Annual licence fees for 900 MHz and 1800 MHz spectrum

Further consultation

Consultation

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About this document

The Government directed Ofcom in 2010 to revise the fees for 900 MHz and 1800 MHz spectrum licences to reflect the full market value of those frequencies. The fees are paid by the mobile operators (Vodafone, Telefónica, EE, H3G) who use the bands for 2G, 3G, including voice calls, and some 4G mobile services.

This document sets out our revised proposals for those fees. The proposals build on earlier analysis, following consideration of responses from stakeholders.

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Section 1

Executive Summary and Introduction

Summary

1.1 This document sets out revised proposals for implementing the Government's Direction to Ofcom to revise the annual licence fees (ALFs). These fees are to be paid by the holders of licences to use radio spectrum in the 900 MHz and 1800 MHz bands, to reflect full market value. It follows responses to Ofcom's previous consultation in October 2013 ("the October 2013 consultation") and the provision of new evidence.

1.2 The effect of these revised proposals would be to set the new base ALF for 900 MHz at £1.57m / MHz per annum and the new base ALF for 1800 MHz at £0.96m / MHz per annum (both expressed in March 2013 prices, the date of the completion of the 4G auction).

1.3 The figure for 900 MHz is 29% below our previous proposal and for 1800 MHz is 28% below our previous proposal, when expressed on a like-for-like basis.[1]

1.4 These revised ALF proposals reflect, in particular, our updated analysis of the:

- market value of 800 MHz and 2.6 GHz spectrum in the UK;
- interpretation of international benchmark evidence; and
- choice of discount rate used to convert the lump-sum values for 900 MHz and 1800 MHz into annual licence fee equivalents.

Market value of 800 MHz and 2.6 GHz spectrum in the UK

1.5 We now consider it appropriate to base our assessment on an analysis of bids by the marginal bidders in the UK 4G auction. This is instead of the linear reference price method on which the proposals in the October 2013 consultation were based.

Interpretation of international benchmark evidence

1.6 We now place the main emphasis on the values of 900 MHz and 1800 MHz *relative* to the values of 800 MHz and 2.6 GHz in each benchmark country. We use the *absolute* values of 900 MHz and 1800 MHz from benchmark countries as a cross-check only. In the October 2013 consultation we considered both absolute and relative evidence points alongside each other.

1.7 For the 1800 MHz band we have adopted the "distance method" (proposed by both EE and H3G). This looks at where the value of 1800 MHz sits *between* the value of 800 MHz and 2.6 GHz in the benchmark country. It applies this "distance" to the differential between the UK market value of these bands. In the October 2013

[1] The like-for-like comparison takes account of the change in inflation index (from RPI to CPI) on the present value of ALF payments over time as set out in paragraphs 5.7-5.9 and Table 5.3.

consultation we looked at the *two* ratios of 1800 MHz to each of 800 MHz and 2.6 GHz in each benchmark country.

Discount rate used to convert lump-sum value to annuity

1.8 We have reconsidered the choice of discount rate that is used to convert a lump-sum value into an annuity over 20 years for the purposes of deriving ALFs.

1.9 We now propose to use a discount rate based on a debt rate, rather than a weighted average cost of capital (WACC). Our revised proposals are therefore based on a discount rate of 2.6%, whereas the October 2013 Consultation proposals were based on a discount rate of 4.2% (both figures are in real terms and after taxation). In reaching these revised proposals, we:

- have updated our figures from those used in the 2011 Mobile Call Termination (MCT) WACC to reflect the latest available data; and
- are minded to use the Consumer Price Index (CPI) measure of inflation rather than the Retail Price Index (RPI) measure of inflation (although this in itself will have an expected NPV neutral impact on payments).

Revised ALFs and implementation

1.10 We are minded, on grounds of fairness, that the new ALF rates should take effect from the same common effective date (CED) for all licensees. We consider this CED should be set at the earliest practicable date after the new fee regulations come into effect. However, we now consider the new fee rates should be phased in in two steps with one half of the increase coming into effect on the CED, and the second half of the increase becoming effective exactly one year following the CED.

Background

1.11 In January 2009, the Government published its interim Digital Britain report[2] setting out a series of actions designed to maximise the opportunities for the UK in the digital age. It identified a complex set of challenges that it considered were hindering the release of spectrum for next generation broadband services and appointed an independent spectrum broker ("ISB") to examine possible solutions to these challenges.

1.12 The ISB's report was published in May 2009. In the Government's final Digital Britain report[3] it indicated it was minded to implement the ISB's proposals, subject to further work designed to address a number of issues. One of the proposals was that the licences for the use of frequencies in the 900 MHz and 1800 MHz bands should be liberalised in the hands of existing licensees. In addition, annual licence fees should be revised to reflect the full economic value of this spectrum.

1.13 The Government noted there was an option to direct Ofcom to implement any decision to take forward the proposals and that it would be obliged to consult on any such direction. Following the ISB's final report it decided to proceed in this way. On

[2] http://webarchive.nationalarchives.gov.uk/20100511084737/http://www.culture.gov.uk/what_we_do/broadcasting/5944.aspx

[3] http://www.bis.gov.uk/assets/biscore/corporate/docs/d/digital-britain-final-report.pdf

16 October 2009 it published its consultation[4] on a direction to Ofcom to implement the Wireless Radio Spectrum Modernisation Programme. This consultation proposed (among other things) that the Government would direct Ofcom to liberalise existing 900 MHz and 1800 MHz licences in the hands of the existing holders.[5] These licences would be clarified as being indefinite, and would be subject to revocation at five years' notice for spectrum management reasons. The licences would, in due course, be made tradable, and would be subject to revised licence fees reflecting their full market value. Ofcom would consult on the appropriate level for the fees after the 4G auction.

1.14 In March 2010, the Government published its response to the consultation[6] and subsequently laid a draft statutory instrument before Parliament in March 2010. This directed Ofcom to undertake a number of measures including the revision of licence fees for the Licences.

1.15 The Government decided to make a revised direction comprising a sub-set of the proposals set out in the previous draft. A revised draft direction was laid before Parliament in July 2010. The Wireless Telegraphy Act 2006 (Directions to Ofcom) Order 2010 (the "Government Direction")[7] was made on 20 December 2010 and came into force ten days after being made.

Ofcom's task

1.16 Under the Government Direction, Ofcom is required to revise the level of ALFs for the 900 MHz and 1800 MHz Public Wireless Networks licences so that they reflect full market value. In doing so, we must have particular regard to the sums bid in the UK 4G auction.

1.17 In accordance with the Government Direction, we set out proposals for revised ALFs in the October 2013 consultation.[8] We received responses from Vodafone, Telefónica, EE and H3G. These Mobile Network Operators (MNOs) all hold Public Wireless Networks licences in one, or both of, the 900 MHz and 1800 MHz bands and so have a direct interest in the relevant ALF. We also received responses from the GSMA, Enders Analysis, the Scottish Government and Prospect, together with one confidential response. Non-confidential versions of the responses are available on our website.

[4] http://www.bis.gov.uk/consultations/ofcom-wireless-modernisation-programme

[5] The UK was required to liberalise use of the 900 MHz and 1800 MHz frequencies under two EC instruments made in 2009.

[6] http://www.bis.gov.uk/assets/biscore/business-sectors/docs/10-737-government-response-consultation-ofcom-implement-spectrum-modernisation

[7] The Wireless Telegraphy Act 2006 (Directions to OFCOM) Order 2010 (S.I.2010 No. 3024) which can be found at: http://www.legislation.gov.uk/uksi/2010/3024/contents/made . The Direction implemented Directive 2009/114/EC of the European Parliament and of the Council amending Council Directive 87/372/EEC on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community (OJ L 274, 20.10.2009, p25) and Commission Decision 2009/766/EC on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing pan-European electronic communications services in the Community (OJ L 274, 20.10.2009, p32).

[8] http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees/

1.18 In April 2014 we published a further consultation on the methodology to derive a discount rate consistent with CPI inflation.[9] This discount rate is used in our methodology to convert lump-sum values for the 900 MHz and 1800 MHz bands into annual equivalents. The MNOs, but no other stakeholders, responded to this further consultation. Non-confidential versions of these responses are available on our website.

1.19 In May 2014 we published an update, and invited comments, on European auctions that had taken place since the time of the October 2013 consultation.[10] The results of European spectrum auctions for the 800 MHz, 900 MHz, 1800 MHz and 2.6 GHz bands are used to inform our estimates of the lump-sum values for the 900 MHz and 1800 MHz bands in the UK. The MNOs, but no other stakeholders, submitted comments on this update. Non-confidential versions of these comments are available on our website.

1.20 In light of these responses we have carried out further analysis and revised some aspects of our methodology. This has led us to revise our proposals in a number of respects. Accordingly, the purpose of this document ("August 2014 consultation") is to set out our revised proposals for further consultation, in particular our analysis of the:

- market value of 800 MHz and 2.6 GHz spectrum in the UK, derived from our analysis of bids in the UK 4G auction;
- international benchmark evidence on the relative values of different frequency bands from other European auctions (in particular, the values of 900 MHz and 1800 MHz relative to either 800 MHz or to a combination of 800 MHz and 2.6 GHz bands in these countries); and
- choice of discount rate used to convert the lump-sum values for 900 MHz and 1800 MHz into annual licence fee equivalents.

1.21 In setting out revised proposals in this document, we have focused on those areas which have changed from the October 2013 consultation. This is to allow stakeholders the opportunity to respond to this updated analysis. Accordingly, this document does not go into detail on those aspects of our analysis which have not changed. Nor does it provide comments on our assessment of all the points raised in the responses to the consultations and update note referred to above.

1.22 In our final statement, we will set out the reasons for our decision, which will include responding to the points raised in response to the October 2013 consultation, the April 2014 consultation on the methodology to derive a discount rate consistent with CPI inflation and the update note of May 2014, to the extent necessary to explain our decision. This document does, however, summarise the main aspects of stakeholder responses which relate to each of the key issues addressed in this new consultation, making clear where we have altered our approach in light of these responses.

1.23 We set out the main features of our updated analysis in the sections in this document. More detailed explanation and analysis is covered in a number of supporting annexes which are cross referred to from the sections.

[9] http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees-cpi/

[10] http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees/update-note/

Revised proposals for ALF

1.24 In this document we set out revised proposals which we consider to be appropriate in light of the available evidence. In doing so, we recognise that we have little direct relevant market evidence of the UK value of the specific spectrum bands for which we are setting revised licence fees, 900 MHz and 1800 MHz. For example, there has been no UK auction of spectrum in either of these bands. The available evidence is instead for the market value of *other bands* in the UK, or for these bands in *other countries* where they have been auctioned. Accordingly, we recognise there is therefore inherent uncertainty in deriving ALFs for the 900 MHz and 1800 MHz bands at full market value. Nevertheless, in order to implement the Government Direction we must conclude on an appropriate amount for ALFs going forward.

1.25 Given the available evidence, the framework we use for deriving an appropriate level of ALF is illustrated in Figure 1.1 below. This is the same framework that we used to develop the ALF proposals in the October 2013 consultation (where we explained the reasons for doing so).[11]

1.26 There are two distinct aspects to our derivation of fees:

- the derivation of the lump-sum value of spectrum in each of the 900 MHz and 1800 MHz bands in the UK; and
- the conversion of those lump-sum values into an equivalent annual fee.

