COMMUNICATION DU CONSEIL DE L'IBPT
DU 13 NOVEMBRE 2019
CONCERNANT
LE RAPPORT D'ANALYSYS MASON DU 7 NOVEMBRE 2019 CONCERNANT LA VALORISATION DU SPECTRE POUR LES SYSTÈMES MOBILES PUBLICS DANS LES BANDES 3600 MHz et 26 GHz

Institut belge des services postaux et des télécommunications
Ellipse Building - Bâtiment C - Boulevard du Roi Albert II 35 - 1030 Bruxelles
Tél. 02 226 88 88 Fax 02 226 88 77 http://www.ibpt.be

Contexte

Les opérateurs autorisés à disposer de droits d'utilisation de radiofréquences en vue de l'exploitation d'un réseau et de la fourniture de services de communications électroniques mobiles offerts au public sont notamment tenus, au début de la période de validité des droits d'utilisation, de payer une redevance unique. Ce principe est défini à l'article 30 de la loi du 13 juin 2005 relative aux communications électroniques et le montant de cette redevance unique est fixé par bande de fréquences. Cet article ne contient actuellement pas encore de montant pour la redevance unique pour les bandes de fréquences 3600 MHz et 26 GHz. L'IBPT a fait appel à un consultant indépendant pour étudier la problématique des redevances uniques pour les systèmes mobiles publics dans les bandes 3600 MHz et 26 GHz. L'objectif de cette étude est la formulation de recommandations en vue de la détermination de la redevance unique pour les procédures d'attribution de ces bandes.

Cette étude a été réalisée par Analysys Mason et a donné lieu au rapport « *Value of spectrum in the 3600 MHz en 26 GHz bands* » du 7 novembre 2019. L'IBPT publie ce rapport ci-joint.

En juillet 2018, le gouvernement fédéral avait déjà approuvé un projet de modification de l'article 30 de la loi du 13 juin 2005 précitée[1]. Un nouveau montant y a été fixé pour la redevance unique pour différentes bandes de fréquences en vue d'une mise aux enchères prévue des droits d'utilisation dans ces bandes. Le montant de la redevance unique pour la bande 3400-3800 MHz repris dans ce projet était le seul montant de la redevance unique pour la mise aux enchères multibande prévue, qui n'était pas basé sur une étude de valorisation du spectre. Ce montant s'élevait à **43 millions d'euros**, soit environ **1 eurocent/MHz/pop**[2]. Compte tenu du contexte modifié et de l'importance accrue de la 5G, l'IBPT a jugé nécessaire de réévaluer cette valeur.

Cette nouvelle étude prend en compte les dernières évolutions et estime la valeur de la bande 3600 MHz à **181,7 millions d'euros**, soit **4 eurocents/MHz/pop**.

Cette étude est basée sur les données les plus récentes et doit être considérée comme la version finale de l'enquête menée par les auteurs. Il convient de tenir compte du fait que les avis et propositions formulés dans cette étude n'engagent que leurs auteurs. Ils ne représentent pas nécessairement le point de vue de l'IBPT. Ils ne représentent pas davantage le point de vue des autorités belges en général.

---

[1] Voir la communication du Conseil de l'IBPT à la demande du ministre des Télécommunications du 13 août 2018 concernant le projet de réglementation pour la mise aux enchères multibande sur le site Internet de l'IBPT (www.ibpt.be).

[2] Il s'agit du prix du spectre par MHz divisé par la population estimée en 2019, ce qui est une approche standard dans le secteur.

Annexe

Le rapport est repris ci-après.

Axel Desmedt
Membre du Conseil

Jack Hamande
Membre du Conseil

Luc Vanfleteren
Membre du Conseil

Michel Van Bellinghen
Président du Conseil

CONSULTING

Report for BIPT

Value of spectrum in the 3600MHz and 26GHz bands

Samer Mourad, Sylvain Loizeau

7 November 2019

Ref: 2018690-454

Contents

Analysys Mason
25 rue d'Artois
75008 Paris
France
Tel: +33 (0)1 72 71 96 96
paris@analysysmason.com
www.analysysmason.com

Registered as Analysys Limited: 410 406 839 RCS Paris
Subsidiary of Analysys Limited, registered in England and Wales No. 1819989
3rd Floor, 8 Exchange Quay, Manchester M5 3EJ, UK

1 Executive summary

This is the final report from a project carried out by Analysys Mason on behalf of the Belgian Institute for Postal services and Telecommunications (BIPT) to determine the value of spectrum for Belgian mobile network operators (MNOs) in two frequency bands and recommend reserve price levels for these bands.

The two bands considered are the 3600MHz and 26GHz bands, both of which are internationally recognised as key bands for the deployment of 5G in the next few years. We have structured our analysis and recommendations around these two bands:

- *The 3600MHz band* is valued based on our own economic analysis and comparison with price benchmarks
- *The 26GHz band* is valued based on high-level qualitative analysis of its future uses and current limitations as well as on price benchmarks.

Our analysis takes into account the characteristics of the Belgian market, the objectives of BIPT, the views of MNOs, international benchmarks and best practices, as well as our professional judgment based on wide experience of previous similar studies. We have also considered the possibility of a new entrant to the market and have recommended prices which would not be a barrier to such entry.

We have carried out valuation modelling using a bottom-up discounted cashflow model to calculate the value of the 3600MHz band for each MNO and for a new entrant. We have also analysed prices paid for the 3600MHz and the 26GHz bands in other markets, and the reserve prices set by national regulatory authorities (NRAs). Our recommendations for the reserve price of each band are presented in Figure 1.1.

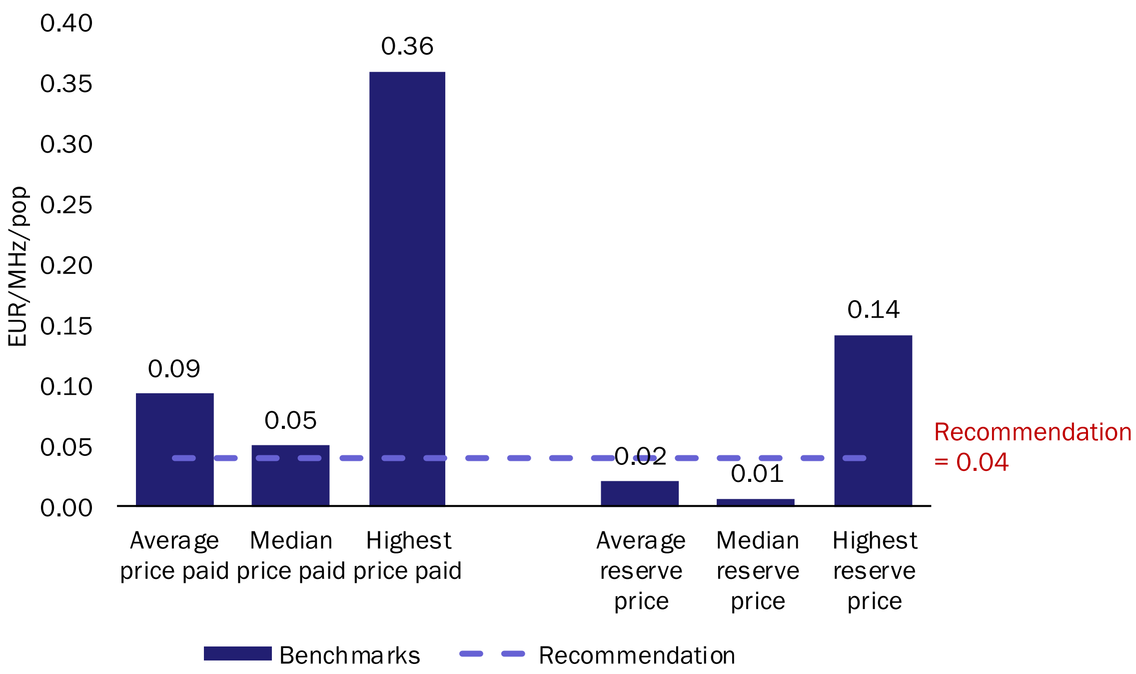
Figure 1.1: Recommended prices [Source: Analysys Mason, 2019]

Band	Lot size (MHz)	Reserve price per lot (EUR million)	Reserve price (EUR/MHz/pop)[1]	Total price (EUR million)
3440–3800MHz	36×10	4.60	0.04	165.60
3420–3440MHz	1×20	9.20	0.04	9.20
3400–3420MHz	1×20	6.9	0.03	6.9
26GHz	16×200	4.70	0.0020	75.20

[1] For ease of comparison this column shows the price of each MHz of spectrum divided by the estimated population in 2019, an approach which is standard practice in the industry.

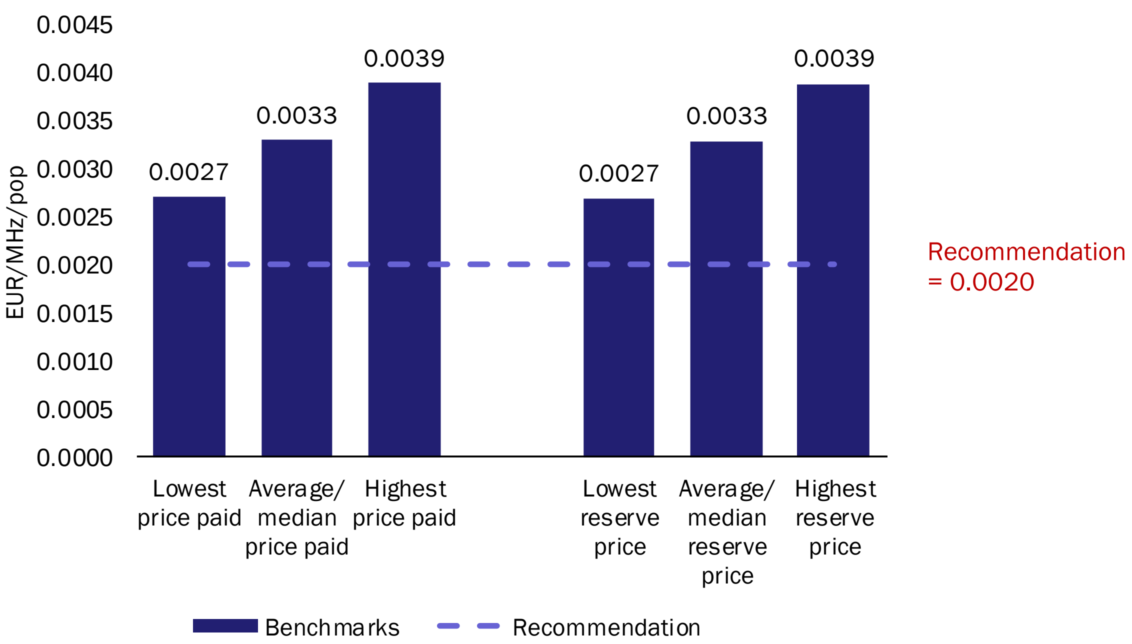
In order to compare our recommended reserve prices with benchmark data, Figure 1.2 presents the prices paid in 3600MHz auctions in other markets, showing the highest price (in EUR/MHz/pop), average price and median price as well as the reserve prices set by NRAs for those same auctions.

