex auction format, consisting of two stages. The first stage is a clock auction. The second is a sealed bid, within which bidders are invited to submit their best and final offers for all combinations of the available spectrum that they would be interested in acquiring. However, restrictions are placed on the bids one can submit in this second stage – all bids must be consistent with the preferences expressed in the first auction stage. The auctioneer then determines the combination of bids that would maximise the price paid, subject to certain constraints – each lot can only be sold once and only one bid from each bidder can be accepted. The price paid is calculated based on all bids and it is typically below the submitted bid price.

The appropriate choice of auction format will evidently be situation-dependent, with policymakers required to consider the following three components in order to identify a suitable format:

- The theoretical merits of candidate auction formats
- The specific circumstances of the auction (market conditions, policy goals, available spectrum etc.)
- The requirements of bidders due to the practical constraints they face.

However, there are some general principles to which policymakers should adhere. Specifically, the auction format should only be as complex as is required to meet the auction's objectives – complexity should only be added where there is a demonstrable benefit. In addition, the auction format should avoid the final results coming as a surprise at the end of the auction – the final outcome should emerge as the auction evolves, allowing bidders to take corrective action where necessary. Finally, the format should be 'tried and tested' – this is not an environment for experimentation, as this creates uncertainty.

If these principles are adhered to, auctions can have many benefits, allowing an efficient allocation of spectrum to be achieved within a robust and transparent process. However, the risks of getting it wrong are severe. Therefore, simplicity is key – it reduces uncertainty and risk for all concerned. In general, we recommend using simple formats (e.g. SMRA, Clock) and avoiding the use of formats which can yield highly uncertain outcomes (e.g. CCA).

One key component of auction design is the information that is made available to auction participants (bidders) during each stage of the auction. Auction theory suggests that full transparency will yield the most efficient outcome – that would include the details/identities of each the bidders and the demand for spectrum/amounts of bids in each round in order to allow price discovery between bidders. However, regulators are often tempted to limit the information flow to maximise competition between participants, thereby maximising assignment revenues. Whilst we can understand that in some cases, full transparency may not be appropriate due to concerns regarding collusion, we recommend the maximum possible amount of information is made available and that the regulator does not focus on boosting assignment revenues.

We outline examples of good and bad practice with regards to auction design and transparency in the case studies below. Finland is positive example of what might be achieved by adopting a pragmatic, tried and tested approach to spectrum auctions, whilst the examples of El Salvador, Honduras and Colombia illustrate the risks of adopting complex experimental auction formats.

## Case studies – Different approaches to auction complexity

### Finland – Pragmatic approach to spectrum auctions

**Background:** Finland has conducted multiple spectrum auctions, typically achieving successful outcomes. It tends to avoid unnecessary complexity, ensuring spectrum is awarded and deployed swiftly. Finland relies on tried-and-test formats (typically the SMRA[120] format) and uses a pragmatic approach to spectrum caps and packaging. For example, in its 700MHz auction in 2016, six lots of 2×5MHz were auctioned with a spectrum cap of 2×10MHz.[121,122] With three incumbent operators, each of them was guaranteed equal access to spectrum, unless an entrant were to participate.

**Key learnings:** In adopting a simplified auction process, Finland retains many of the benefits of competitive awards whilst avoiding common pitfalls. It provides transparent outcomes with equal access to spectrum, whilst offering new entrants the opportunity to bid for spectrum on equal terms with incumbents. At the same time, it prevents auctions from becoming unduly lengthy if only the incumbents participate.

### El Salvador – Complex auction design risks auction ending whilst there is excess demand

**Background:** El Salvador auctioned AWS spectrum in 2019, adopting a unique and complicated format with several flaws. [123,124] The auction rules effectively forced bidders to overstate demand in a preliminary round to enable them to bid on all lots during the auction (and avoid a situation where there is competitive bidding on some lots whilst others remain unassigned).The rules also stated that the auction for a lot would be declared complete if/when the same participant is the declared the provisional winner for three rounds in a row. This meant that the auction could (i) finish at different times for different lots and (ii) award spectrum to a bidder even if there was still excess demand for spectrum in the auction.