1.27 We organise our analysis of these aspects into four analytical steps.

1.28 Steps 1 and 2 relate to the derivation of lump-sum values for the 900 MHz and 1800 MHz bands in the UK:

- **Step 1**: The estimation of the market value for the 800 MHz and 2.6 GHz bands ("the auction bands"), based on analysis of the bids made in the 4G auction (to which the Direction requires us to have particular regard); and
- **Step 2**: The use of evidence on the relative value of the ALF spectrum bands, 900 MHz and 1800 MHz, to the auction bands, 800 MHz and 2.6 GHz. This includes in particular international benchmark evidence on auctions conducted in other European countries in recent years.

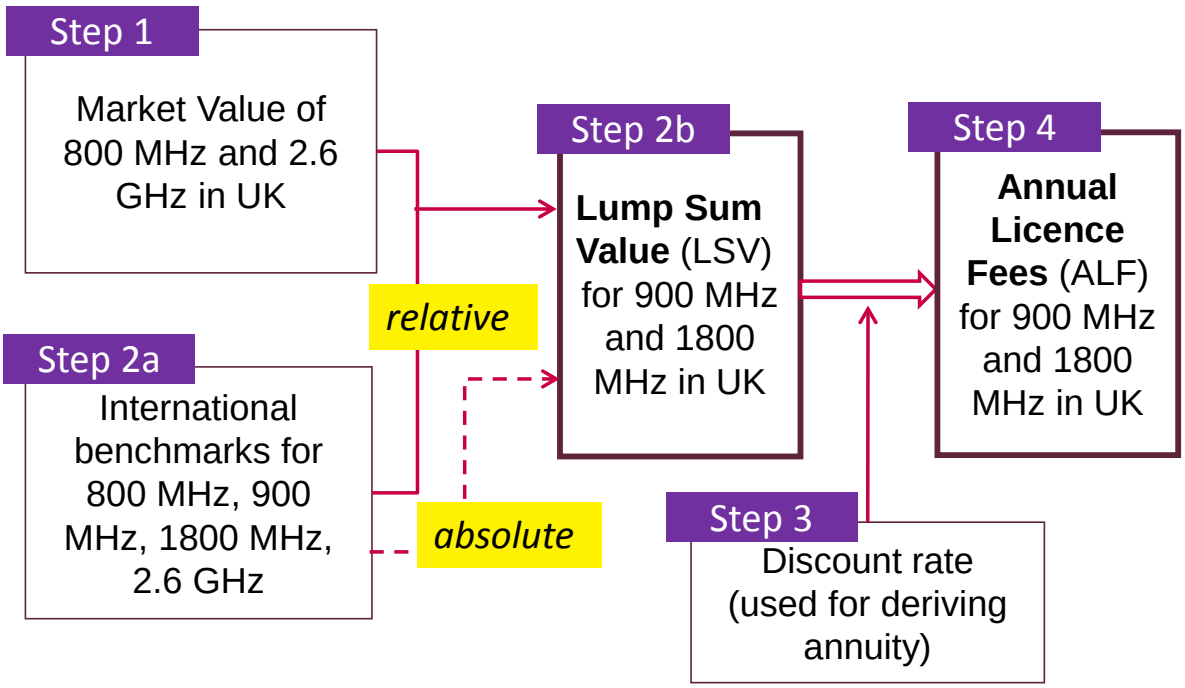
1.29 In **step 2** we estimate lump-sum values by combining an analysis of the value of 900 MHz and 1800 MHz spectrum *relative* to the auction bands in the relevant benchmark countries with our estimation of the market value for those auction bands in the UK (in step 1). We also consider the evidence of the *absolute* values of 900 MHz and 1800 MHz bands in the relevant benchmark countries. However, in the updated analysis presented in this consultation we now place the primary emphasis on the relative values, as explained in Section 3.

1.30 In **step 3** we consider the choice of the appropriate discount rate to convert the lump-sum values for the 900 MHz and 1800 MHz bands in the UK into equivalent annual licence fees.

[11] See paragraphs 2.8 to 2.18 in the October 2013 consultation.

1.31 In **step 4** we set out our revised proposals for ALFs at full market value for 900 MHz and 1800 MHz spectrum using the analysis under steps 1, 2 and 3.

Figure 1.1: Framework of steps 1 to 4



Approach to interpreting the available evidence

1.32 Where there are choices of methodology in steps 1, 2 and 3 in our analysis, we consider in each relevant section in this document which methodology, on balance, we prefer over the alternative(s).

1.33 We apply our preferred methodologies to the available evidence, noting the challenges in interpreting some of that evidence, and exercising our regulatory judgment where necessary.

1.34 We consider that we should exercise the necessary regulatory judgement by adopting a conservative approach when interpreting the evidence. This is for the following key reasons:

- Asymmetry of risk as between the effects on spectrum efficiency from inadvertently setting ALFs either above or below market value, given the uncertainty about the correct estimates for market value.
- Possibility that forward-looking market values today are lower than at the time of the auctions from which we derive our key evidence, due to expectations of greater availability of mobile spectrum in the future.

1.35 We discuss these reasons in turn below (referring to annexes as relevant).

Asymmetry of risk

1.36 In the October 2013 consultation we recognised that the greater risk to spectrum efficiency might be in setting ALFs too high. However, we took the view this was

significantly mitigated by our evidence base (which reflected the opportunity cost, not the private value to the incumbent holders of 900/1800 MHz).

1.37 In their responses the MNOs argued that we should adopt a more conservative approach. They considered that ALFs play no material role in encouraging spectrum efficiency, but if they were set too high they could lead to significant inefficiencies. Specifically, the MNOs generally considered that the existing allocation of spectrum is efficient, or if not, spectrum trading would occur. They also argued that, even in the absence of ALFs, operators have strong incentives to use spectrum efficiently, given the growing demand for mobile services.

1.38 As in our October 2013 consultation, we recognise the potential for spectrum inefficiency from ALFs that are inadvertently set above market value and result in a fallow period. We consider that this risk should not be overstated, and needs to be balanced against the potential for ALFs to improve efficiency. However, we now also recognise that, at least in principle, future spectrum releases will provide some opportunity for any inefficient allocations of spectrum to be mitigated. Therefore, taking account of stakeholder responses, we now consider that in order appropriately to take account of the asymmetry of risk, we should set ALFs more conservatively than we did in the October 2013 consultation. The reasons for our revised view are set out in greater detail in Annex 5.

Possibility of greater certainty of availability of future mobile spectrum

1.39 We recognise the possibility that market values today may have changed since the time of the UK 4G auction early in 2013. It is possible there have been changes which could have increased the value of spectrum in the ALF bands. But there are also developments which may have reduced their value.

1.40 The bands where there is currently most momentum behind mobile use are 700 MHz, 2.3 GHz, 3.4 GHz and 1452 - 1492 MHz. These bands were all recognised at the time of the 4G auction as likely to become available for mobile use. However, developments since the 4G auction have progressed the position in relation to each band and this might have further increased the degree of confidence in their future availability. The evidence suggesting the possibility that there could be greater certainty of availability in one or more of these bands as a result of these developments is set out in Annex 9. This might reduce the forward-looking market value of the ALF bands, 900 MHz or 1800 MHz (or 800 MHz or 2.6 GHz which we use in step 1 of our approach). This is because the bands set out above may be substitutes for the ALF bands (even if not necessarily close substitutes).[12]

1.41 To take account of the possibility of greater certainty of availability since the 4G auction of spectrum bands that may be substitutes for the ALF bands, we propose to set ALFs conservatively.

Impact assessment

1.42 In response to our October 2013 consultation, a number of stakeholders said that we should carry out a full impact assessment of our proposals for revising ALFs. In

[12] We note that 1452-1492 MHz spectrum may be a complement to ALF bands rather than a substitute, because to use as SDL it may be bonded to the paired spectrum deployments in the ALF bands. If so, increased certainty of availability of this band could increase, not reduce the market value of the ALF bands.

essence, their view was that we should not revise ALFs to reflect full market value unless we could demonstrate that taking this approach to setting ALFs (and the specific levels of ALF that we propose) was necessary to promote efficient use of spectrum, and that the potential benefits in terms of spectrum efficiency would outweigh any potential adverse effects on consumer prices, investment in infrastructure, innovation and competition. They considered that unless we did carry out such an impact assessment any decision we made would be unlawful.

1.43 We do not agree with this view. We have been directed by the Government to revise ALFs to reflect full market value, and we are required to implement that direction. We do not have any discretion to decide whether or not to set ALFs at full market value. For this reason, we consider it is unnecessary for us to carry out an impact assessment of the type argued for by stakeholders (and to this extent this is a statement for the purposes of section 7(3)(b) of the Communications Act 2003).

1.44 In implementing the Government Direction, we have considered the impact in those areas where we do have discretion and are exercising regulatory judgment in light of the evidence available to us and our statutory duties. We did conduct a focussed impact assessment in respect of these aspects in our October 2013 consultation. In particular, we assessed whether there was an asymmetric risk of inefficient use of spectrum from inadvertently setting ALFs below or above market value. This document contains our updated views, in light of responses, on certain aspects of how we intend to fulfil the requirements of the Government Direction including in particular a revised assessment of the asymmetry of risk. Our revised assessment, in light of the changes in our approach since the October 2013 consultation, is set out above and in Annex 5.

Structure of this document

1.45 We have revised our analysis in each of the four analytical steps outlined above. This revised analysis is presented in the following sections:

- **Section 2** sets out our revised assessment of the UK market value of bands in the 4G auction, 800 MHz and 2.6 GHz (Step 1).
- **Section 3** presents our revised assessment of the lump-sum values for the 900 MHz and 1800 MHz bands in the UK, based on an updated analysis of the international benchmark evidence from other European countries (Step 2). In addition to revising some aspects of the way we use the international benchmark evidence, we also include new evidence points from auctions that completed after the October 2013 consultation was published.
- **Section 4** sets out our revised consideration of the method and input parameters used to convert the lump-sum values into annual fees for the 900 MHz and 1800 MHz licences (Step 3).
- **Section 5** sets out our revised proposals for the base level of ALFs (Step 4), using the analysis in sections 3, 4 and 5 (by “base level” we mean the value of ALF expressed in March 2013 prices, without indexation for the effects of inflation, and without reduction for any phase-in of the new fee rates).

1.46 Finally, **Section 6** sets out the way in which the revised fees should be implemented, including indexation for inflation, the date at which new fee rates should first be introduced and phasing in the increase from current rates.

1.47 We are also publishing today, for consultation, a Notice on the draft regulations that would give effect to the new ALFs for the 900 MHz and 1800 MHz Public Wireless Networks licences.[13] These draft regulations are based on our current proposals for implementation set out in section 6 of this document.

[13] This is the statutory notice that Ofcom is required under section 122(4) of the Wireless Telegraphy Act 2006 to publish before making any regulations or order under that Act.

Section 2

UK market values of 800 MHz and 2.6 GHz spectrum for the purpose of ALF

Introduction

2.1 This section estimates the full market value of the auction bands, 800 MHz and 2.6 GHz, using bids in the 4G auction. This is step 1 in the analytical framework we set out in Section 1. Supporting material for the issues discussed in this section is set out in Annex 6.