Figure 1.2: 3600MHz price recommendation for generic blocks [Source: Analysys Mason, 2019]



Likewise, Figure 1.3 presents benchmark data for prices paid and reserve prices for the 26GHz band (in EUR/MHz/pop).

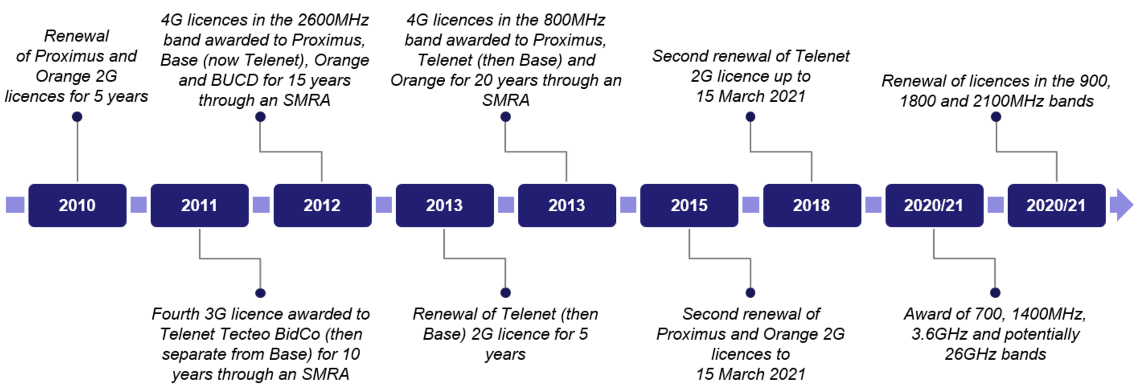
Figure 1.3: 26GHz price recommendation [Source: Analysys Mason, 2019]



2 Introduction

BIPT plans to award a large amount of spectrum for mobile services in 2020/2021, including licence renewals as well as the release of new frequencies in both low and high bands, which makes the next few years crucial for the future of mobile services in Belgium. There have been several awards in Belgium in the past few years, as illustrated in Figure 2.1.

Figure 2.1: Award of mobile licences in Belgium since 2010 [Source: Analysys Mason, 2019]



Note: SMRA stands for Simultaneous Multiple Round Ascending which is the auction type used previously in Belgium.

Among the frequencies that are planned for award in the next few years, some bands have historically been used for 2G, 3G and 4G technologies, and their rights of use are due for renewal in March 2021. These bands are listed in Figure 2.2. The conditions for renewal of the licences that will expire in March 2021 are outlined in the "*Communication du Conseil de l'IBPT à la demande du Ministre des Télécommunications du 13 août 2018 concernant le projet de réglementation pour la mise aux enchères multibande*".

Figure 2.2: Spectrum bands with licences to be renewed in Belgium in 2020/2021 [Source: Analysys Mason, 2019]

Band	Spectrum amount (MHz)	Block size (MHz)	Block reserve price (EUR million, EUR/MHz /pop)	New-entrant reserved spectrum (MHz)	Spectrum cap (MHz)	Licence duration (years)
900MHz	2×35 FDD	2×5	28/0.24	2×5	2×15	20
1800MHz	2×75 FDD	2×5	9/0.08	2×15	2×30	20
2100MHz	2×60 FDD	2×5	9/0.08	2×10	2×25	20

In addition to these renewals, BIPT also plans to award new spectrum which could be used for 4G and/or 5G technologies. These bands are listed in Figure 2.3. The aforementioned "*Communication du Conseil de l'IBPT*" also details conditions for award of the 700 and 1400MHz bands, while conditions for the 3600MHz band are set out in the "*Arrêté royal concernant l'accès radioélectrique dans la bande de fréquences 3400–3800 MHz*". However, it should be noted that the decision to award the 26GHz band with the other bands has not yet been finalised.

Figure 2.3: New bands to be awarded in Belgium in 2020/2021 [Source: Analysys Mason, 2019]

Band	Spectrum amount (MHz)	Block size (MHz)	Block reserve price (EUR million, EUR/MHz /pop)	New-entrant reserved spectrum (MHz)	Spectrum cap (MHz)	Licence duration (years)
700MHz	2×30 FDD	2×5	19.3/0.17	2×5	2×10	20
1400MHz	90 SDL	5	3/0.05	-	35	20
3600MHz	400 TDD	10 and 20[1]	-	-	100	20
26GHz	3250 TDD	200 and 50[2]	-	-	-	20

1 36 generic blocks of 10MHz and 2 specific blocks of 20MHz at 3400–3420MHz and 3420–3440MHz.

2 16 blocks of 200MHz and 1 block of 50MHz.

As regards the 3600MHz ('C band') and 26GHz ('mmWave') bands, a reserve price for the forthcoming auction has yet to be decided. Following a consultation on the future of the 3400–3800MHz band in July 2017 and one on the future of the 24.25–27.5GHz band in May 2019, BIPT has commissioned Analysys Mason to undertake a study of the value of spectrum in these two bands for existing MNOs and a potential new entrant. This study is to make recommendations on suitable reserve price levels for each of the two bands. We have structured our analyses and recommendations around the two bands, as follows:

- Analysis of the value of the **3600MHz band** based on benchmarks from countries where this band was awarded in the last three years, as well as our own spectrum valuation modelling based on a bottom-up discounted cashflow (DCF) model

- Analysis of the value of the **26GHz band** based on benchmarks from countries where this band was awarded in the last two years, as well as a high-level qualitative assessment of potential use cases for this band in Belgium.

These analyses take into account our understanding of the characteristics of the Belgium market, the objectives of BIPT, MNOs' views as laid out in their responses to the two consultations mentioned above, international benchmarks and best practices, as well as our professional judgment based on our wide experience from previous similar studies.

These analyses also take into account the two existing operators that use spectrum in the C band (Citymesh and Gridmax), the technical and geographical limitations associated with operating at the lower end of this band, as well as electromagnetic field limitations in the Brussels region.

It should be noted that our recommendations are based on technical and economic analyses and that we have not considered any specific legal issues.

The remainder of this report is laid out as follows:

- Section 3 summarises the analyses performed to determine the value of the 3600MHz band and presents our recommendation for spectrum prices for future awards
- Section 4, likewise, summarises the analyses performed to determine the value of the 26GHz band and presents our recommendation for spectrum prices for future awards.

In addition, Annex A describes the methodology used for the spectrum valuation model.

3 Price for the 3600MHz band

In this section we discuss the optimal pricing of the 3600MHz or C band (3400–3800MHz). We first analyse benchmarks derived from recent awards in other countries. We then present the results of our economic analysis of the value that the Belgian MNOs, including a potential fourth entrant, can be expected to assign to this band. Finally, we recommend a price for the band.

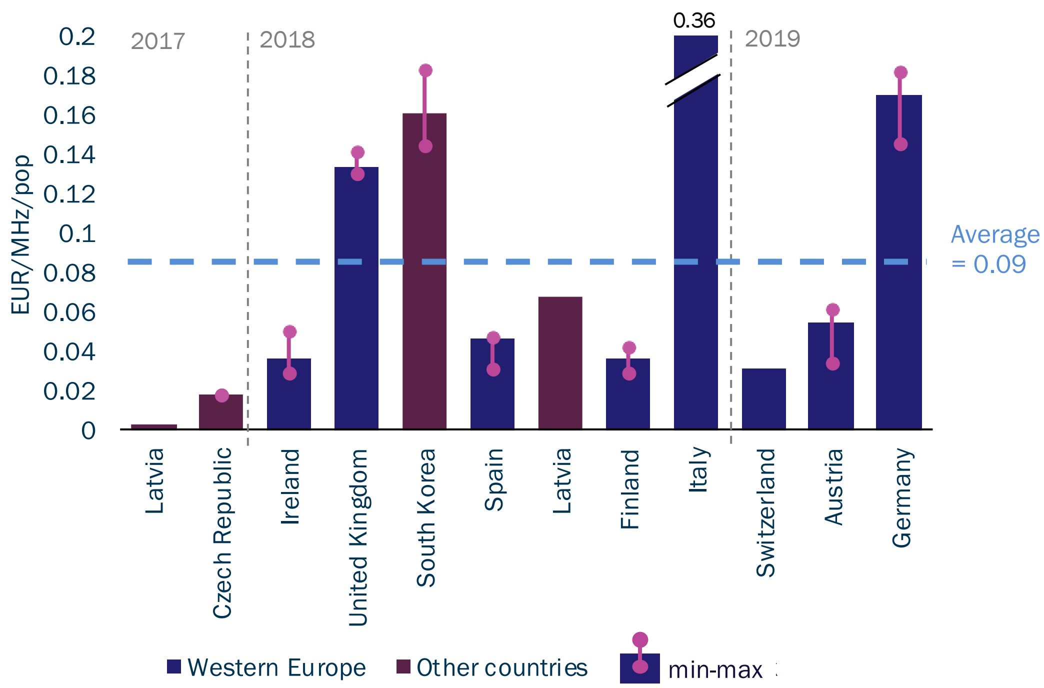
3.1 Price benchmarks

Since the C band has been identified as the core band for 5G in Europe, it has been awarded to MNOs in several countries in preparation for the roll-out of this technology. In order to determine the value of the spectrum in this band and provide a 'sanity check' on the results of our model, we believed it would be informative to benchmark the prices that have been paid for spectrum in this band as well as the reserve prices that were set by NRAs or governments.

In order to compare different countries and different amounts of spectrum awarded, we have normalised these benchmarks based on the amount of spectrum awarded and the population of the country in question. That is, the benchmarks are expressed as the price in EUR per MHz per population (EUR/MHz/pop), to enable comparison across markets.

Figure 3.1 presents the average prices that MNOs have paid for C-band spectrum in recent awards, with a focus on Western European countries (since they are the most comparable to Belgium).