**Key learnings:** The auction format created significant risks for bidders and, as highlighted above, risked certain spectrum remaining unassigned even if there was excess demand for spectrum.

### Honduras – Planned auction will award spectrum if the provisional high bid is >5% higher than all others, even if there is excess demand

**Background:** Honduras is planning an auction of spectrum in the 700MHz, AWS and 3.5GHz bands, expected to occur in 2022, the proposed rules for which were published in November 2021.[125] However, the regulator has opted to adopt a unique and complex auction format with several flaws. Chief amongst these is that the auction for a lot will end if the provisional winning bid is more than 5% higher than all other bids, even if there continues to be excess demand for spectrum.

**Key learnings:** This format creates uncertainty for bidders and risks inefficient spectrum allocations, as the bidders with the greatest value for spectrum are not necessarily guaranteed to be successful – if they misstep, submitting an initial bid more than 5% below the provisional winning bid, the spectrum will be sold to the highest bidder, even if the bidder in question has greater value for the spectrum and would otherwise be willing to increase their bid.

**Colombia – Sequential auction and lack of transparency creates uncertainty**

**Background:** The Colombian 700MHz and 2.6GHz auction in 2019 adopted a sequential format, meaning lots were sold in a series of separate auctions rather than a single parallel auction.[126] There is nothing inherently wrong with such a format; however, the specific rules created problems.

The primary issue was a lack of transparency. The auction required participants to bid for spectrum using a combination of money and coverage commitments, the principle of which we support. However, the implementation was flawed. To facilitate the coverage bidding, the regulator, MinTIC, defined a bid 'index' for a variety of underserved areas within which operators could bid to provide coverage. However, it did not publish details of how coverage bids would be converted into index bids. Further, whilst it did publish the monetary reserve price, it did not publish the reserve index.

**Key learnings:** The auction rules and lack of transparency created uncertainty for bidders, especially as they could not continue bidding in a sequence if their initial bid was below the unknown reserve index. A knock-on effect of this was the possibility that spectrum could remain unsold even if there was excess demand (due to the number of sequences being limited to seven). Short of this, the format risked creating artificial spectrum scarcity and uneven price distributions if several bidders were unsuccessful in bidding above the reserve index in early rounds.

In addition to the case studies above, we note the example of Tele2 (previously discussed in Section 3.3), which was forced to exit the Norwegian mobile market as a result of failing to re-acquire its existing 900MHz spectrum holdings at auction. One of the main contributing factors was the selected auction format: first price, sealed bid. This auction format raises significant problems from a bidding strategy perspective because participants are only permitted to enter a single bid and, if successful, are obliged to pay their full bid price.

Operators' aim is always to pay as little as possible for spectrum (i.e. as far below its theoretical value as possible), to generate a surplus and enable them to direct investment at network deployment. However, in a first price, sealed bid auction, the lower they bid, the less likely they are to win spectrum and vice versa. Furthermore, it is not able to increase one's bid if unsuccessful. Therefore, bidding strategy effecting becomes a 'guessing game' – operators are estimating the minimum price they need to outbid their competitors without any indication of what this might be.

Tele2 lost this 'guessing game', submitting the lowest bid for spectrum and not acquiring any 900MHz spectrum as a result. However, that does not necessarily mean its value for the spectrum was lowest. That is the main flaw of first price, sealed bid auctions – they do not incentivise participants to bid to value and are therefore prone to producing inefficient outcomes. Other auction formats have their own

[120]Simultaneous Multi Round Ascending (SMRA)

[121]Fierce Wireless, 'Finland to hold 700 MHz spectrum auction in November', 10 October 2016.