2.2 In the light of the responses to the October 2013 consultation we have revisited our analysis. This has led us to a significant change of view, which we explain in this section, on both the appropriate methodology and our estimates of market values of the auction bands for the purpose of ALF.

2.3 The rest of this section:

- provides an overview of our proposals in the October 2013 consultation proposals and the stakeholder responses;
- introduces our revised approach;
- explains why we now consider that the proposals in the October 2013 consultation for the market value of 800 MHz and 2.6 GHz are too low for the purpose of ALF;
- outlines the range of methods to derive estimates of market value from bids in the 4G auction, and considers in more detail:
  - Linear Reference Prices (LRPs) without revenue constraint;
  - Additional Spectrum Methodology (ASM); and
  - marginal bidder analysis;
- provides our comments on stakeholders' responses to the October 2013 consultation in light of our revised analysis; and
- summarises our views on why our preferred method is the marginal bidder analysis and sets out our estimates of the market value of 800 MHz and 2.6 GHz which we derive when applying this method to the bids in the auction.

October 2013 consultation and stakeholder responses

2.4 In the October 2013 consultation we proposed the following UK market values for the 800 MHz and 2.6 GHz bands:

- 800 MHz: £26.85m per MHz;[14] and
- 2.6 GHz: £4.95m per MHz.

2.5 These estimates were derived from bids in the 4G auction using the method of LRPs with revenue constraint (the "revenue-constrained LRPs"). This method takes the auction revenue and generates a set of linear prices (one for each lot category) which attributes this revenue to the different spectrum bands in the auction, using information on both winning and losing bids. By 'linear prices' in this context we mean that there is a single price which applies to each 2x5 MHz lot acquired by any winner in a lot category (generally, a frequency band), and also that the same price applies to different winners of spectrum acquired in the same lot category.[15]

2.6 We also considered other methods, including LRPs without revenue constraint and the ASM (which we explain and discuss later in this section). However, we considered that there was not a strong basis for deviating from the base case of the revenue-constrained LRPs.[16]

2.7 We received a range of comments from stakeholders, including the following:

- Some respondents questioned the validity of the LRP method. For example, Vodafone argued that it did not estimate the marginal value of the relevant increment of spectrum (2x5 MHz or smaller). Vodafone claimed that instead the LRP method mathematically decomposed the opportunity cost of whole large packages into average prices, which risked overestimating market value.
- Stakeholders also commented on the reliability of the LRP results. For example, Telefónica suggested that they were sensitive to questionable assumptions and dependent on a small set of bids which might not be reflective of market value. It also argued that the relevant LRP results should include 800 MHz with coverage obligation. Vodafone suggested that particular auction rules (such as spectrum caps and spectrum reservation) distorted bids and market clearing prices in the auction, and as such the LRP results did not reflect market value.
- Telefónica and Vodafone claimed that our proposed market values were inflated by reserve prices. Their argument was that the reserve price was included in the calculation of auction prices, but did not reflect a value expressed by the highest losing bidder. They claimed therefore that it was above the market-clearing price.
- Vodafone considered that the sums bid by EE, which was the highest losing bidder, for an incremental 2x5 MHz of 800 MHz spectrum provided the best direct indication of the market value of this band that can be derived from the UK auction. Frontier Economics (on behalf of Vodafone) set out a detailed analysis of bids by EE.

[14] The October 2013 consultation proposed a figure for 800 MHz without coverage obligation of £29.85m/MHz, which was gross of expected DTT co-existence costs of £3m/MHz. In this section, to ensure direct comparability of figures, we set out all figures net of expected DTT co-existence costs (i.e. as reflected in bids in the auction) – the corresponding net figure for the October 2013 consultation proposal was £26.85m/MHz as shown above.

[15] Sometimes such prices are referred to as being 'uniform'. The auction prices were non-linear / non-uniform – see, for example, Table 2.3.

[16] See, for example, paragraphs A8.28 and A8.43 in the October 2013 consultation.

- A confidential respondent suggested that the auction price of £27.5m/MHz paid by Telefónica for 800 MHz spectrum with coverage obligation gave a clear indication of the lower bound of the market value of this band.

- Analysys Mason (on behalf of EE and H3G) suggested that budget constraints prevented H3G and Telefónica from bidding their full values for 800 MHz and 2.6 GHz spectrum respectively.

2.8 Our comments on stakeholders' responses are discussed later in this section at paragraph 2.82 onwards.

Introduction to our revised approach

2.9 As in the October 2013 consultation, we interpret full market value for the purpose of ALF to mean the market-clearing price in a well-functioning market[17], or the marginal opportunity cost of the spectrum. This is also the highest losing bid for the marginal increment of spectrum in a (competitive) auction.[18] We also take account of adjustments which stakeholders proposed were needed (such as for a contiguity and/or coverage premium) when using the auction results as a basis for valuing the ALF bands.

2.10 Taking Vodafone's holdings of 900 MHz as an example, we are *not* therefore seeking to establish Vodafone's value of its 900 MHz licence. Instead what is relevant is the value that is denied at the margin to other operators by Vodafone continuing to hold this spectrum. In particular, the value to the other operator that would gain the highest value if it were to acquire a marginal increment of Vodafone's 900 MHz frequencies.

2.11 Relevant information on the value denied to non-holders of the spectrum, or the opportunity cost, is provided by losing bids in the 4G auction. Such information is the focus of this section. Of course, these losing bids were for the spectrum bands in that auction, 800 MHz and 2.6 GHz. We consider the relative value of the ALF bands to the auction bands in step 2 of our analysis, discussed in Section 3.

2.12 Deriving the price of a specific band of spectrum, e.g. 800 MHz, from the 4G auction bids is not straightforward, because it was a package auction and yielded prices for the winning packages, not prices by spectrum band nor a single price for all 2x5 MHz lots within each band. Auction prices were determined for each winner on the basis of the highest losing bids for the particular package of spectrum acquired by that specific winner.

2.13 In the October 2013 consultation we discussed several different methods to derive market values of the auction bands from the bids in the auction. We still consider a range of methods (indeed a wider range than previously). However, as noted above, we have revised our view on the appropriate methodology and our estimates of market values of the auction bands for the purpose of ALF in light of stakeholder responses.

2.14 The remainder of this section is set out as follows:

[17] October 2013 consultation, paragraph 2.8.

[18] We discuss below the complications in identifying the marginal increment of spectrum in the presence of synergies and that there may be no linear market-clearing price.

- We start by explaining why we now consider that the market values of 800 MHz and 2.6 GHz which we proposed in the October 2013 consultation are too low for the purpose of ALF.

- Then we explain the range of methods we examine to derive estimates of market value from bids in the 4G auction.

- Thereafter we explain why our preferred method is the marginal bidder analysis and set out our estimates of the market value of 800 MHz and 2.6 GHz which we derive when applying this method to the bids in the auction.

Why we now consider the proposals in the October 2013 consultation for market value of 800 MHz and 2.6 GHz were too low for the purpose of ALF

2.15 As set out above, some of the stakeholder responses to the October 2013 consultation questioned the relevance or validity of LRPs, and proposed alternative methods to assess bids in the 4G auction to derive market values. In considering the points raised, we have undertaken a thorough re-examination of the LRP methodology and alternative methods. This has led us to substantially revise our analysis and our views on market values for the purpose of ALF.

2.16 For the reasons explained below, we now consider that the method of revenue-constrained LRPs is not an appropriate basis to derive estimates of full market value of the auction bands in the specific circumstances of the UK 4G auction (reflected in the auction bids). In particular, we now consider that this method, when applied to the 4G auction bids, yields estimates that are materially below full market value.

2.17 Revenue-constrained LRPs are constrained to sum to the total auction revenue (which for the 4G auction was £2,341m).[19] However, in our view the 4G auction revenue understates the market value of the auction bands as a basis for ALF, especially 800 MHz, because of the specific circumstances of the auction.[20] The auction prices in practice were significantly below the marginal opportunity costs of the spectrum and the market-clearing prices, because of: spectrum reservation; there only being a single losing bidder for the 800 MHz band; and a 'packing issue' (which is explained below).[21]

[19] This was the auction revenue from base prices (i.e. without the additional revenue raised in the assignment stage).

[20] For the avoidance of doubt, there is nothing in our analysis in this section which suggests or implies that the auction prices were in any way inappropriate for the purpose of the 4G auction. Instead our concerns relate to the different purpose of estimating full market value as a basis for of ALF.

[21] The auction cleared the market, since it allocated all of the available spectrum to the winning bidders with no unsold spectrum, but it did *not* do so by setting linear market-clearing prices. In some auction formats the prices provide signals to clear the market as well as affecting bidders' incentives about the bids they make. But in the format used for the 4G auction, the combinatorial clock auction (CCA), these two roles are separated. There is a deliberate divergence between auction bids and prices (since prices are based on the highest losing bids, not the winning bid). The intention of the auction prices is to provide incentives for bidders to bid straightforwardly. The allocation of the spectrum, and the role of clearing the market, is then based on the bids made (not the prices). Auction prices are computed subsequently (both logically and in practice) consistent with the winning allocation and the bids made, reflecting the highest losing bids for each particular package of spectrum acquired by each specific winner. This represents the opportunity cost to other bidders

2.18 To explain our reasoning, we consider the following issues:

a) Why the auction revenue from the prices paid by H3G and EE for 800 MHz spectrum at the reserve price is below market value for the purpose of ALF, due respectively to spectrum reservation for H3G and EE being the only losing bidder for additional 800 MHz spectrum.

b) Why the auction revenue from the prices paid by Telefónica and Vodafone for 800 MHz spectrum is below market value for the purpose of ALF. This arises because of a 'packing issue', which means that the reserve price set the price for half of the 800 MHz spectrum won by each of these bidders, even though in general there was excess demand for the spectrum at the reserve price.

2.19 There are some possible arguments going in the opposite direction, i.e. that there is a risk the auction prices may *overstate* market value for the purpose of ALF (such as the argument in Vodafone's response that a contiguity premium included in auction prices should be subtracted for the purpose of ALF). We address these arguments in a later sub-section when we discuss the implementation of the methodology we are minded to use, which is the marginal bidder analysis.

Auction prices of H3G and EE for 800 MHz below market value for the purpose of ALF

2.20 The 4G auction revenue attributable to the 800 MHz band is set out in Table 2.1. This is well-defined in the case of Telefónica, H3G and EE. The winning packages of Telefónica and H3G only included 800 MHz spectrum and so all of the revenue in their auction prices is attributable to that band. EE won a multi-band package of 800 MHz and (paired) 2.6 GHz spectrum. However, the derivation of EE's auction price involved a separation between the revenue attributable to the spectrum it won in each of the 800 MHz and 2.6 GHz bands (see the discussion below and Annex 6 for further details).

2.21 The situation is more complicated in the case of Vodafone, which won a package of spectrum including all three bands in the 4G auction: 800 MHz, paired 2.6 GHz and unpaired 2.6 GHz. The way in which Vodafone's auction price was derived is consistent with more than one way to attribute the revenue between bands (specifically, between the 800 MHz and paired 2.6 GHz bands). We have identified two attribution approaches - Table 2.1 shows the approach which involves the higher revenue attributed to 800 MHz.[22] Further details are set out in Annex 6.

2.22 The auction revenue attributable to 800 MHz shown in Table 2.1 is £1,608.5m. This corresponds to averages of:

- £26.81m/MHz for the entire 800 MHz band; and
- £26.46m/MHz for the 800 MHz spectrum without coverage obligation (i.e. excluding Telefónica).