Figure 3.1: Average market price for C-band spectrum, showing the minimum and maximum price paid by MNOs [Source: Analysys Mason, 2019]



As shown in Figure 3.1, the price paid for this band has varied widely. However, we observe that prices have generally increased over time, across Europe (and globally) as the C band started being identified as the core mid-spectrum band for rolling out 5G networks.

In some cases, the strategic nature of the C band for 5G roll-out, as well as the auction format, led to somewhat irrational bidding behaviours in some countries:

- In Italy, the limited amount of spectrum and the asymmetric format of the auction, with two blocks of 20MHz and two blocks of 80MHz in a highly competitive market, led to a bidding war and a highly inflated price
- In Germany, the arrival of a new entrant (an MVNO bidding for spectrum) pushed prices up
- In South Korea, the high reserve price was the main driver for the price paid.

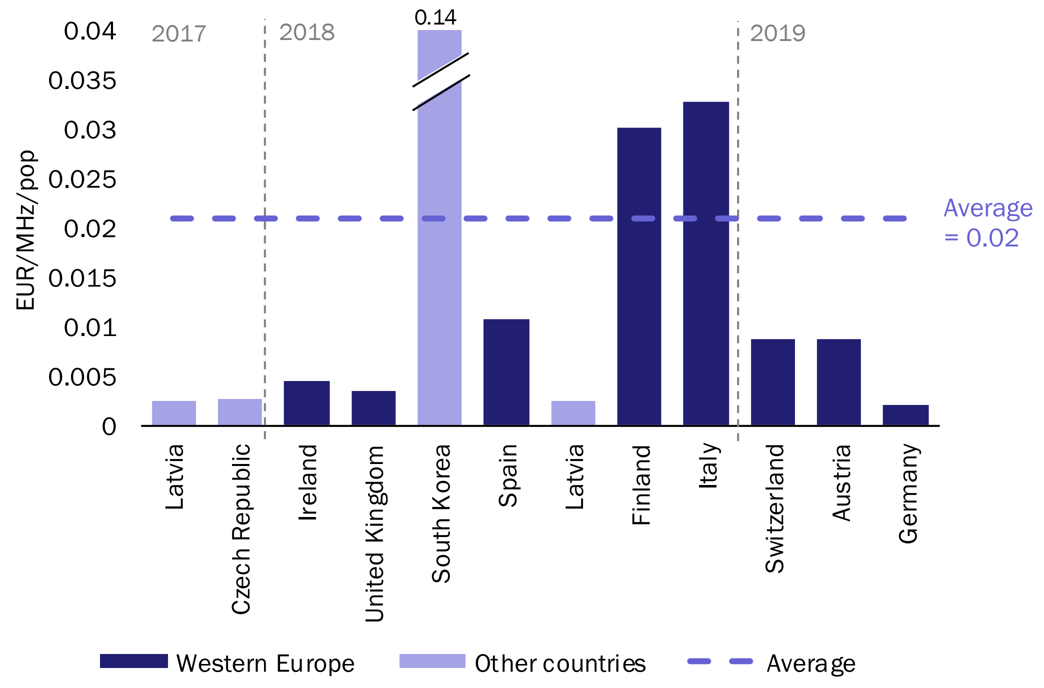
There are also circumstances that can explain lower prices in some auctions:

- In the Czech Republic and Latvia, auctions were held in 2017, before the band had been properly identified for 5G
- In Switzerland, the band was awarded alongside the 700MHz band in a combinatorial auction, and so MNOs focused their efforts on that band.

When both of these types of outliers are included, the average price for C-band spectrum in the benchmark countries was EUR0.09/MHz/pop.

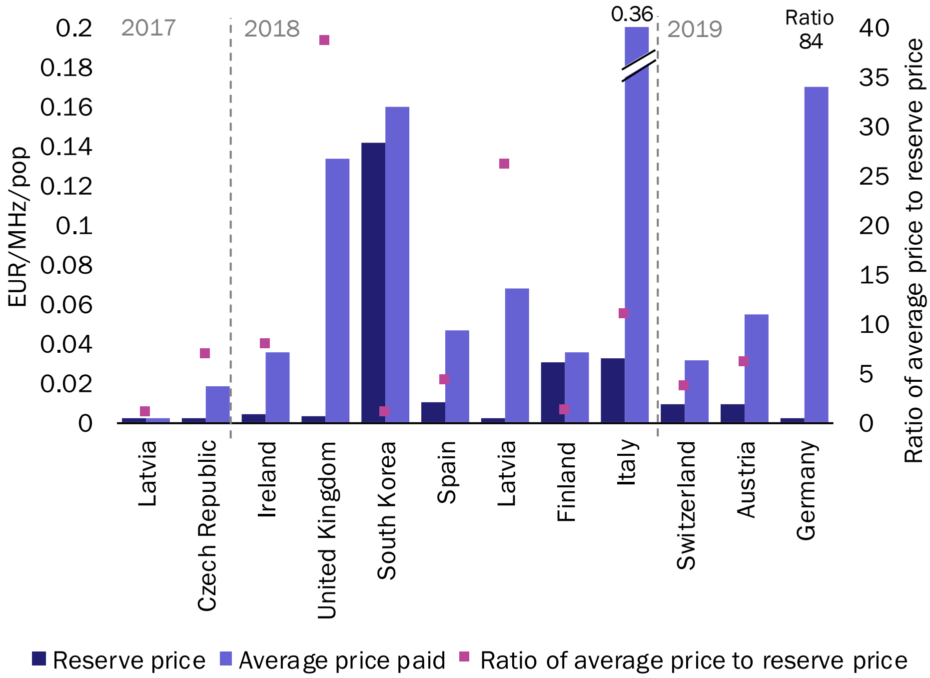
Figure 3.2 presents the auction reserve prices that were set in these same auctions.

Figure 3.2: Reserve prices set for the C band [Source: Analysys Mason, 2019]



Low reserve prices were set in Western Europe, with only Italy and Finland setting a price above the average of EUR0.02/MHz/pop. In general, MNOs largely outbid these reserve prices, as shown in Figure 3.3.

Figure 3.3: Reserve price as a multiple of prices paid for the C band [Source: Analysys Mason, 2019]



It is worth noting that, in most markets, potential demand for the spectrum exceeded the total amount offered, which explains why prices could rise much higher than the reserve price. In Germany, for instance, MNOs paid on average more than 80 times the reserve price. In contrast, in countries like South Korea or Finland, the amount of spectrum offered was close to the demand, which led to a price paid very similar to the reserve price (the paid price is around 1.1 and 1.2 times the reserve price for South Korea and Finland respectively).

3.2 Economic analysis methodology

In our economic analysis we have developed a spectrum valuation model to assess the value of the C band to each of the existing Belgian MNOs as well as a potential new entrant.

We have calculated the value of the spectrum by assessing the incremental change in cashflows generated by the mobile business as a result of acquiring additional blocks in that band. We have done this by comparing the net present value (NPV) of these different cashflows over the entire licence period using an appropriate discount rate. The value of the spectrum is the difference in valuation between the scenario where an MNO holds that frequency and the scenario where it does not.

There are three main sources of value that spectrum can provide for an MNO:

- **Technical value**: the acquisition of spectrum can save network costs by providing additional coverage and capacity, and avoiding the need to build new base stations. In the Belgian market, roll-out of the 3600MHz band would help MNOs to increase the capacity of their networks, to accommodate increased data consumption associated with the arrival of 5G.
- **Commercial value**: spectrum can affect the services that an MNO is able to offer, which in turn will have an impact on subscriber numbers and revenue. In particular, the ability to offer high-speed next-generation services with certain spectrum can reduce churn rates and increase competitiveness. We consider that having spectrum in the 3600MHz band is crucial for MNOs to offer 5G services in the short term, and that having access to a sufficiently large spectrum portion (or carrier) will allow MNOs to differentiate their 5G offerings from existing 4G services.
- **Strategic value**: by acquiring spectrum, an MNO may gain strategic benefits over its competitors. For instance, the spectrum can be used to improve the MNO's service offerings, thus increasing its competitiveness and raising the barriers to market entry. An MNO may also gain strategic advantage by preventing other MNOs from acquiring the spectrum (or at least, the amount that they want). The C band could have a high strategic value for some players, because, as mentioned before, it is key to being able to offer next-generation high-speed enhanced mobile broadband 5G services in the short term.

In our modelling for this study *we have only considered the technical and commercial values of the spectrum*. We have not considered the strategic value, as this would require detailed insight into the commercial strategies of potential bidders and could lead to an overestimate of the demand for spectrum. Furthermore, given the low probability of a classical[1] mobile fourth entrant, as discussed in Section 3.2.3 below, there is a high chance that spectrum supply will exceed the demand, which in itself drastically reduces the strategic value of the spectrum (since there is no possibility to evict one MNO or obtain a substantially larger portion of the spectrum than competitors). In addition, given we were not provided with detailed commercial and technical inputs from MNOs, and in order to avoid overestimating the value of the spectrum, we have used conservative assumptions in our model.

Further details of our valuation methodology are provided in Annex A.

To make a valuation of the C band we have looked at different spectrum award scenarios where each MNO obtains between 30MHz and 100MHz of spectrum, which is the spectrum cap. For each MNO we have compared these award scenarios to a reference scenario where the MNO is not awarded any C-band spectrum. When carrying out the valuation, we have taken account of several key factors which could affect the capacity and relevance of the C band over time:

1 In the sense of an operator focused on providing the same type of mobile voice and data services to business and consumers as the existing MNOs, and in opposition to highly specialised operators that would target new and specialised market sub-segments addressing the needs of specific verticals.

- the availability of terminals which can operate with 5G and the C band
- plans for an auction of the C-band spectrum in 2020, with spectrum made available the same year
- plans for an auction of the 700MHz and 1400MHz bands in 2020 as well, via a symmetric award (where each MNO obtains the same amount of spectrum in both bands), with spectrum made available the same year
- the possibility that most bands which MNOs currently use for 4G will eventually be *refarmed* for 5G use
- the assumption that MNOs' spectrum portfolio in the other bands (apart from 700MHz, 1400MHz and 3600MHz) would remain unchanged in future renewals
- the technical characteristics of the different bands and technologies, which translates into different capacities per band
- electromagnetic field limitations in the Brussels region.

It is important to note that we have not considered any potential incremental revenue from verticals and have focused our valuation on the enhanced mobile broadband use case for 5G. For now, we believe that vertical revenue streams are highly speculative, as use cases for the Internet of Things (IoT) or mission-critical applications are still largely hypothetical at this stage. If we had based part of our valuation on such hypothetical business lines this might have artificially increased the value of the spectrum and reduced the reliability of our modelling. In addition, based on our experience, due to the speculative nature of these applications, most MNOs tend not to take them into account when valuing 5G spectrum in the context of an auction.