[122]Ministry of Transport and Communications, 'The Government adopted a decision on the details of the 700 MHz spectrum auction', 6 October 2016.

[123]Telegeography, 'Tigo and Claro secure AWS spectrum in El Salvador auction', 9 December 2019.

[124]SIGET, 'Terms of Reference with Addendum and Amendments for the granting process of 120MHz in the AWS band. Resolution No. T-1132-2019', 5 November 2019.

[125]Conatel, 'Rules of the national public contest CNT-CP00x / 2021, for the granting of licenses for the use and reservation of the radioelectric spectrum in the 700 MHz, 3.5 GHz and 1700/2100 MHz bands for mobile phone service', November 2021.

[126]MinTIC, 'Resolution Number 003078 of 2019 by which the opening is declared, and the requirements, conditions and procedure are established, to participate in the objective selection process through the auction mechanism to grant permits for the use of the radio spectrum at the national level in the 700MHz, 1900MHz and 2500MHz bands', 25 November 2019.

flaws and therefore the appropriate format is dependent on the auction's objectives. However, this is a powerful example of what can happen if regulators get it wrong.

### Ensuring that the auction does not unduly impact on natural evolution of the market

We recommend that the auction design and rules do not prevent natural evolution of the underlying market (e.g. forcing a new entrant through a spectrum reservation or forcing consolidation through limiting supply of spectrum) and instead allow existing players to continue operating in the market.

Specifically, we refer here to (i) avoiding artificial market entry where there is no desire and/or proven need for it given the market context, and (ii) ensuring that the auction process imposes reasonable restrictions on operators' acquisition options, both to avoid spectrum hoarding and to ensure a minimum quantity of spectrum is available for all operators, whilst acknowledging the importance of ensuring that all spectrum is awarded and does not remain unassigned for long periods of time.

We highlight the examples of Chile, the Netherlands and Belgium below. In all cases, onerous spectrum caps and/or reservations have risked spectrum remaining unassigned and/or being awarded at high prices which ultimately result in windfall profits.

## Case studies – Auction processes impacting natural market evolution

### Chile – Onerous spectrum caps guarantee access to spectrum for a new entrant

**Background:** Chile hosted a multi-band spectrum auction in 2021, awarding 700MHz, 1700MHz (AWS), 3.5GHz and 26GHz spectrum.[127] However, prior to this auction, the supreme court made a ruling regarding spectrum caps, deciding that an operator could hold no more than 32% of spectrum below 1GHz, 30% in the 1-3GHz and 3-6GHz frequency ranges, or 25% above 24GHz.[128]

This guaranteed access to spectrum in each frequency range for at least four operators because the cap is below 33% (1/3) in each case. As there were only three incumbents (Entel, Claro and Movistar), this guaranteed spectrum for new entrants. Spectrum was ultimately acquired by four bidders in the auction: the three incumbents and WOM. WOM acquired 700MHz, AWS, 3.5GHz and 26GHz spectrum[129] which it used to launch 5G in March 2022.[130]

**Key learnings:** From the regulator's perspective, this process has ultimately had a positive outcome in Chile, at least for now, with the entry of a new operator. However, the spectrum caps risked spectrum remaining unassigned, which would have been a negative outcome. This process therefore illustrates the importance of understanding spectrum demand prior to reserving spectrum.

### Netherlands – Entrant reservations lead to high auction prices and windfall profits

**Background:** Spectrum auctions were held in the Netherlands in 2010 and 2012, including spectrum reservations for new entrants in the 2.6GHz and 800MHz bands, respectively. Tight spectrum caps in the 2010 auction effectively reserved 2.6GHz spectrum for new entrants.[131] Ultimately, 2×40MHz was acquired by two new entrants: 2×20MHz each for Tele2 and Ziggo.[132] In addition, all of the 2.6GHz TDD spectrum in the auction remained unsold. Overall, this was an inefficient outcome. In the 2012 auction, 2×10MHz of 800MHz spectrum was reserved for new entrants.[133] This created spectrum scarcity for the incumbents, resulting in competitive bidding for the non-reserved 800MHz spectrum. This resulted in a 300% price differential between reserved and non-reserved spectrum – the reserved spectrum was acquired below its market value by Tele2.[134]