(according to their bids) but it may differ from the marginal opportunity cost for several reasons, such as: for reserved spectrum; if the auction price is for the bidder whose bid sets the marginal opportunity cost; and depending on the size of the winning package being priced, the auction price could be an average of marginal and infra-marginal opportunity costs.

[22] We would reach the same view set out below that the auction revenue is too low for the purpose of ALF with the lower revenue attributed to 800 MHz.

Table 2.1: Auction revenue attributable to 800 MHz

	Vodafone	Telefónica	EE	H3G	Total / average per MHz
Revenue attributable to 800 MHz	£608.5m	£550m	£225m	£225m	£1,608.5m
Amount of spectrum	2x10 MHz	2x10 MHz	2x5 MHz	2x5 MHz	2x30 MHz
£m per MHz	£30.425m per MHz	£27.5m per MHz	£22.5m per MHz	£22.5m per MHz	£26.81m per MHz
Comment	Not unique	With coverage obligation	Reserve price	Reserve price	

Source: Ofcom

2.23 These averages are similar to, but slightly below, the revenue-constrained LRP for 800 MHz (without coverage obligation) of £26.85m/MHz, i.e. when the auction revenue is treated as a constraint on the sum of the LRPs. The difference is because the LRP methodology takes account of losing bids by each bidder as well as its winning bid, and derives the closest linear prices to market clearing (given the revenue constraint).

2.24 H3G's auction price is below full opportunity cost and so below market value for the purpose of ALF. This is because H3G won reserved spectrum and there was a specific auction pricing rule that deliberately set a price below full opportunity cost for reserved spectrum; and in practice, it was the reserve price.[23] Based on the bids made, if the pricing rule of full opportunity cost were applied to H3G's winning package, the price would be £15.9m/MHz higher at £38.4m/MHz.[24]

2.25 EE's auction price for 800 MHz is the reserve price. EE was the only auction bidder for "additional" 800 MHz spectrum, i.e. for more 800 MHz than it won in the auction (or equivalently, spectrum in addition to its winning package which it failed to win and for which it was therefore a losing bidder). So for the 2x5 MHz of 800 MHz in EE's winning package there was no losing bidder. However, EE's demand for additional sub-1 GHz spectrum is highly relevant to the opportunity cost of the 900 MHz held by

[23] The way that H3G chose to bid guaranteed it would win reserved spectrum at the reserve price (£22.5m/MHz), given the specific auction pricing rule. Further information on this point can be found in a paper written by Ofcom's Director of Competition Economics, Geoffrey Myers, in his personal capacity: "The innovative use of spectrum floors in the UK 4G auction to promote competition", Centre for the Analysis of Risk and Regulation, London School of Economics, Discussion Paper 74, November 2013, ISSN 2049-2718, http://www.lse.ac.uk/researchAndExpertise/units/CARR/pdf/DPs/DP74-Geoffrey-Myers.pdf.

[24] This is not to suggest that the auction outcome would necessarily have been the same in the absence of reserved spectrum. This is because we expect that the bids made in such a case would have been different from the bids actually made in the auction with reserved spectrum. We certainly expect H3G's bids to have been different, given that its bidding strategy was fundamentally based on spectrum reservation. Therefore, without spectrum reservation, we do not know whether H3G would have won the same as its actual winning package. However, if in the absence of reserved spectrum H3G had won the same package and if other bidders had made the same bids, then H3G's auction price would have been £38.4m/MHz.

Telefónica and Vodafone. Therefore, the 800 MHz component of its auction price is below market value for the purpose of ALF.

2.26 Another way to see this point about EE's auction price is related to the meaning of full market value as the marginal opportunity cost (as set out above). In the 4G auction it was EE's bid which set the marginal opportunity cost for spectrum in the 800 MHz band. However, EE's own auction price does not reflect this opportunity cost, because the pricing rule in the auction was that EE's price was determined by the highest losing bids made by *other* bidders. Therefore, EE's own bids are excluded when determining EE's auction price which is instead set by the much lower losing bids for 800 MHz made by other bidders (in fact, as noted above, its price was set at the reserve price, because of the absence of losing bids for additional 800 MHz by bidders other than EE).

2.27 We can also use Telefónica's auction price as a further illustration of the arguments above about H3G's and EE's auction prices. In its response to the October 2013 consultation, a confidential respondent suggested that we should take as a lower bound on the market value of 800 MHz the auction price of £27.5m/MHz paid by Telefónica for 2x10 MHz of 800 MHz with coverage obligation. The reasoning given was that Telefónica's winning package included only 800 MHz spectrum and so it is straightforward to attribute it only to that band. The argument for this price to be the lower bound was that Telefónica won the 800 MHz spectrum with coverage obligation, which may impose a cost to fulfil and so may have been sold at a discount to 800 MHz without coverage obligation.

2.28 By examining the derivation of the auction price, we can quantify the discount that Telefónica obtained for winning the 800 MHz spectrum with coverage obligation. This discount is £31m for the 2x10 MHz block.[25] Removing this discount yields an adjusted auction price for Telefónica of £29.05m/MHz.

2.29 H3G's and EE's auction prices per MHz for the 800 MHz band are materially below Telefónica's. As pointed out by a confidential respondent, the revenue-constrained LRP for 800 MHz of £26.85m/MHz is below Telefónica's auction price. The averages of auction revenue attributable to 800 MHz are also lower than Telefónica's auction price. We agree with the respondent to the extent that, in our view, Telefónica's auction price provides an illustration why both the revenue attributable to 800 MHz spectrum from EE's and H3G's auction prices and the figure proposed in the October 2013 consultation are too low as estimates of full market value for the purpose of ALF. The specific reasons why this is the case for each of EE's and H3G's auction prices are set out above.

2.30 We now consider why Telefónica's and Vodafone's auction prices are, in turn, also too low as a basis for ALF.

[25] Telefónica's own bids suggested the coverage obligation would not cause it to incur any net cost (as it bid the same – in fact £1,000 more – for 800 MHz with, compared to without, the coverage obligation). However, it was not Telefónica's bids that determined its auction price, but the bids of the highest losing bidder. £31m is the relevant discount in Vodafone's bids as between 800 MHz with and without the coverage obligation.

Auction prices of Telefónica and Vodafone for 800 MHz below market value for the purpose of ALF – packing issue

2.31 We consider that Telefónica's (adjusted) auction price of £29.05m/MHz and Vodafone's price of £30.425m/MHz for 800 MHz spectrum understate market value for the purpose of deriving ALF, because of a 'packing issue' that arose in determining the prices in the 4G auction. There is a packing issue in a combinatorial auction, such as the UK 4G auction, if the bids made by relevant bidders do not 'fit together' well with the available supply by band. This led to the first 2x5 MHz won by each of Telefónica and Vodafone being priced at the reserve price, even though in general there was excess demand for the 800 MHz spectrum at the reserve price.

2.32 Taking Telefónica's auction price as an example, the specific packing issue in the 4G auction was that Telefónica's winning package size was 2x10 MHz of 800 MHz, whereas the highest losing bids for 800 MHz were only for an additional 2x5 MHz or 2x15 MHz. Therefore, Telefónica's package size of 2x10 MHz did not 'fit together' well with the highest losing bids for 800 MHz for the following reasons:

- EE's demand for 800 MHz spectrum was for block sizes of 2x5 MHz, 2x10 MHz or 2x20 MHz. Given that EE's winning package included 2x5 MHz in the 800 MHz band, this meant that its demand for additional spectrum was only for a further 2x5 MHz or 2x15 MHz, but not for an additional 2x10 MHz of 800 MHz.

- Vodafone's winning package included 2x10 MHz of 800 MHz spectrum and it was prevented from bidding for more by the sub-1 GHz cap which applied in the 4G auction.[26] Therefore Vodafone's bids included no demand for additional 800 MHz spectrum.

- H3G won a reserved spectrum package of 2x5 MHz of 800 MHz spectrum. H3G made no (meaningful) bids for additional 800 MHz.[27]

2.33 Therefore there were no losing bids for an additional 2x10 MHz of 800 MHz (only losing bids by EE for both more and less). In Table 2.2 we show the winning and highest losing bids for 800 MHz by Telefónica and EE. For ease of exposition, we can assume for the purpose of this table that there is 2x15 MHz of 800 MHz available and competition in the auction to win that spectrum between only Telefónica and EE. Therefore, any spectrum acquired by Telefónica is denied to EE and vice versa. This is reflected in Table 2.2 by the quantity of spectrum for Telefónica going from left to right; whereas the quantity of spectrum for EE goes from right to left.

2.34 The incremental bid values (IBVs) shown in Table 2.2 are the relevant bidder's difference in bid value between two different packages for a specified increment of spectrum. For example, EE made a bid of £696.5m for a package of 2x35 MHz of 2.6 GHz spectrum. It also made a bid of £1,049.5m for a larger package of 2x35 MHz of 2.6 GHz *plus* 2x5 MHz of 800 MHz spectrum. Therefore, the specified increment of

[26] Two types of spectrum cap applied in the 4G auction: (i) sub-1 GHz cap; and (ii) overall spectrum cap. The sub-1 GHz cap restricted operators to no more than 2x27.5 MHz of sub-1 GHz spectrum including their pre-auction holdings. Since Vodafone held 2x17.4 MHz of 900 MHz spectrum before the auction, it was limited to acquiring at most 2x10 MHz of 800 MHz spectrum in the 4G auction (and Telefónica was in the same position). The overall spectrum cap restricted operators to no more than 2x105 MHz including their pre-auction holdings.

[27] H3G made a small number of bids for additional 800 MHz, but they were at such low incremental bid values that they had no impact on the auction outcome or prices. [✂]

spectrum between these two packages is 2x5 MHz of 800 MHz, and the IBV is £353m or £35.3m/MHz. This is the figure shown in the bottom row of Table 2.2 in the final column. Furthermore, the larger package described above was also EE's winning package, so £35.3m/MHz is EE's IBV for the 2x5 MHz lot of 800 MHz which it won in the auction.

Table 2.2: Telefónica's and EE's winning and highest losing incremental bid values for 800 MHz (in £m per MHz)

Telefónica → EE (highest loser) ←	2x5 MHz 2x15 MHz	2x10 MHz 2x10 MHz	2x15 MHz 2x5 MHz
IBVs of Telefónica	£60.95m[28]		np
IBVs of EE	dnb	£35.6m	£35.3m

Source: Ofcom

np Telefónica was not permitted to bid for this package because of the sub-1 GHz cap
dnb EE did not bid for this package

2.35 The figure of £35.6m/MHz in the middle column of the last row in Table 2.2 reflects EE's IBV for a further 2x5 MHz lot of 800 MHz, which it failed to win in the auction.[29] This represents the highest losing bid for this increment of spectrum. As explained above, EE did not make a bid for a package including 2x15 MHz of 800 MHz spectrum. The entry in the first column of the last row is therefore "dnb".

2.36 In Table 2.2, EE is therefore shown as both a winner of 2x5 MHz of 800 MHz (in the final column on the right-hand side) and the highest losing bidder for the additional 2x5 MHz of spectrum it bid for unsuccessfully. Telefónica outbid EE to win 2x10 MHz. i.e. its IBV for that spectrum (at £60.95m/MHz) was higher than EE's IBV.