As mentioned above, we have evaluated the technical and the commercial value of the 3600MHz band separately, as illustrated in Figure 3.4.

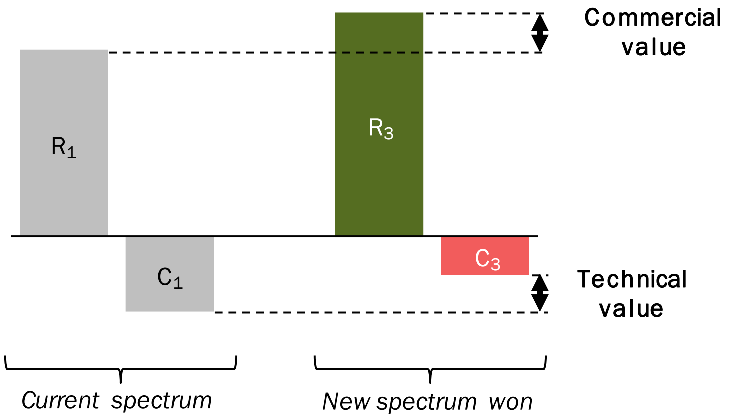


Figure 3.4: Illustration of the commercial and technical value of spectrum [Source: Analysys Mason, 2019]

Note: R = revenue and C = cost.

3.2.1 Technical value

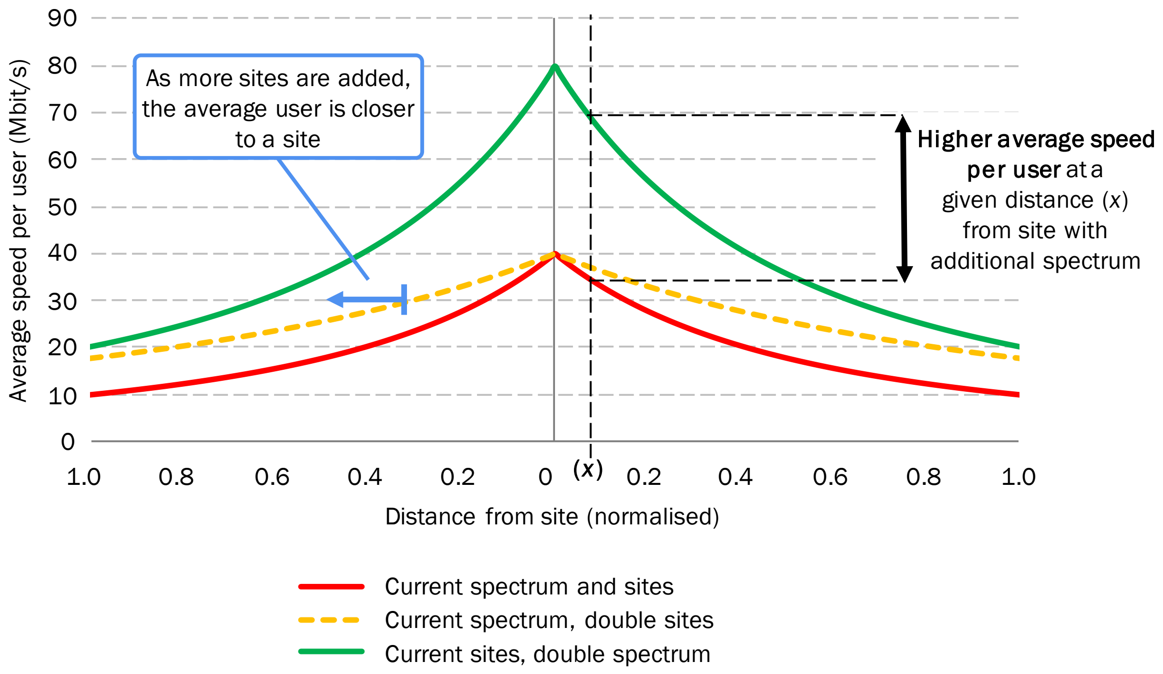
For the technical value of the 3600MHz band, we forecast an increase in mobile data traffic in Belgium, but we also take into account the characteristics of the Belgian market, with lower mobile data usage than in other markets, and investigate how operators could cope with the increase in traffic depending on the amount of 3600MHz spectrum that is available to them. The more spectrum an MNO has, the fewer sites it needs to construct or upgrade to accommodate capacity requirements. This leads to less spending by the MNOs overall (both capex and opex). These costs savings, discounted over time, correspond to the technical value of a band for the MNO.

The technical value of the band is affected by a number of factors. In particular, we estimate that electromagnetic field limitations in the Brussels region (which accounts for around 10% of the Belgian population and 40% of the urban population) will limit deployment of the 3600MHz band in the area and limit the capacity of this spectrum where it is rolled out, due to artificially limiting the emission power.

3.2.2 Commercial value

The commercial value of spectrum is based on a variation in the number of subscribers that an MNO is likely to win or lose, depending on the quality of service resulting from the amount of spectrum owned. If an MNO has a larger amount of spectrum than its competitors this may give it a non-replicable competitive advantage, as shown in Figure 3.5.

Figure 3.5: Average speed per user in Mbit/s [Source: Analysys Mason, 2019]



An MNO which has larger amounts of spectrum can offer higher peak speeds (which cannot be replicated with less spectrum) as well as generally higher average speeds, which can be approximated (but not necessarily equalled) by site densification. An MNO which offers a better quality of service (due to having an increased amount of spectrum) may increase its market share. Conversely, an MNO which has a smaller spectrum portfolio than its competitors may lose market share.

The commercial value of the spectrum corresponds to the incremental revenue which is attributable to the increased spectrum portfolio. In this study, the commercial value for an MNO comes from comparing the increased revenue it can expect as a result of being awarded C-band spectrum to its revenue in the event that the MNO is not awarded any C-band spectrum, as illustrated in Figure 3.4 above.

3.2.3 Potential new entrant

As well as modelling the value of the 3600MHz band for the three existing MNOs, we have also investigated the possibility of a classical mobile new entrant bidding for the band. In particular, we did not consider alternative business cases for a potential new operator focusing on providing services to specific businesses or verticals, for example.

While we consider the likelihood of a fourth classical MNO entering the market to be extremely low, it is nonetheless important to determine whether the reserve price we recommend could be a barrier to the launch of a new MNO. There are a number of factors which make the arrival of a new entrant hard to envision:

- Previous attempts by new entrants have failed (i.e. Telenet Tecteo BidCo fourth 3G licence)
- The mobile market in Belgium is saturated and competitive, with a high level of mobile penetration
- The large amount of spectrum currently held by existing MNOs in various bands means it would be challenging for a new entrant to develop a profitable business model in the long term, based on a relatively low share of spectrum compared to existing MNOs
- The main mobile operators are integrated and also have fixed arm, which are key to generating economies of scale and scope (in terms of infrastructure and commercialisation)
- With a population of around 11 million, the Belgian market is rather small for four MNOs
- In the last ten years, many European countries have seen their number of MNOs reduce from four to three, rather than increasing from three to four
- The use of mobile broadband is still modest in Belgium when compared to other European markets, mainly due to competition from a fixed broadband network which provides very good coverage and quality of service, and to significant use of Wi-Fi technology. Hence, a business case for a fourth entrant based on mobile broadband services does not seem very attractive
- Several spectrum awards in other European countries that included a spectrum reservation for a new entrant failed to result in the successful launch of a new player.

To model the value of the C band for a new entrant, we have used many of the same market and technical assumptions that we used in the economic model for existing MNOs. We have also benchmarked the profile of new entrants in several countries that had achieved high levels of mobile penetration after their launch, in countries relatively similar to Belgium, in order to make assumptions about new-entrant strategy and, in particular, how their market share could evolve over time (if they were successful).

The spectrum value we obtained for a new entrant varies widely across the spectrum scenarios we have considered, depending on what other bands the new entrant might also acquire. We believe that the reserve price we recommend would not prevent a new player from entering the market.

3.3 Approaches to setting spectrum prices

There are three main approaches that NRAs take when setting spectrum prices for awards, as summarised in Figure 3.6 below.

Figure 3.6: Main approaches for setting spectrum prices [Source: Analysys Mason, 2019]

Approach	Objectives	Details	Comments
Low but not insignificant price	Efficiency of outcome	Prices are set at a modest level considered sufficient only to deter frivolous participation Prices are set with no consideration of the expected value of the frequencies being awarded	Appropriate if the NRA's core objective is efficiency of outcome and it does not aim to raise revenue This approach is very popular with bidders, as under low-competition scenarios they may acquire licences at a very low price relative to their expected return
Revenue maximisation	Raising significant revenue	Prices are set at (or very close to) the estimated value of the licence to the marginal winning bidder (the winning bidder who assigns the lowest value to the spectrum)	Pricing at this level incurs a significant risk that spectrum lots may be priced too high and therefore remain unsold
Minimum expected return	Efficiency of outcome Raising revenue even when there is no excess demand	Prices are set with a discount on the estimated value of the licence to the marginal winning bidder, but at a level that will still ensure a significant revenue return	An approach that is widely used in spectrum auctions This approach will suit the leading MNO in the market, which will assign a much higher value to the spectrum

In the case of Belgium, **we recommend using the minimum expected return** when setting prices for the C band. This approach should ensure that BIPT's two main objectives are met, namely making sure that all the available spectrum is sold and used in the most economically efficient manner, and ensuring that the government receives adequate revenue from the spectrum.[2]

2 Note that since our recommendations are based on the minimum expected return approach, in our valuation model we significantly discount the estimated value of the spectrum to a marginal winning bidder.