**Key learnings:** Neither Tele2 nor Ziggo had made use of the reserved 2.6GHz spectrum at the time of their subsequent mergers with T-Mobile/Vodafone, many years after the auction.[135,136] Moreover, in 2017, Tele2 merged with T-Mobile without having deployed significant network assets. The net effect of these reservations were thus windfall profits for Ziggo's / Tele2's shareholders, with the spectrum remaining underutilised for a long period of time.

### Case study: Tight spectrum caps lead to unsold spectrum in Belgium

**Background:** Belgium's 2.6GHz auction in 2011 attempted to encourage market entry by effectively reserving spectrum for a fourth participant through the application of a spectrum cap – the cap was set at 2×20MHz, with 2×70MHz of spectrum being available, resulting in a reservation of 2×10MHz.[137] However, interest from potential new entrants was not forthcoming and, as there was no mechanism by which the cap could be relaxed, 2×15MHz of spectrum went unassigned.[138]

**Key learnings:** The unsold spectrum illustrates that this was clearly an inefficient auction denying Belgian consumers of the potential benefits of this spectrum being used by incumbent operators.

## Prioritising non-monetary objectives, such as coverage

If expanding network coverage is the key policy objective, regulators could consider accepting lower spectrum fees in return for operator commitments to expanding mobile coverage/5G deployment.

There are myriad benefits of expanding connectivity, both social and economic. These benefits arise across a wide range of industries, with 5G having the potential to increase both productivity and sustainability. Given the magnitude of the knock-on benefits of non-monetary spectrum award objectives, they should be prioritised. However, we highlighted previously how spectrum fees and coverage obligations are both key components of the TCSO. Therefore, if policymakers' objectives include the expansion of network coverage (or other non-monetary objectives), it is important to acknowledge the costs that operators will incur in achieving these objectives. Specifically, it may be appropriate for spectrum prices to be reduced in exchange for operators' agreement to address policymakers' non-monetary objectives.

Ultimately, the social inclusion and economic growth benefits from greater connectivity and faster access to 5G services will yield considerably greater economic value for the country than any short-term gains from higher auction/assignment revenues. Furthermore, the income for governments will ultimately be greater as a result of the additional taxes that will be raised as a result of the greater economic growth (e.g. additional sales tax/VAT, additional corporation tax and additional taxes associated with employment (income tax, employee and employer social security contributions etc). This has been highlighted by the GSMA, which estimated the benefits of 5G to the global economy at >USD960 billion annually by 2030.[139]

We highlight the examples of Brazil, Colombia and Austria below, all of which have offered discounts on spectrum prices in exchange for operators' commitments to increasing coverage.

[139]GSMA, 'The Mobile Economy 2022', 28 February 2022.

## Case studies – Auction processes trading off auction fees with coverage commitments

### Brazil – Spectrum discounts in exchange for coverage commitments

**Background:** Brazil auctioned spectrum in the 700MHz, 2.3GHz, 3.5GHz and 26GHz bands for a total of BRL47.2 billion in 2021.[140] Of this total however, BRL39.3 billion (83%) will not be paid as auction fees but instead as investments in extending coverage to underserved areas. Winning bidders are required to deploy standalone 5G networks (i.e. not making use of DSS) in all state capitals by July 2022, all municipalities with > 100 000 people by July 2027, and all municipalities with < 30 000 people by December 2029.[141]

Anatel, the regulator, took other positive steps in preparation for this auction. For example, it updated Brazilian telecoms laws in 2019 to extend licence terms to 20 years and introduce a presumption of renewal for spectrum licences, as well as to introduce a secondary spectrum market.[142] Anatel also introduced favourable payment terms for spectrum licences in the auction.