2.37 With the pricing rule used in the 4G auction, Telefónica's auction price is determined not by the level of its own winning bid, but by the level of the highest losing bid by EE. Hence Telefónica's auction price was derived in different ways for each 2x5 MHz in its winning package:

- its second 2x5 MHz was priced to reflect EE's demand for an additional 2x5 MHz (£35.6m/MHz without the discount for the coverage obligation); whereas
- its first 2x5 MHz was priced at the reserve price (£22.5m/MHz), because there was no losing bid for that spectrum.

2.38 In its response to the October 2013 consultation, Telefónica and Vodafone put forward the argument that the relevance of the reserve price to the determination of Telefónica's (and others') auction price means it was inflated above market value. However, for the purpose of ALF, we disagree with this argument for two reasons.

[28] Telefónica's winning bid of £1,219.003m for 2x10 MHz of 800 MHz with coverage obligation, expressed in £m per MHz.

[29] EE's IBV, compared to its winning package, is £31.05m/MHz for an additional 2x5 MHz of 800 MHz and 2x5 MHz less of 2.6 GHz (which was necessary for EE to remain within the overall spectrum cap). In addition, the figure of £35.6m/MHz takes into account the IBV of that 2x5 MHz of 2.6 GHz to other bidders of £4.55m/MHz including the effect of package rearrangements (rearranging 2x5 MHz of 2.6 GHz each from EE and Niche to H3G, and 5 MHz of unpaired 2.6 GHz from Vodafone to Niche).

2.39 First, the absence of a losing bid for Telefónica's first 2x5 MHz of 800 MHz did not reflect a general lack of demand for additional 800 MHz. As noted above, EE made a number of bids for larger amounts of 800 MHz, 2x20 MHz, at IBVs well above the reserve price. For example, EE's IBV was £32.63m/MHz for its third and fourth 2x5 MHz.[30]

2.40 Second, it is the marginal opportunity cost which is more relevant for the purpose of ALF and in the 4G auction this is £38.4m/MHz for a 2x5 MHz increment[31], composed of EE's losing bid for 2x5 MHz of additional 800 MHz compared to its winning package (plus the value of rearrangements).[32] This is substantially *higher* than the reserve price or the average per MHz auction price paid by Telefónica.

2.41 Therefore, in our view, the packing issue means that Telefónica's auction price is a significant understatement of market value for the purpose of ALF.

2.42 Vodafone also won a package of 2x10 MHz of 800 MHz spectrum. The same packing issue means that Vodafone's auction price for 800 MHz is also a significant understatement of market value for the purpose of ALF.

Summary of why auction revenue for 800 MHz understates market value for the purpose of ALF

2.43 For the 4G auction itself, the auction prices for 800 MHz were an appropriate reflection of the bids made and the specific circumstances (such as spectrum reservation). However, as explained above, we consider this revenue is inappropriately low for the related but different question of market value for the purpose of ALF. The revenue-constrained LRPs, which formed the market values we proposed in the October 2013 consultation, reflect an attribution of the 4G auction revenue. Therefore, the figures (£26.85m/MHz for 800 MHz and £4.95m/MHz for 2.6 GHz) that we set out in the October 2013 consultation are in our view too low as estimates of market value for the purpose of ALF.

2.44 The reasons in the case of the 800 MHz band are summarised in Table 2.3:

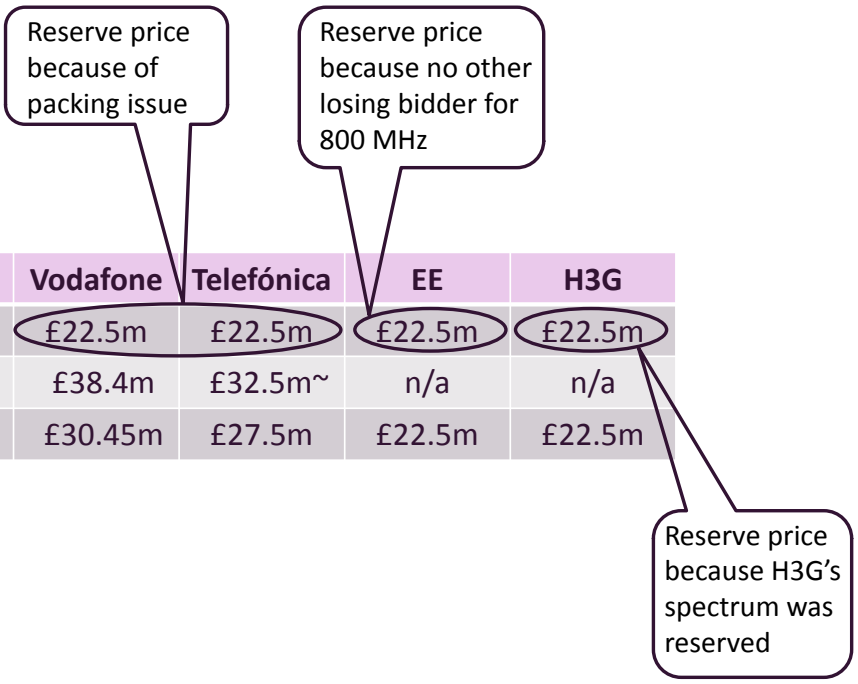
[30] This was in a package with 2x20 MHz of 2.6 GHz, the largest package including 2x20 MHz of 800 MHz that EE was permitted to make a bid for under the overall spectrum cap in the 4G auction.

[31] Table 2.2 includes the figure of £35.6m/MHz in the derivation of Telefónica's auction price. The marginal opportunity cost is higher at £38.4m/MHz, which is included in the derivation of Vodafone's auction price (see Table 2.3 below). This is because Vodafone's auction price includes the higher value of package rearrangements involving Telefónica (whereas rearrangements involving Telefónica are not considered when determining Telefónica's own auction price as all bids made by the winning bidder are excluded). The extra £2.8m/MHz (i.e. the difference between £35.6m/MHz and £38.4m/MHz) is the excess of Telefónica's IBV for 2x10 MHz of 2.6 GHz over H3G's (the second highest losing bidder for 2x10 MHz of 2.6 GHz after Telefónica) – the former is included in the value of the highest losing bids when determining Vodafone's auction price whereas the latter is included when determining Telefónica's auction price.

[32] This is also one component of a set of market-clearing prices. However, there is no linear market-clearing price because of the synergies in EE's bids, i.e. EE's IBV is larger for its second 2x5 MHz lot of 800 MHz (which it failed to win) than for its first 2x5 MHz (which it won). The marginal opportunity cost for a 2x5 MHz increment reflects EE's higher IBV for its second 2x5 MHz lot of 800 MHz. With a linear price, there is either excess supply or excess demand. Any linear price above EE's average IBV for its first and second 2x5 MHz lots would choke off EE's demand for the first 2x5 MHz of spectrum and so lead to excess supply in the band; but at any lower linear price EE's demand would be for 2x10 MHz, i.e. both its first and second 2x5 MHz lots, which would lead to excess demand in the band.

- H3G's auction price at the reserve price was intentionally below opportunity cost because it won reserved spectrum.
- EE's auction price at the reserve price was below opportunity cost for the purpose of ALF, because EE itself was the only losing bidder for 800 MHz spectrum.
- The auction prices of Telefónica and Vodafone for 800 MHz were affected by a packing issue, which led to their first 2x5 MHz being priced at the reserve price even though in general there was excess demand for the spectrum at the reserve price.

Table 2.3: Auction prices for 800 MHz in £m per MHz



	Vodafone	Telefónica	EE	H3G
First 2x5 MHz	£22.5m	£22.5m	£22.5m	£22.5m
Second 2x5 MHz	£38.4m	£32.5m~	n/a	n/a
Average	£30.45m	£27.5m	£22.5m	£22.5m

Source: Ofcom

~ Including discount of £31m for the coverage obligation, implying £581m or £29.05m/MHz as the average adjusted price without discount for the 2x10 MHz block. Since the price of the first 2x5 MHz is at the reserve price, the adjusted price of the second 2x5 MHz is £35.6m/MHz, as shown in Table 2.2.

2.45 For the 2.6 GHz band, the October 2013 consultation figure of £4.95m/MHz is also too low for the purpose of ALF, because it is constrained by the application of the auction revenue as an overall constraint on the sum of the revenue-constrained LRPs. As we discuss below in the context of the marginal bidder analysis, the highest losing bids and the market-clearing price for 2.6 GHz were higher than this figure.

Overview of methods to derive estimates of market value from auction bids

2.46 Having explained why the method of revenue-constrained LRPs understates market value for the purpose of ALF for the reasons set out above, we now outline the three other methods we consider to assess the bids in the 4G auction and obtain estimates of market value:

- LRPs without revenue constraint;

- ASM; and
- marginal bidder analysis.

2.47 The first and second of these methods were included in the October 2013 consultation. We set out below our revised interpretation of the estimates of market value derived by applying these methods.

2.48 The third method, the marginal bidder analysis, is in principle the approach advocated by Vodafone in its response to the October 2013 consultation. However, our implementation of the marginal bidder analysis is different to Vodafone's and the resulting estimates of market value are accordingly different. We explain the key reasons for these differences in a later sub-section.

2.49 Table 2.4 provides a summary of the estimates of market value derived in our application of these three methods.

Table 2.4: Summary of results for 800 MHz and 2.6 GHz spectrum from applying the three methods to the 4G auction bid data (in £m per MHz)

Method	800 MHz	2.6 GHz
LRPs without revenue constraint[33]	£31.2m	£5.7m
Additional spectrum methodology for 2x5 MHz increment	£35.6m or £38.4m	£4.55m or £7.35m
Marginal bidder analysis (for different spectrum increments in the 800 MHz band)	£32.63m (2x10 MHz) £38.3m (2x5 MHz)	£5.5m or £6.4m

Source: Ofcom

2.50 The method of LRPs without revenue constraint derives the closest linear prices to market-clearing prices, based on the bids made in the auction (and the winning allocation), allowing the sum of the LRPs to exceed the 4G auction revenue.[34] This method provides a better fit with the bids than when the revenue constraint is imposed. It also mitigates the concern explained above, when using the method of revenue-constrained LRPs, that the resulting estimates of market value are too low for the purpose of ALF.

2.51 In its response to the October 2013 consultation Vodafone suggested that the LRP method was not appropriate because it involved averaging and did not reflect the highest losing bid at the margin (or marginal opportunity cost). We do not agree with Vodafone's position. The LRP method does not seek to average in the manner suggested. Instead it is intended to identify an approximate market-clearing price,

[33] The LRPs without revenue constraint reported in Table 2.4 are slightly higher than those set out in the October 2013 consultation (£30.93m/MHz for 800 MHz and £5.43m/MHz for 2.6 GHz). The reason for these revised estimates is a refinement in our application of the methodology to the 4G auction bids, which is explained in Annex 6.

[34] LRPs do not fully explain the auction prices, because they were non-linear. This means that if any set of linear prices were implemented, the market would not clear in the sense that not all winning bidders would prefer their winning packages to any other package at those prices. But the set of LRPs are the linear prices that come closest to achieving this for all bands in the auction considered simultaneously.

which would be the marginal opportunity cost.[35] However, as we explain below, and in greater detail in Annex 6, we still consider that this method may yield estimates of market value that are too low (for a different reason related to the overall cap in the 4G auction).