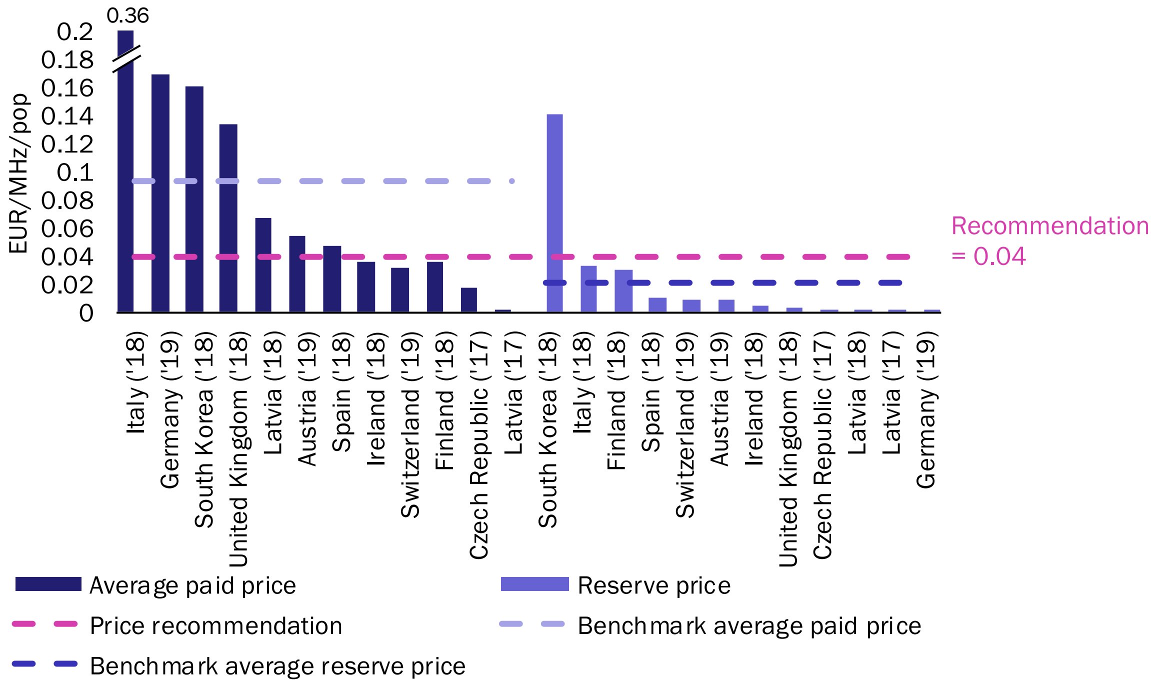
3.4 Recommendations for Belgium

3.4.1 Generic blocks (3440–3800MHz)

Based on our economic analysis, **we recommend that BIPT set a reserve price for the 3440–3800MHz band of EUR4.60 million per 10MHz block, which translates into a price of EUR0.04/MHz/pop**. This is higher than the average reserve price of EUR0.02/MHz/pop of the benchmark but significantly lower than the EUR0.09/MHz/pop average paid price across the benchmark, as shown in Figure 3.7.

This recommended reserve price reflects the risk that supply could be higher than demand during the forthcoming 3600MHz auction, which implies that the available spectrum is unlikely to be awarded at much higher than the reserve price. Indeed, if there is no new entrant to the mobile market, a total of 380MHz will be available, but the 100MHz spectrum cap set by Royal Decree means that existing MNOs can only be awarded a total of 300MHz.

Figure 3.7: Recommended price for the 3600MHz band in Belgium [Source: Analysys Mason, 2019]



3.4.2 3420–3440MHz block

Regarding the 3420–3440MHz spectrum block, for which Citymesh and Gridmax have been awarded licences, **we recommend that BIPT should set a reserve price of EUR9.20 million for the 20MHz block, which is the same price per MHz as for the 3440–3800MHz spectrum.**

As regards the existing licences held by Citymesh and Gridmax, we do not consider that the award of new national licences in 3420–3440MHz warrants a lower reserve price for the affected spectrum, for several reasons.

- Firstly, the existing authorisations are only regional, and the operators cover only a limited portion of the Belgian population (less than 12% of the population).
- Secondly, the restrictions imposed on this specific frequency block are limited in time and expire at the latest in mid-2025, which represents at most only one quarter of the planned licence duration.
- Finally, if no new entrant were to take part in the forthcoming auction, it would be possible for the existing MNOs to bid for 100MHz (their authorised spectrum cap) without having to bid on this specific 3420–3440MHz block (i.e. each of the three MNOs will bid on 10 blocks in the 3440–3800MHz band which contains 36 blocks).

3.4.3 3400–3420MHz block

Finally, regarding the lower end of the spectrum, i.e. **the 3400–3420MHz band, we recommend setting a lower reserve price of EUR6.90 million for the 20MHz block, which corresponds to a 25% reduction in the price per MHz compared to the remainder of the band.**

In general, the main reason for governments or NRAs to set a lower reserve price on the lowermost 20MHz of the 3600MHz band is the potentially limited usability of this spectrum. In Europe, Commission Implementing Decision (EU) 2019/235 allows regulators to impose limits on emissions by electronic communications systems (such as future 5G systems) under 3400MHz, to reduce interference with radiolocation (radar) systems operating in that band. For example, in France, this frequency block will not be awarded for use by 5G mobile networks.[3] Similarly, the 3400–3410MHz block was not awarded in in Austria, Finland, Ireland or the UK. In Germany, the NRA decided to define a reserve price for this block that was roughly 60% of the price of spectrum in the rest of the band.[4]

In June 2019, BIPT put out for public consultation a project on the technical conditions for use of the 3400–3800MHz band in Belgium which proposes to implement such power restrictions below 3400MHz. These restrictions would only apply to zones within a 10km radius of the coast or a maritime port, which should help to improve the usability of the block.

However, in addition to these power restrictions, BIPT has decided to limit the number of candidates that can bid on this specific block. To give Citymesh and Gridmax a better chance of continuing to operate their infrastructure after their existing licences expire, BIPT will only allow these two operators to bid on this spectrum.

We therefore consider that, given both the usability limitations and bidding restrictions, the reserve price for the 3400–3420MHz block should be set at a lower value than the generic blocks in the 3440–3800MHz band. A 25% reduction in the reserve price would also make the spectrum more affordable for smaller operators such as Citymesh or Gridmax.

---

3 Technology-neutral licences for this spectrum were awarded to wireless local loop operators, with the intention that it would be used for TD-LTE technology, subject to strong usability restrictions.

4 BNetzA defined a reserve price of EUR2 million for the 3400–3420MHz block, whereas the rest of the band (3420–3700MHz) was priced at EUR1.7 million for a 10MHz block.

4 Price for the 26GHz band

In this section we discuss the pricing, and more generally the release strategy, for a new type of spectrum called mmWave that will be used for electronic communications for the first time in 5G networks. In Europe, the preferred mmWave spectrum is the 26GHz band (24.25–27.5GHz).

We present pricing benchmarks for the release of this band, as well as qualitative analysis of the value of the spectrum in the short to medium term. Finally, we provide recommendations for BIPT on setting reserve prices for this band.

4.1 Price benchmarks

In order to determine the value of spectrum in the 26GHz band, we believed it would be helpful to benchmark the prices that have been paid for spectrum in this band, as well as the reserve prices that were set by NRAs or governments. Undertaking a benchmark for the 26GHz band is less informative than for other bands such as 3600MHz, as very few countries have awarded mmWave spectrum. We have only included Italy and South Korea in our benchmark, as both have awarded 26GHz spectrum through an auction and both are developed markets.[5,6]

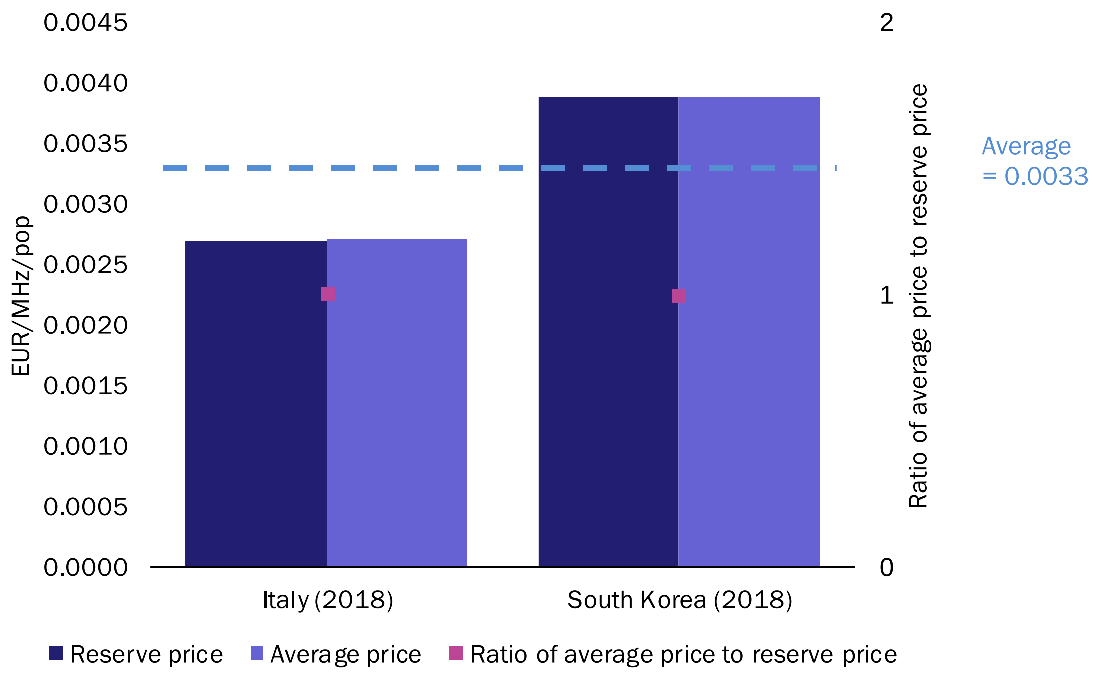
In order to compare different countries and different amounts of spectrum awarded, we have normalised the benchmark data based on the amount of spectrum awarded and the population of the country in question. That is, the benchmarks are expressed as the price in EUR per MHz per population (EUR/MHz/pop), to enable comparison across markets.

Figure 4.1 presents the average prices that MNOs have paid for 26GHz band spectrum in recent awards against the reserve prices that were set.

5 However, South Korea is much more advanced than Europe in terms of 5G roll-out, and geography or population densities are hardly comparable between Italy and South Korea.

6 We decided not to include the USA in the benchmark, primarily because although local operators are vigorous proponents of the use of mmWave spectrum, the awards are difficult to compare. For instance, most of the spectrum used by Verizon was bought on the secondary market.

Figure 4.1: Comparison between prices paid for the 26GHz band and reserve prices [Source: Analysys Mason, 2019]



Two main conclusions are worth pointing out: firstly, prices for this spectrum have been very low, at an average of EUR0.0033/MHz/pop; secondly, the spectrum was sold almost at reserve price. Although there have been very few auctions of mmWave spectrum, the available data suggests that the value of this spectrum is extremely low and highly speculative. Our understanding is that MNOs probably purchase this spectrum to ensure that they have access to it once new use cases and business models materialise.