**Key learnings:** Operators were offered a discount in exchange for coverage commitments, allowing the regulator to achieve its coverage aims in exchange for reduced fees.

### Colombia – Operators bid in terms of coverage during 700MHz auction

**Background:** The Colombian 700MHz and 2.6GHz auction in 2019 required participants to bid for spectrum using a combination of money and coverage commitments.[143] To facilitate the coverage bidding, the regulator, MinTIC, defined a bid value for a variety of underserved areas within which operators could bid to provide coverage – these areas were grouped into categories. It also defined a minimum proportion of bids that could be attributable to monetary and coverage commitments.

**Key learnings:** This is interesting example of how auctions can be used to achieve regulators coverage aims in return for lower auction fees. However, other aspects of this process did not follow best practice; as we highlighted previously.

### Austria – Discounting auction fees in exchange for white area coverage

**Background:** In Austria's 2020 multi-band auction, operators were offered the opportunity, during an additional auction stage, to bid for discounts on their auction fees in exchange for extended coverage obligations (beyond those committed to during the main auction).[144,145]

The regulator outlined which locations it wanted to cover additionally (as operators were offered choice regarding which underserved locations would be covered by their basic coverage obligations). Operators could then indicate which additional locations they would cover at which discount. The coverage obligations and discounts were then assigned to operators in a way that maximised the total locations covered within the regulator's budget. Ultimately, operators committed to cover more than 800 additional locations in exchange for total discounts of ~EUR87 million.[146]

**Key learnings:** By offering an additional discount on the auction fees, the regulator was able to extend the coverage obligations beyond those already included in the original licences.

## Enabling reconfigurations of bands

In cases where spectrum is being assigned in a frequency band where some of the spectrum has already been previously assigned, we recommend that the auction includes a process for the reconfiguration of spectrum holdings in the band to enable all operators to have contiguous holdings, since this maximises spectral efficiency.

In some cases, regulators have been tempted to leave this to the operators' to resolve in commercial negotiations following the auction. However, often not all operators are in the same position – for example, one operator may have two blocks of non-contiguous spectrum whilst another may already have contiguous spectrum – and so the operators may not have the same incentives to find a solution, resulting in non-optimal assignments and less efficient use of the spectrum.

We highlight examples of where spectrum has and has not been reconfigured in the case studies below, as well as the impacts this has had on (i) the complexity of the auction process and (ii) the efficiency of spectrum use. All necessary steps should be taken to ensure contiguity where possible, as has occurred in Paraguay and Sweden. Otherwise, inefficient spectrum allocations are possible, like those in the 3.5GHz band in the UK. However, the implementation must be carefully thought out. Otherwise, the reconfiguration itself can create risk for operators, as was the case in Paraguay.

[140]Ministry of Economy, 'Biggest auction in the history of telecommunications in Brazil, 5G guarantees BRL 47.2 billion in investments', 8 November 2021.

[141]Anatel, 'Bidding No. 1/2021-SOR/SPR/CD-ANATEL. Radio frequencies in the bands of 700MHz, 2.3GHz, 3.5GHz and 26GHz', 27 September 2021.

[142]GSMA, 'Brazil multi-band auction: one of the largest in mobile history', 22 December 2021.

[143]MinTIC, 'Resolution Number 003078 of 2019 by which the opening is declared, and the requirements, conditions and procedure are established, to participate in the objective selection process through the auction mechanism to grant permits for the use of the radio spectrum at the national level in the 700MHz, 1900MHz and 2500MHz bands', 25 November 2019.

[144]RTR, 'Tender Document in the procedure for awarding spectrum in the 700, 1500 and 2100MHz ranges', 11 December 2019.

[145]RTR, 'Auction rules for the awarding of spectrum in the 700, 1500 and 2100MHz bands', 11 December 2019.