2.52 The marginal bidder analysis and ASM both involve looking at bids from bidders for more 800 MHz spectrum than they won in the auction. The ASM addresses the question of what would have happened, given the bids made by *all bidders* for all bands in the auction, if hypothetically there had been more spectrum available in the auction. The marginal bidder analysis focuses, in a band-by-band assessment, on the *single* bidder that had the highest value for additional 800 MHz spectrum (EE) or additional 2.6 GHz spectrum (Telefónica) for which it was a losing bidder. Both of these methods use information on highest losing bids.

2.53 The marginal bidder analysis and ASM allow us to consider a specific question that is highly relevant to the market value of the 900 MHz and 1800 MHz bands for the purpose of deriving ALF:[36] what value did bidders in the auction express for more spectrum in addition to their post-auction spectrum holdings?[37] This is especially relevant, because ALF should reflect opportunity cost, the value denied by the licensees of 900 MHz / 1800 MHz to the non-holders of that spectrum, i.e. the value the non-holders could obtain by adding some 900 MHz / 1800 MHz spectrum to their holdings.

2.54 We now consider each of these three methods in more detail.

Linear Reference Prices (LRPs) without revenue constraint

Why these LRPs may be below market value on a forward-looking basis due to the overall spectrum cap in the 4G auction

2.55 The LRP method depends on bids in the auction for which the overall spectrum cap in the 4G auction of 2x105 MHz (including pre-auction holdings) was a constraint. In particular, the overall spectrum cap was binding on EE, preventing it from winning, or bidding for, more than 2x40 MHz of spectrum in the auction. This restriction on the bids that EE was permitted to make implies some constraints on the relative prices of different bands in the set of LRPs derived by this method.

2.56 We discuss this issue in further detail in Annex 6. A potential advantage of the LRP method is that it considers bids for all bands in the auction simultaneously and so takes account of cross-band effects as reflected in the auction bids. For example, the rate of substitution between bands for a bidder such as EE. However, for EE which was constrained by the overall cap, the rates of substitution implied by its bids may in some cases reflect the effect of the overall cap, not EE's intrinsic values. This appears to constrain the LRPs to lower levels, especially for 800 MHz.

[35] The market-clearing price is 'approximate' in the sense of being as close as possible to a market-clearing price with linear prices.

[36] This is subject to differences in value between these bands and 800 MHz and 2.6 GHz, which we consider in step 2 of our analysis.

[37] That is, the spectrum they held before the auction and acquired in the auction (net of any spectrum trades known at the time of the auction, such as EE's sale of 2x15 MHz of 1800 MHz to H3G).

2.57 The relevant question, therefore, is whether or not, for the purpose of ALF, we should treat the overall spectrum cap in the 4G auction as a binding constraint on a forward-looking basis.

2.58 The overall spectrum cap only formally applied at the time of the 4G auction. On a forward-looking basis as more mobile spectrum becomes available (e.g. 2.3 GHz and 3.4 GHz bands), we would not expect EE to be precluded from acquiring some more spectrum. To put the point starkly, treating the overall spectrum cap in the 4G auction as binding on a forward-looking basis would imply that EE would not be permitted to acquire any spectrum in the auction for the 190 MHz of spectrum in the 2.3 GHz and 3.4 GHz bands planned for 2015/16. Or, more directly relevant for this document, it would also imply that EE would not be permitted to acquire any 900 MHz spectrum (without also relinquishing an equal amount of spectrum in other bands of spectrum that it currently holds). In our view, it would not be a reasonable assumption for the purpose of ALF to restrict EE only to its current overall spectrum holdings, given that more spectrum will soon be available for mobile use.[38]

2.59 We consider the LRP results without revenue constraint provide useful reference points. However, our view that we should not regard the overall cap in the 4G auction as binding on a forward-looking basis implies that these LRPs without revenue constraint may understate market values for the purpose of ALF (especially for 800 MHz) - see Annex 6 for further details.[39]

Additional Spectrum Methodology (ASM)

2.60 The ASM considers hypothetical additional spectrum in the auction. For example, in computing the ASM with Telefónica as the excluded bidder, we exclude Telefónica's auction bids from the analysis and consider the value of additional 800 MHz to the other bidders. In this way the ASM estimates a value that the other three bidders, but not Telefónica, would place on additional 800 MHz (as a proxy for the same amount of 900 MHz spectrum from Telefónica's holdings). The estimates derived using the ASM are set out in Annex 6 and summarised in Table 2.4 above for a 2x5 MHz increment.

Our view on the ASM results

2.61 We consider the ASM results provide useful reference points. For example, we can reconcile the differences between relevant results of our marginal bidder analysis, our decomposition of auction prices and ASM results (see Annex 6 for details).

2.62 However, ASM is not our preferred methodology. This is because:

[38] This is not to suggest that there should be no limits on the amount of spectrum that can be acquired by any operator in the forthcoming 2.3 GHz / 3.4 GHz award. Whether there should be any such competition measures will be addressed by Ofcom through consultation in the context of that award. Instead the pertinent point here is that we do not consider that any such competition measure would reasonably be so extreme as to ban EE from acquiring any more spectrum than it currently holds. We also note that our marginal bidder analysis below only relies on EE not being prevented from acquiring 2x5 MHz or 2x10 MHz of spectrum in addition to its current holdings.

[39] There were two types of spectrum cap in the 4G auction: sub-1 GHz cap and overall spectrum cap . For the avoidance of doubt, our analysis does not depend on treating the sub-1 GHz cap in the 4G auction as non-binding on a forward-looking basis.

- On the one hand, it may overstate realisable market value because the calculated value allows for package rearrangement[40] that may be practically difficult to achieve either in a single-band auction or through trading, as it would involve a series of interdependent bilateral trades.

- On the other hand, it treats the overall spectrum cap in the auction as a binding constraint on a forward-looking basis, which tends to suppress the size of the value derived.

2.63 These two effects operate in different directions. One of the advantages of the marginal bidder analysis is that we can seek to correct for these two effects.

Marginal bidder analysis

2.64 The marginal bidder analysis seeks to derive the marginal opportunity cost by examining the highest losing bid at the margin. It has the benefit of being transparent in how the estimates of market value are derived. We can also take account of differences from the auction as regards the purpose of ALF, such as:

- Removing the value of package rearrangements which are included in the ASM results.

- Not treating the overall cap in the 4G auction as a binding constraint on a forward-looking basis.

- Features which may apply to the bid examined in the 4G auction but may not apply to a corresponding increment of 900 MHz or 1800 MHz spectrum, in particular:

  - contiguity premium; and

  - declining incremental value with larger quantities of spectrum (which we refer to as a declining coverage premium in the context of sub-1 GHz spectrum).

800 MHz

2.65 The highest losing bidder for 800 MHz spectrum was EE. Table 2.5 shows EE's demand for 800 MHz in the 4G auction in the form of its IBVs for different amounts of 800 MHz spectrum, e.g. 2x5 MHz in the first column and a further 2x5 MHz in the second column (i.e. for a contiguous block of 2x10 MHz). EE made no bids for 2x15 MHz blocks in the third column, but it did bid for 2x20 MHz blocks in the fourth column. Table 2.5 shows the average IBV for the third and fourth 2x5 MHz in the 2x20 MHz block taken together. We can use the information in Table 2.5 to consider both 2x5 MHz and 2x10 MHz increments of additional 800 MHz spectrum compared to its winning package.

[40] For example, the highest value combination for an additional 2x5 MHz of 800 MHz involves a set of bid packages which (compared to the winning packages) rearrange spectrum among four operators: 2x5 MHz of 2.6 GHz each from EE and Niche to H3G, and 5 MHz of unpaired 2.6 GHz from Vodafone to Niche.

Table 2.5: EE's demand (IBVs) for 800 MHz spectrum[41] in £m/MHz

Packages with:	First 2x5 MHz (1xA1)	Second 2x5 MHz (2xA1)	Third 2x5 MHz (3xA1)	Fourth 2x5 MHz (4xA1)
No 2.6 GHz (0xC)	£23.0m	£42.0m	£26.33m[42]	
2x5 MHz of 2.6 GHz (1xC)	dnb	Dnb	dnb	dnb
2x10 MHz of 2.6 GHz (2xC)	£23.0m	£60.5m	£29.02m	
2x15 MHz of 2.6 GHz (3xC)	£23.0m	£55.59m	£26.65m	
2x20 MHz of 2.6 GHz (4xC)	£23.0m	£50.55m	**£32.63m**	
2x25 MHz of 2.6 GHz (5xC)	£23.0m	£49.12m	dnb	np
2x30 MHz of 2.6 GHz (6xC)	£27.5m	£46.1m	np	np
2x35 MHz of 2.6 GHz (7xC)	£35.3m*	**Np**	**np**	np

Source: Ofcom

dnb EE did not bid for this package
np EE was not permitted to bid for this package by the overall spectrum cap
* EE's winning package

2.66 The different rows in Table 2.5 are for these bids for 800 MHz being combined in packages including different amounts of 2.6 GHz spectrum. As shown by the variation in IBVs between the rows, the amounts that EE bid for 800 MHz depended on the amount of 2.6 GHz spectrum also included in the package. This seems to reflect cross-band effects.

2.67 We can use the information in Table 2.5 to identify suitable estimates of EE's values for additional 800 MHz. There is, however, a challenge because some of the most relevant IBVs are bids that EE was not permitted to make because of the overall spectrum cap which applied in the auction. If we treat the overall cap in the 4G auction as non-binding on a forward-looking basis, the IBVs that are most relevant are the second and third columns in the final row of Table 2.5, i.e. the highlighted cells. This is because EE's winning package was in the first column in the final row, i.e. a package of 2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz. As we explain above at paragraph 2.53, this means that we are examining the value bid by EE for an increment of spectrum in addition to its post-auction spectrum holdings, which provides an estimate of the marginal opportunity cost.

2.68 We consider first an increment of 2x5 MHz and then an increment of a block of 2x10 MHz of 800 MHz spectrum for EE additional to its winning package. A more detailed analysis is set out in Annex 6.

2x5 MHz increment

2.69 In Annex 6 we explain how we derive an estimate for the 2x5 MHz increment of £38.3m/MHz, using information on EE's IBVs. However, we are concerned that this

[41] Table 2.5 only shows EE's IBVs for 800 MHz spectrum without coverage obligation (lot category A1), not the IBVs for 800 MHz spectrum with coverage obligation (A2). Lot category C was for paired 2.6 GHz spectrum. In lot categories A1 and C, the size of each lot was 2x5 MHz.

[42] This is the average value for EE's third and fourth A1 (since EE did not bid separately for a third A1).

value may not provide a suitable indication of the value of 900 MHz spectrum for the purpose of ALF, in particular because of complications related to a contiguity premium and a coverage premium.

2.70 **Contiguity premium**: The estimate of £38.3m/MHz is for EE's *second* 2x5 MHz lot of 800 MHz. But there is a risk it may overstate the relevant market value for a 2x5 MHz increment, by including a contiguity premium for a 2x10 MHz block of 800 MHz. This premium reflects the synergies in block size, meaning that the value of a 2x10 MHz contiguous block is more than double the value of a 2x5 MHz block. If an additional 2x5 MHz of spectrum were acquired by EE in the 900 MHz band, it would be EE's first spectrum in that band and so would not form a contiguous 2x10 MHz block, since EE has no current holdings in the 900 MHz band. This concern about overstating market value is consistent with an argument put forward in Vodafone's response to the October 2013 consultation (and we adopt Vodafone's terminology of a contiguity premium).