4.2 Qualitative analysis

There are several reasons why it is not possible to make a spectrum valuation for mmWave-type spectrum (such as the 26GHz band) on the basis of network roll-out, as we did for the 3600MHz band.

One issue is the level of maturity of technology in the 26GHz band, as this type of spectrum has never been used for mobile communications. As a result, technical performance with miniaturised devices, such as smartphones, is limited and is likely to remain so for the next few years. By way of comparison, the 3600MHz band has been in use for some time, initially for WiMAX devices and then for TD-LTE smartphones in some regions of the world. The first generation of mmWave-compatible devices are known to face integration issues, such as overheating or rapid battery draining. While technology will certainly improve to mitigate these issues over time, this could take a number of years, which raises uncertainties about the usability of this spectrum in the short term.

The second issue is the extremely poor propagation properties of mmWave spectrum, resulting in low coverage potential. Even with the use of beamforming and de-coupling (both technologies that enable 3600MHz spectrum to reach acceptable levels of coverage for a macro-type roll-out), the cell radius of mmWave cells will still only be a few hundred metres at best. As a result, in the short term, the use of such frequencies in mobile networks may only be limited to bespoke small-cell roll-outs in capacity-constrained areas or in areas that require extremely high data rates. The first use of mmWave spectrum (mostly in the USA and in developed Asia, like South Korea or Japan) has been for the roll-out of very-high-speed small cells in dense urban areas for mobile use, as well as for local fixed-wireless access networks in fibre-deprived areas. For now, these limited roll-outs serve more of a marketing purpose than a way of providing widespread improvements in quality of service across a network footprint in dense areas.

In Europe, there is a plentiful supply of spectrum in the 26GHz band, compared to historical awards in other bands, and indeed it should be possible for MNOs to obtain enough of this mmWave spectrum to provide much higher data speeds for end users. This abundance of spectrum, combined with its very limited coverage properties, has led governments and NRAs to consider what licensing regime would be most appropriate. Some countries, like South Korea or Italy, have awarded nationwide and exclusive licences. However, others, like France or the UK, have been considering regional licences or even unlicensed use for part of this spectrum, given the limited interference potential and the variety of possible use cases. In addition, restrictions on the use of the spectrum are still being debated at European level, such as power limitations at the lower end of the 26GHz band (to protect Earth observation satellites). As a result, it is still hard to predict how intense the competition will be for providing services using this kind of spectrum (that is, who will or will not have direct access to spectrum).

We note that the use cases for mmWave spectrum have not yet been clearly defined. To date, as explained previously, usage of the spectrum has been very limited. Furthermore, given the lack of maturity of 5G networks and limited roll-outs of mmWave cells, it is too early to determine whether these ultra-high-speed services will be successful. Nevertheless, a wide range of potential use cases are being developed which could benefit from gigabit-class wireless links (such as virtual or augmented reality, advanced autonomous driving, video surveillance and advanced robotics). However, it is difficult to predict whether these use cases will require an operated network (i.e. an MNO runs the network) or a private network (i.e. the user runs his own network).

In addition, the incremental revenue that could be expected from such use cases – which are *a priori* cost intensive given the nature of the spectrum used – remains unclear, making the value of this spectrum highly uncertain.

For the reasons discussed above, it is not practical to use a traditional valuation methodology to estimate the value of 26GHz spectrum. Moreover, because the technology is very new, there have been very few spectrum awards in these bands and roll-outs are extremely limited. Therefore, the use of benchmarking to estimate spectrum value might be a meaningless exercise.

Nevertheless, the arguments presented in this subsection suggest that:

- mmWave roll-outs will be costly (low coverage, immature technology)
- competitive intensity in this band is hard to predict
- the revenue potential is highly speculative.

In conclusion, we believe that if 26GHz spectrum is awarded in Belgium in the short term, it should be offered at a very low reserve price that reflects the uncertainties attached to its potential uses.

4.3 Recommendations for Belgium

In light of the discussion in Section 4.2, our initial recommendation is that BIPT should not award 26GHz spectrum in the coming auction, but rather it should wait until the technology, usability and revenue potential for this spectrum are more clearly understood by MNOs, users and NRAs. This recommendation is in line with views that MNOs have shared with BIPT when responding to the public consultation on the award of spectrum in the 26GHz band.

However, if BIPT decides to proceed with a short-term award of the spectrum, we recommend setting a low reserve price that will incentivise MNOs to seek a licence and may foster the development of innovative use cases.

Considering the limitations discussed above, including the band coverage characteristics, the deployment cost and the potential roll-out strategies, **we recommend setting a price of EUR4.7 million per block of 200MHz, which corresponds to EUR0.0020/MHz/pop, which is lower than the benchmark prices.**

Annex A Spectrum valuation methodology

In this annex we first present the high-level objectives, approach and scope of the model used to analyse the value of the C band. We then present in more detail the methodology used for the spectrum valuation model.

A.1 Objectives and data sources

In order to inform our recommended reserve prices for the 3600MHz and 26GHz bands, we have undertaken a detailed benchmarking exercise. For the 3600MHz band specifically, we have also developed a valuation model in order to analyse the value of the band for each MNO. The valuation model informed our recommendation which we have then validated against our benchmark.

The valuation model has been developed using data from a variety of sources, but where possible we have used publicly available information. The main data sources we used are:

- **BIPT**: subscriber numbers, data usage with split by technology, revenue, ARPU, existing licences, existing coverage
- **Belgian MNOs**: site data
- **Statbel**: population by municipality, municipality areas
- **Analysys Mason DataHub**: data usage, subscriber split by segment
- **EIU**: population data
- **Euromonitor**: population data
- **GSMA Intelligence**: subscriber split by technology, operator revenue.

Data from GSMA Intelligence, Analysys Mason DataHub and Euromonitor was mainly used as a countercheck to verify the validity of our inputs.

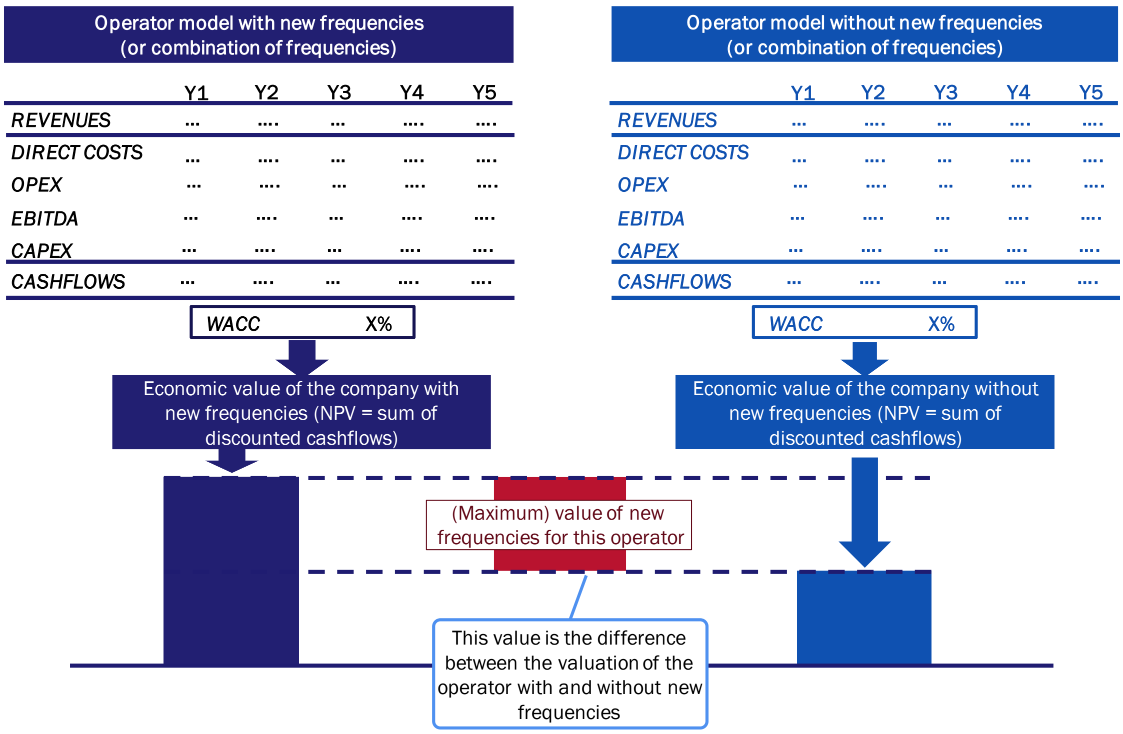
In addition, a number of technical inputs and unit costs have been informed by our own experience, gained while working on previous similar projects.

We have also produced a second model to analyse the value of the C band for a classical mobile new entrant, in order to determine whether the recommended reserve price for the 3600MHz could be a deterrent to potential future operators. For this model we have used the same sources as listed above, particularly our own experience from previous projects, as well as a benchmark of fourth entrants in mature markets to inform our assumptions on potential market share, for example.

A.2 Approach and scope of valuation model

The maximum valuation of a band for an MNO is the difference in the MNO's economic value with and without that spectrum, as presented in Figure A.1.

Figure A.1: Spectrum valuation methodology [Source: Analysys Mason, 2019]



The valuation model determines the incremental value of spectrum acquisition to a potential bidder's NPV. In order to calculate this, we have developed a bottom-up DCF model for each of the three main MNOs (Proximus, Telenet and Orange). The model considers the total value of the spectrum acquisition over a 20-year period by calculating revenue and costs over this period and discounting these values to the acquisition date (assumed to be in 2020). In order to calculate the incremental value of a particular spectrum assignment, the model is run twice, first using a "reference" scenario with no new spectrum or alternative spectrum, and then with that spectrum made available. The incremental spectrum value is therefore the difference between the two cases, as demonstrated in Figure A.2.