[146]DotEcon, 'Second Austrian 5G auction ends with prospect of substantial improvements in coverage', September 2020.

## Case studies – The importance of ensuring contiguity

### Paraguay – AWS auction guarantees contiguity, but at a price …

**Background:** Paraguay awarded 2×30MHz of AWS spectrum via auction in December 2015, with 2×15MHz being acquired by each of Tigo and Claro.[147,148] In this auction, which used the SMRA format, the spectrum was split into 6 concrete lots of 2×5MHz covering the 1725-1755/2125-2155MHz range. This meant each lot could be bid on separately and referred to a specific frequency range. However, the auction rules included provision for spectrum in the band to be redistributed following the auction to ensure contiguity for spectrum holders.

**Key learnings:** Generally speaking, this was positive. It is preferable for operators to gain contiguous spectrum holdings to ensure the spectrum is used as efficiently as possible. However, the implementation here was problematic – theoretically, one could pay a premium to gain access to a specific frequency range but then see the spectrum redistributed, such that it did not gain access to the spectrum it targeted (and was potentially given frequencies it specifically bid to avoid).

### Sweden – 900MHz renewal based on industry proposals

**Background:** PTS, the Swedish regulator, conducted a refarming processes for spectrum in the 900MHz band in 2009. This was an administrative process based on industry proposals for the sharing of spectrum between operators and included the redistribution of spectrum to ensure all operators had access to a minimum quantity. This process included renewing the licences of incumbent licensees (with new expiry dates of 31 December 2025), as well as expanding the 900MHz band from 2×30MHz to 2×35MHz and relaxing technology restrictions.[149] The process also included the transfer of 2×5MHz of spectrum (2×2.5MHz each from Tele2 and Telenor) to Hi3G, which did not have prior access to 900MHz spectrum, and the redistribution of spectrum to ensure that each operator's holdings were contiguous. The outcome was that all five incumbent operators had access to at least 2×5MHz of 900MHz spectrum.

**Key learnings:** In this case, the adoption of an administrative process provided certainty to operators regarding future spectrum availability and pricing, whilst achieving the regulator's objective of redistributing spectrum to ensure that all operators had access to a sufficient quantity to compete effectively. It also avoided the need for a potentially complex auction procedure.

### United Kingdom – Operators left with non-contiguous 3.5GHz holdings

**Background:** The United Kingdom has twice auctioned spectrum in the 3.5GHz band, in 2018 and 2021. In the first auction, a total of 150MHz of spectrum in the 3.41-3.48GHz and 3.50-3.80GHz ranges was awarded.[150] In the second, a further 120MHz of spectrum in the 3.68-3.80GHz range was awarded.[151] In addition to this, spectrum was already held by UK Broadband, which was acquired by Three in 2018.[152] Neither of these auction processes included provision for spectrum to be redistributed in order to ensure contiguous spectrum holdings for each operator.[153,154]

**Key learnings:** The result is that all operators' holdings in the 3.4-3.8GHz band are fragmented, reducing the efficiency of spectrum use. For example, EE holds a total of 80MHz but across two separate blocks (3.54-3.58GHz and 3.68-3.72GHz).

## 5.3 The benefits of applying best practice approaches to spectrum awards

In this section, we have outlined best practice principles for policymakers to follow when awarding spectrum. We believe that awarding spectrum in a timely manner with extended licence periods, using either administrative spectrum awards where demand does not exceed supply or simple auctions where demand does exceed supply, would have several benefits:

- Reducing the level of risk/uncertainty perceived by mobile operators in acquiring spectrum licences, thereby releasing funding for strategic investments such as increasing network coverage and rolling out the latest technologies (e.g. 5G).
- Helping to stimulate a secondary market in spectrum, thereby increasing spectral efficiency – for example, if a mobile operator has more certainty in holding Asset A, it may be more inclined to trade a less important Asset B to another party who needs it more/can generate greater value from it.