2.71 **Coverage premium**: A reference point that excludes a contiguity premium is EE's IBV of £35.3m/MHz for its *first* 2x5 MHz lot of 800 MHz in its winning package (see the first column in the last row of Table 2.5). This is derived from a bid for a package with no more than 2x5 MHz of 800 MHz. However, there is a risk this figure may still overstate the relevant market value, if there is a declining coverage premium. This is because it reflects EE's value for its first 2x5 MHz lot of sub-1 GHz spectrum, whereas the relevant value for the purpose of ALF is for its second 2x5 MHz. However, identifying a reliable basis to make a quantified adjustment for such a declining coverage premium is not straightforward (see the discussion of this issue in Annex 6.

2x10 MHz increment

2.72 The issues of a contiguity and a coverage premium are also present when considering the value of a 2x10 MHz increment. But they can be addressed differently and, in our view, in a more satisfactory manner. For example, our preferred estimate of £32.63m/MHz, discussed below, is a directly observed IBV for EE.

2.73 **Contiguity premium**. As discussed above, we accept the potential for a contiguity premium. However, where it exists, in our view the implication is that the relevant marginal increment of additional spectrum for the purpose of ALF is likely to be 2x10 MHz, not 2x5 MHz. This is because the contiguity premium would be relevant to the opportunity cost of the 900 MHz spectrum. By maintaining their current holdings of 900 MHz spectrum, the existing licensees are denying the value to non-holders of acquiring a 2x10 MHz block (the value of which, with a contiguity premium, is more than double a 2x5 MHz block). Therefore, we consider that the contiguity premium should be included and averaged over 2x10 MHz (whereas Vodafone argued in its response to the October 2013 consultation that it should be subtracted from the observed value of a 2x5 MHz block).[43]

2.74 EE made no bids for an additional 2x10 MHz of 800 MHz spectrum, so the most relevant IBVs cannot be directly observed. Instead we can examine EE's observed IBVs for its first 2x10 MHz of 800 MHz (its first and second 2x5 MHz lots), and also for its second 2x10 MHz (third and fourth 2x5 MHz lots):

[43] Some further issues in using the value for a 2x10 MHz increment are discussed in Annex 6.

- The estimate for the first 2x10 MHz of 800 MHz spectrum is £36.8m/MHz, which is derived as follows. The first 2x5 MHz of 800 MHz is the lot that EE won, which has an IBV of £35.3m/MHz. The value of the second 2x5 MHz is the estimate of £38.3m/MHz for the 2x5 MHz increment of additional spectrum discussed above. The average of £35.3m/MHz and £38.3m/MHz is £36.8m per MHz.

- The estimate for the second 2x10 MHz (third and fourth 2x5 MHz lots) of 800 MHz is £32.63m per MHz, derived as EE's directly observed IBV in a package with the largest amount of 2.6 GHz for which EE was permitted to bid alongside 2x20 MHz of 800 MHz. This IBV is highlighted in Table 2.5 by a dotted box.

2.75 **Coverage premium**. There is a risk this first estimate of £36.8m/MHz may overstate the relevant market value as a basis for ALF. This is because it represents an estimate of EE's value for its first 2x10 MHz of sub-1 GHz spectrum, whereas if EE were to acquire a 2x10 MHz block of 900 MHz, it would be additional to the 2x5 MHz of sub-1 GHz spectrum at 800 MHz which EE also holds (having won it in the 4G auction). If there is a declining coverage premium for sub-1 GHz spectrum, in principle a downward adjustment should be made to account for this. However, in our view there is not a reliable basis to make such an adjustment (see Annex 6 for further details).

2.76 We consider there is a risk that the second estimate of £32.63m/MHz may understate the relevant market value as a basis for ALF for the following reasons:

- £32.63m/MHz reflects the IBV with 2x20 MHz of 2.6 GHz spectrum, not the relevant larger package of 2x35 MHz which EE won in the auction. The IBV is generally higher in packages with more 2.6 GHz spectrum (compare the £32.63m/MHz with the lower figures in the previous rows in Table 2.5 of £26.33m/MHz, £29.02m/MHz and £26.65m/MHz).

- Similarly, for all observed IBVs, EE's average IBV for its third and fourth 2x5 MHz lots is higher than the IBV for its first 2x5 MHz lot (for a given number of lots of 2.6 GHz spectrum), whereas £32.63m/MHz is lower than the observed IBV for the first 2x5 MHz in a package with 7xC of £35.3m (compare the last and first columns in Table 2.5).

- To the extent that EE's bids reflect a declining coverage premium, this IBV for EE's third and fourth 2x5 MHz lots of sub-1 GHz spectrum is too low compared to the relevant value for the purpose of ALF, which is the incremental value for its second and third 2x5 MHz lots of sub-1 GHz spectrum.

2.77 We nonetheless prefer this second estimate of £32.63m/MHz as an appropriate basis for ALF because, in our view, we should adopt a conservative approach when interpreting the evidence (see Section 1).

2.6 GHz

2.78 The highest losing bidder for the 2.6 GHz band was Telefónica at £6.4m/MHz for a 2x10 MHz block. This suggests that the marginal increment for 2.6 GHz is 2x10 MHz, not a smaller 2x5 MHz increment.[44]

[44] The next highest losing bid was also for a 2x10 MHz block (by H3G at £5m/MHz).

2.79 It might also suggest that the market value of 2.6 GHz spectrum should be £6.4m/MHz, the highest losing bid. However, there is a material complication – there is no linear market-clearing price, given the bids made in the auction (as for the 800 MHz band).

2.80 A price below £6.4m/MHz would imply excess demand in the band, because it would fail to choke off the demand for 2x10 MHz by Telefónica, the highest losing bidder. But whilst a higher price would achieve that, it would also involve less demand than in the winning allocation by one of the winners, Niche, by 2x5 MHz, leading to excess supply in the band. This is because Niche's IBV for the last 2x5 MHz in the 2x15 MHz block it won in the auction was only £5.5m/MHz.

2.81 This means that any price above £5.5m/MHz would lead to this reduced demand by Niche of 2x5 MHz. Below £6.4m/MHz it would be more than offset by the extra demand for 2x10 MHz by Telefónica, leading to excess demand in the band (by 2x5 MHz). But a higher price would result in excess supply for the band (of 2x5 MHz).[45] Therefore, in our view, there is a risk that £5.5m/MHz may understate market value. Nevertheless we prefer this estimate as an appropriate basis for ALF because we consider that we should adopt a conservative approach when interpreting the evidence.

Our comments on stakeholder responses to the October 2013 consultation

2.82 We now comment directly on the stakeholder responses, addressing in turn each of the points summarised at paragraph 2.7 above.

2.83 **Validity of the LRP method**. Contrary to Vodafone's suggestion, the LRP method seeks to estimate the marginal value of the relevant increment of spectrum by deriving the closest linear prices to market-clearing prices. In particular, Vodafone is incorrect that the LRP method decomposes the opportunity cost into average prices. Further detailed explanation of the LRP method is set out in Annex 6.

2.84 **Reliability of the LRP results**. Although we do not necessarily agree with some of the specific suggestions made in responses, we no longer rely on the LRP results to derive our preferred estimates of market value.

2.85 **Reserve prices**. We address above the claim that our proposed market values were inflated by reserve prices above market value (and we explain why our view is the opposite of the argument made by the respondents – see paragraphs 2.38 to 2.41.

2.86 **Marginal bidder analysis for 2x5 MHz increment**. We agree with Vodafone that assessing the sums bid by EE, the highest losing bidder, provides the best direct indication of the market value of the 800 MHz band. However, we explain above why we prefer 2x10 MHz as the marginal increment of spectrum to the 2x5 MHz increment suggested by Vodafone (see paragraph 2.73).

2.87 **Telefónica's auction price**. We comment above on a confidential respondent's suggestion that Telefónica's auction price provides a lower bound on the market value of 800 MHz spectrum (see paragraphs 2.27 to 2.29).

[45] A set of non-linear prices would be needed to clear the market for the 2.6 GHz band, given the bids made in the 4G auction.

2.88 **Budget constraints**. We note that the National Audit Office (NAO) in its report on the 4G auction commented as follows: "*In this auction, our analysis indicated that at least two bidders appeared to be subject to budget constraints which meant that they sought to limit the amount they would be required to pay for spectrum in the auction. These budget constraints meant that they were not necessarily bidding the full value of the spectrum to their businesses*".[46] [✂] The evidence of budget constraints suggests there is a risk that some auction bids may understate the full market value of the spectrum. In the absence of a way reliably to quantify the effect of the budget constraints on market value, we have not relied on this evidence in deriving our proposed estimates. However, it provides a further reason why there is a risk that our estimates may understate market value. As explained above, we nevertheless consider it appropriate to use these estimates as the basis for ALF because of our view that we should adopt a conservative approach when interpreting the evidence.

Vodafone's proposed market value for the 800 MHz band

2.89 In the stakeholder responses to the October 2013 consultation there was a detailed submission on the UK market value of the 800 MHz band by Vodafone (including a report by Frontier Economics – for simplicity, in the discussion below we refer to any point in this report as if it were made by Vodafone). Vodafone provided an analysis of EE's auction bids as the marginal bidder for 800 MHz spectrum, and proposed a number of adjustments it argued were relevant to the 900 MHz band, leading to a value of 800 MHz of between £17.9m and £21.5m per MHz.[47] Vodafone argued that the relevant value for the purpose of ALF is for 2x5 MHz of 800 MHz, the smallest increment of spectrum (either of 800 MHz available in the auction or of 900 MHz which could realistically be sold by Vodafone or Telefónica). It analysed all of EE's bids and attempted to decompose IBVs for 800 MHz into: a generic value of marginal spectrum; a contiguity premium reflecting synergies of a 2x10 MHz block, which it argued should be excluded as it would not be relevant to 2x5 MHz of 900 MHz; and a coverage premium. It considered that its estimate of between £17.9m and £21.5m per MHz should be preferred to the figures in the October 2013 consultation.

2.90 In principle, Vodafone's approach corresponds to the marginal bidder analysis. The main reasons why Vodafone's figure is, in practice, much lower than our estimates are as follows.

2.91 First, our marginal bidder analysis focuses on the specific IBVs of EE which are directly observed and most relevant to the question of ALF, whereas Vodafone seeks to fit a model of drivers of bid values and assumptions to the generality of EE's bids. We note that, when Vodafone's model with the proposed parameter values is compared to EEs actual bids, it provides an inaccurate prediction of those bids, suggesting either the model and/or the parameter values are unreliable. For example, the model used by Vodafone may omit material drivers of bid values, such as cross-band effects or financial constraints; or the assumptions made by Vodafone in order to derive parameter values may be incorrect. The size of the contiguity premium implied in Vodafone's model of more than £30m/MHz is especially inaccurate for some of EE's actual bids, e.g. it is significantly overstated for the largest packages which are most relevant for the purpose of ALF.