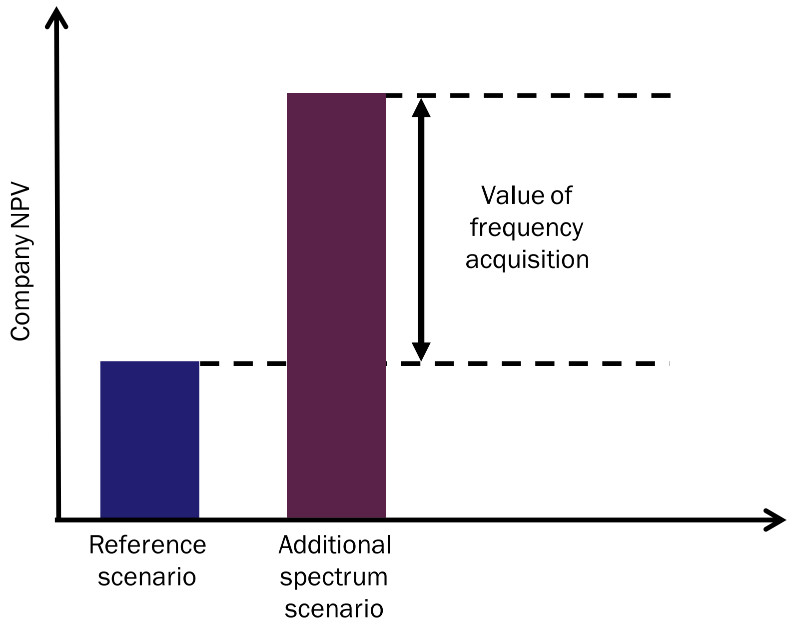


Figure A.2: Illustration of incremental spectrum value calculation [Source: Analysys Mason, 2019]

There are three potential sources of value that additional spectrum can present to an MNO:

- **Technical value**: this represents a saving on network costs arising from increased capacity per site and increased coverage (if low-band spectrum is won). Extra spectrum delays the need to build new sites at greater expense than site extensions, but also results in a slower rate of build when it becomes necessary to build new sites.
- **Commercial value**: this represents value from being able to offer higher-quality services with greater levels of coverage and may be realised through increased market share (i.e. an increase in net subscriber additions) and ARPU or reduced levels of churn.
- **Strategic value**: this represents a wider value to the potential bidder, whereby participation in the auction can potentially offer strategic benefits, such as synergies with other areas of the business or increasing the barriers to entry for new players. This could similarly be realised through increased market share (or flat market share in a scenario where it would have otherwise decreased), increased ARPU or decreased churn.

We have not considered any strategic value from spectrum acquisition, as this would require detailed insight into the commercial strategies of potential bidders and could lead to an overestimate of the demand for spectrum. Furthermore, given the low probability of a fourth entrant, there is a high chance that spectrum supply will exceed the demand, which in itself drastically reduces the strategic value of the spectrum (since there is no possibility to evict an MNO or obtain a substantially larger portion of the spectrum than competitors). In addition, given we were not provided with detailed commercial and technical inputs from MNOs, and in order to avoid overestimating the value of the spectrum, we have used conservative assumptions in our model.

We have considered both the technical and commercial value separately. The technical value arises from the fact that the C band can be used to accommodate increases in traffic over the next 20 years. Meanwhile, the commercial value is due to a portion of subscribers being particularly sensitive to quality of service and specifically data rates. These customers are likely to churn from operators that have a small amount of 3600MHz spectrum (or no spectrum in this band), as the speed of their network should be lower than that of MNOs with more spectrum. The availability of more spectrum is therefore linked to an increase in the number of subscribers, and so the commercial value is the incremental margin generated by this increase in market share.

The valuation model calculates the value of the band for each of the three MNOs, but the recommended price is largely dependent on the valuation for the lowest "marginal bidder"(i.e. the bidder that has the lowest valuation), since setting a reserve price above this would effectively exclude that bidder and lead to decreased competition.

In relation to a potential new entrant, we have modelled a high-level business plan, taking into account several scenarios with various amounts of C-band spectrum as well as different amounts of spectrum in other bands. This has allowed us to derive the value of the C band for a new entrant and also look at the viability of a new-entrant business plan under different spectrum scenarios.

A.3 Criteria used for the 3600MHz band

The C band creates value for MNOs by increasing the capacity and peak speeds on new-build sites as well as on existing sites where the spectrum is added. We have considered the following criteria when assessing the value of this band:

- the availability of 5G-compatible terminals in the current and future ecosystem
- an availability date of 2020
- the possibility of using 5G-comptible devices with a 4G network (i.e. 5G devices will be backwards compatible with 4G and capable of routeing all or part of their traffic through existing 4G base stations)
- the potential repurposing, or *refarming*, of existing bands (mainly from 4G to 5G)
- the technical characteristics of the band in terms of potential bandwidth/capacity (driven by spectral efficiency)
- the amount of bandwidth acquired by the modelled MNO
- the possible uplift/downlift in market share resulting from the amount of spectrum owned.

Subscribers are split into three segments: “voice only”, “voice & data” and “data only”, with each forecast separately to reflect future trends. Machine-to-machine (M2M) subscribers are excluded from the model. The technical value is calculated by considering the forecast 4G and 5G traffic levels, and the ability of current bands and sites to meet increasing capacity requirements. Where possible, additional spectrum is added to existing sites, and then new-build sites are added, with sites that are intended to increase 4G capacity having all 4G bands, and sites that are intended to increase 5G capacity having both 4G and 5G bands (since 4G bands can be repurposed for 5G in future). The model calculates the revenue, capex and opex of each MNO in each situation and discounts future cashflows using a weighted average cost of capital (WACC) of 7.98% (as used by BIPT).

Furthermore, for the new-entrant model, we have considered a number of additional factors:

- the amount of spectrum reserved for a potential new entrant in the different bands that are going to be auctioned
- a go-to-market date of 2020
- coverage obligations for new entrants (if 700MHz or 900MHz is acquired)
- national roaming over 8 years after having reached 20% population coverage)
- the technical characteristics of the band in terms of potential bandwidth/capacity and coverage
- effects of coverage on market share.

The new entrant is assumed to be a purely 4G/5G operator (i.e. no roll-out of legacy technologies like 2G or 3G). We apply a downlift to market ARPU, an uplift to market data usage, and make assumptions regarding the churn rate and the share of gross adds in order to reach a market share that is in line with those of fourth entrants in other markets. 4G and 5G traffic is treated as a whole, with capacity enhancements being given to bands that are used with 5G technology. Where new sites are built, these are equipped with spectrum acquired in all bands. We have used a higher WACC than for the valuation model (12%), to reflect the higher risk involved in launching a new MNO.

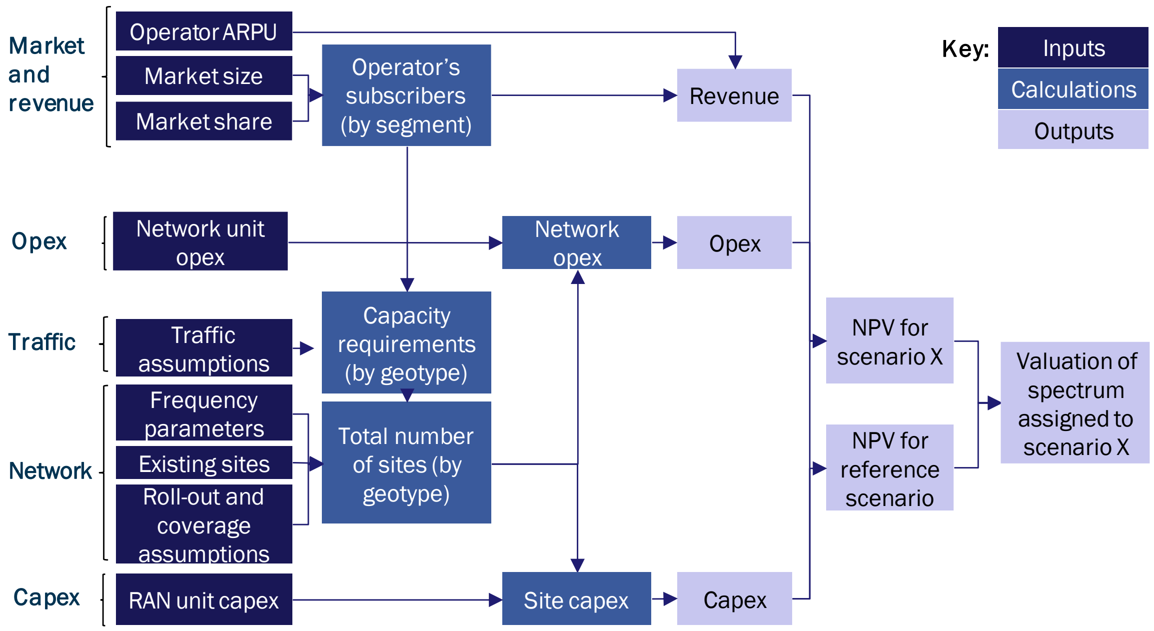
A.4 Methodology

In this section we detail the methodologies used for both the existing MNO valuation model and the new-entrant model.

A.4.1 Valuation model for existing MNOs

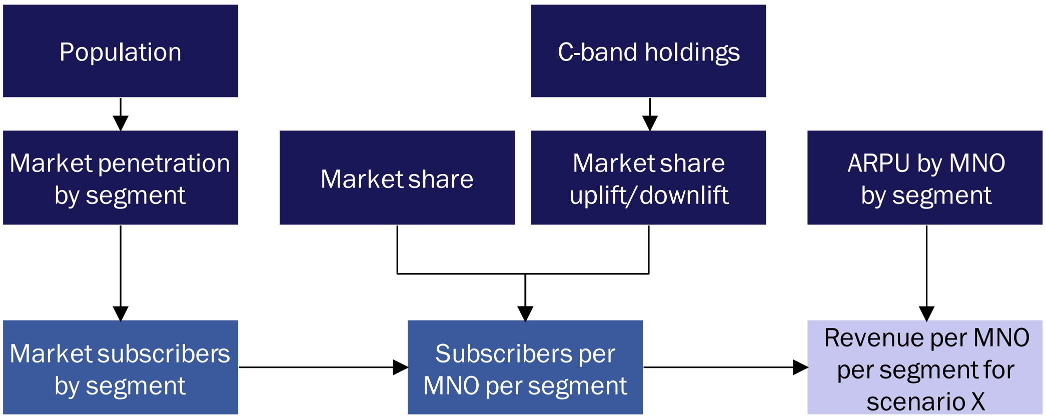
The valuation model calculates the sum of the discounted cashflows over the licence period by considering revenue, opex and capex for the modelled MNO. Figure A.3 provides a high-level overview of the architecture of the model.

Figure A.3: Overview of the model structure [Source: Analysys Mason, 2019]



On the commercial side, revenue is calculated by first considering the change in subscriber numbers at the market level split by segment. Each MNO's market share is forecast over the period using a scenario where the operator does not acquire any frequencies in the C band (the "reference" scenario). We then add to this "reference" market share an uplift or downlift, depending on the amount of C-band spectrum the MNO has acquired. This is used to calculate each MNO's number of subscribers, which is then multiplied by a forecast ARPU to give overall revenue for each MNO (as illustrated in Figure A.4), for each considered spectrum scenario. The commercial value of the spectrum represents the incremental revenue over the modelled period, in the considered scenario compared to the "reference" scenario and arising from the difference in spectrum holdings.