Importantly, the social inclusion and economic growth benefits of improved connectivity will yield considerably greater economic value than any short-term gains from higher spectrum assignment revenues, as we highlighted above. In addition, government income is likely to ultimately be greater as a result of the additional taxes that will be raised due to the greater economic growth. Therefore, policymakers should prioritise investment confidence and coverage expansion to maximise the chance of achieving universal connectivity and unlocking the many benefits associated with it.

[147]Conatel, 'Tender No. 01/2015 Mobile Broadband. For the granting of licenses for the provision of cellular mobile telephony and Internet access services and data transmission in the 1700/2100 MHz frequencies through simultaneous ascending auction, and the obligations for its operation and exploitation', October 2015.

[148]Telegeography, 'Conatel hands 4G licences to Tigo, Claro', 16 December 2015.

[149]GSMA, '900MHz band refarming case study – Sweden', 29 November 2011.

[150]Ofcom, 'Award of 2.3 and 3.4 GHz spectrum bands - Publication under regulation 111 of the Wireless Telegraphy (Licence Award) Regulations 2018 of results of auction', 13 April 2018.

[151]Ofcom, 'Award of the 700 MHz and 3.6-3.8 GHz spectrum bands – Notice under regulation 121 of the Wireless Telegraphy (Licence Award) Regulations 2020 ("the Regulations")', 27 April 2021.

[152]Telecoms.com, 'Three completes £250m UK Broadband acquisition', 31 May 2017.

[153]Ofcom, 'The award of 2.3 and 3.4 GHz spectrum bands. Information Memorandum', 11 July 2017.

[154]Ofcom, 'Award of the 700 MHz and 3.6-3.8 GHz spectrum bands. Information Memorandum', 13 March 2020.

# 6. Conclusions

We recommend that policymakers look to reduce the uncertainty faced by mobile operators in spectrum award processes, promoting investment and increasing the chances of achieving universal connectivity. Specifically, we make recommendations regarding both spectrum pricing and the award process. In respect of spectrum pricing, we recommend adopting the following best practice approaches:

- Consider all aspects of the TCSO, including auction payments, annual licence fees and indirect licence costs, as operators' investment decisions will be dependent on the sum of these components. International comparisons should consider all three components – a country with high annual fees should not expect to raise the same auction price as a country with low annual fees.
- Accept that the unit price of spectrum (price per MHz) has to decline as the quantity of available spectrum increases – operators' ability to pay for spectrum in totality is not increasing. Regulators should not use the outcomes of historic auctions in the country to directly set the prices for upcoming auctions.
- Review existing spectrum fee formulas for 'fitness for purpose' – specifically, the unit price of spectrum (price per MHz) should vary with frequency and factors in fee formulas related to income or wage levels and number of base station deployments should be removed.
- Prioritise non-monetary objectives (e.g. operator commitments to maximise coverage) over auction prices – the greater the cost of commitments, the less operators can pay in annual and auction fees.
- Set low but non-trivial reserve prices, thereby letting the market determine an efficient allocation of spectrum and the corresponding market price of the spectrum.

In respect of the spectrum award process, we recommend adopting best practice in the following areas:

- Timing of award process – Award spectrum as soon as possible once there is demand from mobile operators, co-existence conditions with other existing users have been defined and it has been cleared of incumbent use in cases where this is necessary.
- Spectrum availability – Ensure that sufficient spectrum is made available to meet the needs of all mobile operators. There should not be any preferential treatment for local uses/vertical industries.
- Objectives of process – Ensure the process's priorities/objectives are understood prior to award.
- Conditions of spectrum use – Award licences of at least 20-years, and ideally indefinite licences, coupled with supporting spectrum trading.
- Design of award process – Select an appropriate award process:
  - Whilst auctions are increasingly the default approach for assigning mobile spectrum, and are a very useful tool, it is worth considering administrative spectrum awards in cases where demand does not outstrip supply – this may involve either the equal distribution of spectrum in the band to all operators or, in the case of renewals, direct renewal of the existing holdings of each operator.
    - An industry-led solution/distribution of spectrum can be a good means of ensuring spectrum is efficiently assigned and funds that would be spent on a competitive auction can instead be used for expanding network coverage to lessen the digital divide.