Figure A.4: Variation of the modelled MNO's market share and revenue [Source: Analysys Mason, 2019]



We decided to model the relationship between commercial performance (specifically market share in the present model) and C-band spectrum holdings over the modelled period, as we believe that C-band portfolio will be the determining factor for service differentiation during initial 5G roll-outs.

The variation in market share was defined in accordance with our own market studies on the percentage of subscribers who consider network speeds to be an important factor in their choice of operator in Western Europe, which amounts to around 19% of mobile subscribers. As a result, a certain share of this segment of consumers (around 10%) is likely to churn or be captured each year, which leads to an overall market-share variation over the modelled period. If an MNO acquires less than 40MHz of C-band spectrum, we consider that the 5G network speeds that can be achieved will be very similar to 4G and so this segment of customers is likely to move towards another MNO with more C band (and hence better network performance). Conversely, once an MNO has more than 80MHz of C-band spectrum, the benefits in terms of perceived network speeds are hardly noticeable, and so we consider that incremental amounts of C band above 80MHz will not lead to higher market shares. Between 40MHz and 80MHz of C-band spectrum, we scale the gains linearly for simplicity.

On the technical side, the value of the band arises from its ability to help an MNO accommodate growth in traffic over the licence duration at a lower cost than it could without this spectrum. In our modelling we have made a series of assumptions in order to forecast the evolution of mobile networks in Belgium as realistically as possible. These include:

- **Busy-hour dimensioning**: Communications networks are usually dimensioned so that they are able to handle peak traffic, not simply average traffic. Peak traffic generally happens during a specific part of the day, known as the busy hour. We have therefore modelled the Belgian MNOs' networks as having enough capacity to handle busy-hour traffic.
- **Inhomogeneous geographical traffic split**: To reflect the fact that not all regions have the same constraints in terms of busy-hour capacity,[7] we have divided the country into three geotypes –

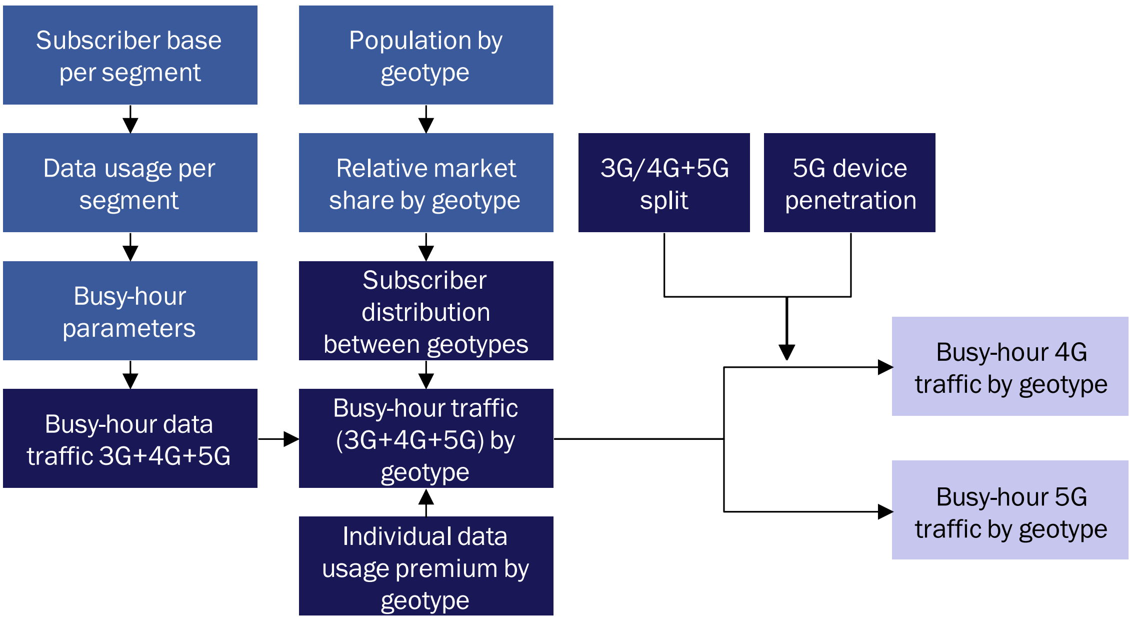
7 In general, mobile sites in urban areas tend to experience higher busy-hour traffic peaks.

urban, suburban and rural – and forecast the busy-hour traffic for each, as shown in Figure A.5. We have also considered the EMF limitations in the Brussels region (which represents 40% of Belgium's urban population), which require the roll-out of additional sites due to limits on emission power (and hence coverage) in this region.

- **4G and 5G constrained roll-out only**: In our network dimensioning model, we have chosen to take into account only 4G and 5G traffic, since 2G and 3G traffic levels are on a downward trend and both technologies are becoming obsolete. Therefore, it makes little sense for an MNO to continue rolling out such technologies.

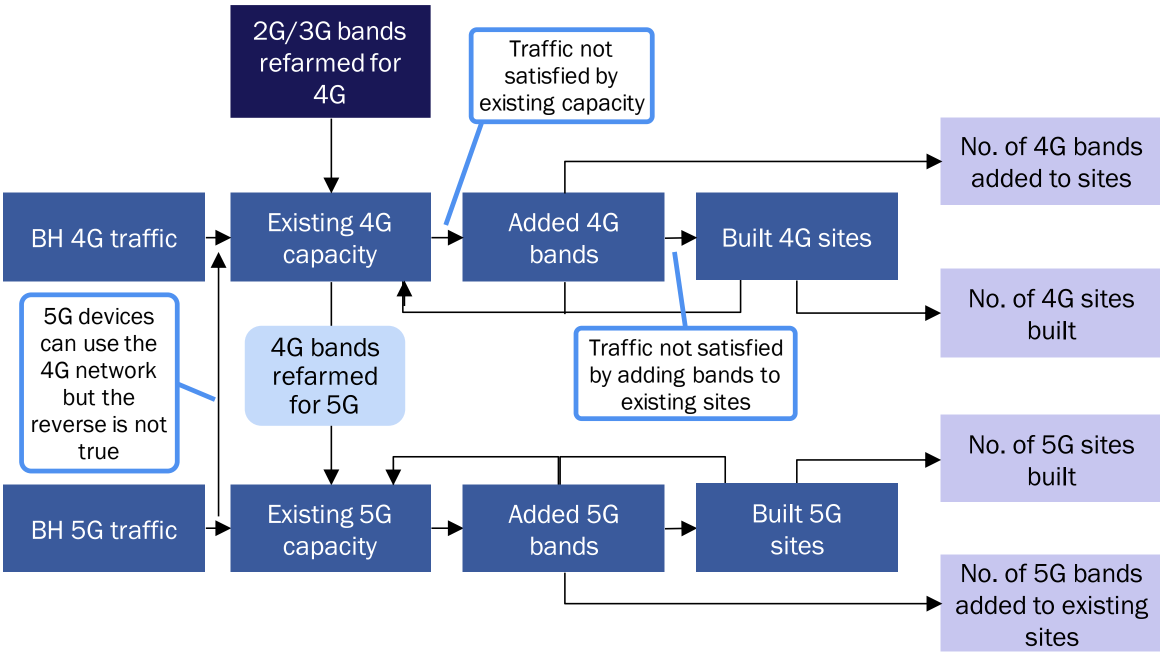
Taking into account these assumptions, we have calculated busy-hour traffic for each MNO from its respective number of subscribers, usage per subscriber and busy-hour parameters (i.e. the proportion of data usage that occurs in the busy hour). In addition, we have used population coverage, the share of compatible devices and a data usage premium over average national data usage for each geotype in order to derive the busy-hour data traffic of each MNO by technology and geotype. This process is shown in Figure A.5.

Figure A.5: Methodology for calculating 4G and 5G data traffic [Source: Analysys Mason, 2019]



The next step is to dimension the network of each MNO, in order to be able to route forecast 4G and 5G busy-hour traffic, for each geotype. It is economically cheaper for operators to add new bands to existing mobile sites rather than build new sites. As a consequence, our roll-out algorithm starts by using the existing network capacity to handle as much traffic as possible, then additional bands are added to existing sites with prioritisation between bands, and only when no further spectrum can be added to existing sites are new sites built. This algorithm is illustrated in Figure A.6.

Figure A.6: Network deployment methodology [Source: Analysys Mason, 2019]



Unit capex and opex are associated with the installation of a new band on an existing site or the construction of a new site. The technical value of the 3600MHz spectrum is obtained by calculating the difference between the NPV of capex and opex for scenarios with 3600MHz spectrum and our reference scenario (with no C band).

A.4.2 New-entrant model

The new-entrant model works in a very similar way to the existing MNOs' model, with some notable differences (which are detailed in this section).

One difference is that, since a future entrant's spectrum holdings are not known, we have developed several scenarios with different amounts of spectrum in different bands. For each scenario we have used the relevant reserve prices for these bands as the capex, and the annual licence fees for these bands as opex.

On the revenue side, the calculation is slightly different from the one for existing MNOs. In particular, the number of subscribers is calculated using the new entrant's share of gross adds as well as a churn rate, which is related to the coverage achieved by the new entrant (either through its own network or via national roaming). Revenue is calculated by multiplying this subscriber base by an ARPU which is lower than the market-average ARPU, to reflect the most likely market entry strategy.

As regards traffic, we have applied a data usage uplift to the usage of the new entrant's subscribers, since we expect that a new entrant's market strategy would most likely be to disrupt the market by offering more data at a cheaper price.

By definition, a new entrant would have no network to upgrade in order to cope with growing capacity requirements. Therefore, before driving network roll-out through capacity requirements, as we do for existing MNOs, our network roll-out algorithm for the new entrant rolls out a coverage layer, building sites in order to reach a certain population coverage.[8] Our coverage algorithm factors in the variations in single-site coverage, depending on the type of spectrum held as well as the geotype being considered.

Finally, in addition to network opex and capex, we have had to forecast additional costs in order to assess how realistic it would be for a new operator to launch in the short term. These additional costs include interconnection, marketing, sales, staff, general and administrative (G&A) and debt-associated costs. Moreover, if national roaming was used, relevant roaming costs would need to be added on the basis of a margin that the MNO would derive from roaming revenue. Regarding capex, we have considered core network, IT and spectrum costs, in addition to the site costs (which include access and backhaul).

8 The new entrant will have coverage obligations if it is awarded 700MHz or 900MHz spectrum.