  - Use auctions where demand for spectrum exceeds supply, ensuring that policymakers focus on the objectives of the award process and do not get distracted by auction dynamics – the objective should be to encourage competition and investment in the mobile market itself.
  - For previously assigned spectrum, consider the use of partial renewal for critical parts of operators' spectrum holdings This is likely to be appropriate in cases where spectrum exceeds supply but there is a continuity risk to existing licensees if they lose key spectrum. This approach is particularly important in the short-term where specific technologies (2G/3G) can only be deployed in particular frequency bands.

- Auction best practices – Where an auction is required, adopt the following best practices:
  - Package the spectrum to ensure efficient use whilst ensuring operators are able to acquire the spectrum they require and compete over the marginal blocks.
  - Make use of simple, predictable, well-proven auction designs (e.g. SMRA, Clock) and avoid complex or risky formats with unpredictable outcomes (e.g. CCA, first price, sealed bid).
  - Ensure the auction is as transparent as possible in terms of information provided to bidders.
  - Ensure the auction does not prevent natural evolution of the underlying market (e.g. forcing a new entrant or consolidation).
  - For bands where spectrum has already been assigned, the auction should include provision for reconfiguration of the band to enable all operators to have contiguous spectrum holdings.

We have separately discussed best practice approaches to award processes and spectrum pricing. However, there is often a linkage between the two – a successful outcome can only be achieved if best practice is followed with respect to both. This is shown by the fact that an auction design can work well in one case whilst leading to unassigned spectrum in another due to the spectrum pricing decisions:

**Case study: Clock auctions result in very different outcomes in Romania and Sweden**

**Background:** Romania applied a Clock format in both its 2012 and 2021 spectrum auctions. However, the success of these auctions was limited with much spectrum remaining unassigned, including in the 800MHz and 2.6GHz bands. The main reason for this was the high reserve prices, particularly the annual fees. The failure to assign all spectrum was clearly an inefficient outcome.

In contrast, several countries have successfully assigned spectrum using the Clock format. For example, the Swedish regulator, PTS, used a Clock format for its auction of 2.3GHz and 3.5GHz spectrum in 2021.[155] This auction resulted in all spectrum being successfully assigned, with each of the four bidders acquiring at least 80MHz of 5G-suitable spectrum.[156]

**Key learnings:** These contrasting examples illustrate how, when allocating spectrum, all elements of the award procedure and licence conditions must be considered to achieve a successful outcome.

Spectrum assignment and pricing decisions can have a major impact on operators and the functioning of the mobile market. Poor decisions could result in operators either not acquiring the spectrum they require or having to pay a high price for it, damaging their ability to invest in 5G deployment.

[155]PTS, 'Open invitation to apply for licences to use radio transmitters in the 3.5GHz and 2.3GHz bands', 17 April 2020.

[156]PTS, 'Decision on permission to use radio transmitters in the 3.5 GHz and 2.3 GHz bands', 20 January 2021.

In contrast, policymakers that de-risk the spectrum award process will enable operators to release funds for strategic purposes such as expanding coverage. This will reduce the 'investment gap', increasing the likelihood and lowering the cost to the public of meeting policymakers' connectivity ambitions.

Optimising spectrum policy has always been important. However, with the introduction of 5G it becomes even more so because 5G will impact on every corner of society and the economy. Policymakers should be aware that the societal and economic gains enabled by universal 5G connectivity will compensate many times over for any short-term reductions in spectrum assignment revenue. Indeed, over time, government income will also be maximised due to the resulting growth of the economy.

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