[46] Paragraph 2.23 in NAO (2014), "4G radio spectrum auction: lessons learned", Report by the Comptroller and Auditor General, HC 968, Session 213-14, 12 March 2014, http://www.nao.org.uk/wp-content/uploads/2015/03/4G-radio-spectrum-auction-lessons-learned.pdf

[47] The range of figures is because Vodafone set out two methods (labelled A and B) and considered both the mean and the median.

2.92 Second, our marginal bidder analysis takes as the starting point EE's IBVs for additional 800 MHz spectrum compared to its winning package. This answers the question of what EE's auction bids tell us about its value for 800 MHz spectrum in addition to its current, post-auction spectrum holdings. We estimate the relevant IBV for 2x5 MHz is £38.3m/MHz (and it is certainly significantly larger than £31.05m/MHz). In contrast, Vodafone takes as its upper bound EE's median value for its first 2x5 MHz block of £23m/MHz (or the mean of £24.9m/MHz).

2.93 Third, the relevant marginal increment of spectrum for the purpose of ALF also depends on the demand side, not only the supply side. If there is a contiguity premium associated with 2x10 MHz of 900 MHz, then it is relevant to the opportunity cost of the 900 MHz band (which is imposed by the current holders of 900 MHz spectrum retaining their holdings) and should not therefore be excluded. Our preferred estimate is a directly observed IBV by EE for a 2x10 MHz block of 800 MHz spectrum of £32.63m/MHz. In fact, if Vodafone's model is used to estimate the value of a 2x10 MHz increment, it yields a value at a similar or higher level than this estimate. Vodafone's model implies a value between about £32m/MHz and £35m/MHz for a 2x10 MHz block of 800 MHz. The contiguity premium implied by Vodafone's model accounts for roughly half of this value (between 44% and 51%).

Summary of our revised proposals on UK market values of 800 MHz and 2.6 GHz spectrum

2.94 Taking account of the responses to the October 2013 consultation, we have re-visited the analysis of the 4G auction bids to derive estimates of market values of the auction bands for the purpose of ALF. In contrast to the October 2013 consultation, we now consider that the results of the method of revenue-constrained LRPs, which attributes the auction revenue between the different bands in the auction, are too low as a basis for ALF. Whilst the auction revenue was derived properly for the purpose of the 4G auction and appropriately reflected the bids made in the auction, for the related but different question of market value for the purpose of ALF, in our view, it is too low. This is because the marginal opportunity cost of the spectrum is especially relevant for the purpose of ALF and it is higher than the auction prices, especially for the 800 MHz band.[48]

2.95 In summary the specific reasons are:

- H3G's auction price at the reserve price was intentionally below opportunity cost because it won reserved spectrum;
- EE's auction price at the reserve price was below opportunity cost for the purpose of ALF, because EE itself was the only losing bidder for 800 MHz spectrum; and
- the auction prices of Telefónica and Vodafone for 800 MHz were affected by a packing issue, which led to their first 2x5 MHz being priced at the reserve price even though in general there was excess demand for the spectrum at the reserve price.

[48] The market-clearing price is also relevant and that is also generally higher than the auction prices, although the comparison is not straightforward because there is no linear market-clearing price, given the synergies in the bids made in the 4G auction.

2.96 We therefore consider in detail the following three methods to estimate market value of 800 MHz and 2.6 GHz for the purpose of ALF:

- LRP without revenue constraint;
- ASM; and
- marginal bidder analysis.

2.97 Our preferred method is the marginal bidder analysis, for the following reasons:

a) The results of the method of LRPs without revenue constraint are reduced by bids that were constrained by the overall spectrum cap in the 4G auction. We consider that we should not treat the overall cap in the 4G auction as a binding constraint on a forward-looking basis.

b) The results of ASM involve effects in both direction which we consider are better removed for the purpose of ALF:

   o package rearrangements which may not be achievable outside a multi-band auction; and

   o treating the overall spectrum cap in the auction as a binding constraint.

c) These effects, which represent disadvantages of the two methods as described above, can be accounted for in the marginal bidder analysis, including through careful interpretation of the results. We consider spectrum increments of both 2x5 MHz and 2x10 MHz. On balance, our view is that the market values using a 2x10 MHz increment are more appropriate as a basis for ALF, given the synergies in block size reflected in auction bids.

2.98 Our preferred figures, which are conservative estimates of market values derived from our marginal bidder analysis for a 2x10 MHz increment, are:

- 800 MHz band: £32.63m/MHz; and
- 2.6 GHz band: £5.5m/MHz.

Question 1. Do you have any comments on our proposal to base our assessment of the market value of 800 MHz and 2.6 GHz spectrum in the UK on an analysis of bids by the marginal bidders in the UK 4G auction?

Section 3

Assessment of lump-sum values

Introduction

3.1 This section sets out our revised assessment of the lump-sum values which we propose as a basis for setting revised annual licence fees. This is step 2 in the analytical framework we set out in Section 1. Supporting material for the issues discussed in this section is set out in Annexes 7, 8 and 9.

3.2 The rest of this section:

- provides an overview of our October 2013 consultation proposals, and stakeholder responses to those proposals;
- explains our revised approach to making a judgement on the appropriate lump-sum values of 900 MHz and 1800 MHz spectrum in the UK, drawing on the international benchmark evidence;
- presents our assessment of the lump-sum value of 900 MHz spectrum in UK;
- presents our assessment of the lump-sum value of 1800 MHz spectrum in UK; and
- summarises our revised proposals.

October 2013 consultation, May 2013 update, and stakeholder responses

3.3 In our October 2013 consultation we considered that it was appropriate to derive lump-sum values for 900 MHz and 1800 MHz licences based on a notional licence with a 20-year initial term, reflecting the 20-year initial terms for the 800 MHz and 2.6 GHz licences in the 4G auction, and then to use these lump-sum values to derive annual fees. In deriving lump-sum values we considered the following evidence (noting that bids in the UK 4G auction are discussed separately in Section 2).

i) International auction prices: We considered evidence from auctions in other countries, particularly 4G auctions in the EU from 2010 onwards, as to the absolute value of 900 MHz and 1800 MHz licences, and their relative values compared to 800 MHz and 2.6 GHz licences.

ii) Technical and commercial evidence: We considered evidence relating to the different technical and commercial characteristics of spectrum bands, including technical modelling previously carried out by and for Ofcom. Due to the sensitivity of such estimates to the modelling assumptions, we did not use technical modelling to develop estimates of the values of 900 MHz or 1800 MHz licences. However this analysis informed our interpretation of the auction-based evidence.

3.4 We then derived a number of benchmarks, of the following types:[49]

i) Absolute measures of the value of 900 MHz and 1800 MHz spectrum in other countries. We considered that, despite variations in conditions between countries, these measures were potentially informative if taken in the round and considered alongside other evidence.

ii) Relative measures of value. For example, if the value of 900 MHz spectrum was 60% of the value of 800 MHz spectrum in a particular country, we calculated an evidence point for the value of 900 MHz in the UK at 60% of the estimated value of 800 MHz spectrum in the UK.

3.5 We considered the likely relevance of individual benchmarks of each type, distinguishing between "more important" evidence points on which we considered it appropriate to place more weight, and "less important" evidence points on which we placed less weight. We considered the evidence for each band in the round, used our judgement to develop a best estimate for each band and explained how these best estimates were supported by the evidence.

3.6 In May 2014, we published an update relating to auctions that had taken place following our consultation, including estimates of prices in the Austrian auction.

3.7 Stakeholders commented in detail both on our overall approach to assessing lump-sum values, and also on the relevance and interpretation of specific benchmarks.

3.8 As regards our overall approach, comments from stakeholders included the following:

- Absolute values of spectrum should be given limited or no weight in our benchmarking, as they are highly sensitive to country-specific factors. Our assessment of benchmarking evidence should focus on relative values of different spectrum bands within a country, which are less affected by country-specific factors.

- Vodafone and others also argued that we did not take sufficient account of a number of explanatory factors related to the market structure and demand conditions in the markets concerned, which could have different effects on the relative value of different spectrum bands from one country to another.

- Analysys Mason and Aetha (AM&A) (in a report for EE and H3G) presented the "distance method" as a more appropriate way of deriving benchmarks for the value of 1800 MHz spectrum than benchmarks based on the ratio of 1800 MHz values to either 800 MHz or 2.6 GHz values.

- Benchmark prices reflect differing coverage obligations and requirements to mitigate DTT interference costs, and may not be directly comparable to prices from the UK 4G auction.

- We did not set out specific criteria for including a benchmark in the sample, assessing its relevance and weighting in estimating lump-sum values, which reduced transparency and generated inconsistencies. Stakeholders suggested

[49] We also included averages of the UK 800 MHz and 2.6 GHz LRPs as further reference points within the evidence base for the value of 1800 MHz.

alternative approaches that relied on weighted averages with different weights for more and less important evidence points.

- Some stakeholders contested our view that, on the basis of technical evidence, 900 MHz spectrum was unlikely to have a higher value than 800 MHz in the UK. Other stakeholders argued against our approach of treating as less important evidence those benchmarks which implied that 1800 MHz spectrum has a lower value than 2.6 GHz spectrum in the UK.

- Vodafone and EE argued that we should consider evidence from technical modelling alongside auction values as a cross check, using available models or creating a dedicated model.

3.9 Stakeholders also submitted a significant number of comments on the interpretation of auctions in individual countries in response to both the October 2013 consultation and in response to the May 2014 update that we published on more recent European auctions. They also disagreed with our categorisation of specific benchmark points (as being more important or less important evidence) and, in some cases, with the decision to include or exclude particular countries within the benchmark data set.

3.10 Following our consideration of consultation responses and further analysis that we have carried out, we have revised our proposed approach as set out below. In particular:

a) We now focus on relative benchmarks as evidence for the market value for 900 MHz and 1800 MHz spectrum.

b) We consider it appropriate to use the distance method as the main measure of relative value for 1800 MHz spectrum.

c) We have further considered the scope for some country-specific factors to influence spectrum values (see Annex 7, paragraphs A7.58 to A7.85) and taken account of this when interpreting benchmarks.

d) In deriving relative values for each country, we have adopted an approach which ensures consistency of treatment of DTT co-existence costs and coverage obligations in the benchmark country and in the UK.

3.11 We have also taken account of comments and evidence relating to specific countries and awards as part of our interpretation of individual benchmark points, as discussed in Annex 8.

3.12 Some of the issues raised by stakeholders are less relevant in the context of our revised approach. For example, since we now focus on relative values the ratio of the value of different bands within a country is not affected by the method adopted for currency conversion.

3.13 We remain of the view that it is sensible to derive market values by considering the evidence for each band in the round. AM&A suggested taking a weighted average of the evidence points, with weights depending on the quality of evidence. As a cross-check, we have derived average benchmarks using this approach and compared the results to our proposals.

3.14 We have given further consideration to the available technical evidence, as set out in Annex 9. In particular, we adapted the 700 MHz model which informed our recent

UHF Strategy Implementation Consultation, to see whether this could assist in informing our assessment of the value of 900 MHz. Overall we do not believe the adjusted 700 MHz model is well-suited to modelling the value of 900 MHz spectrum to those operators who do not currently hold any of this spectrum. Therefore we have not placed weight on the above results in informing our proposals on ALFs. Moreover, this example illustrates some of the difficulties of network cost modelling in deriving reliable estimates of the value of spectrum to individual operators. Any such model will be subject to significant uncertainty about the specification of the model and appropriate parameter assumptions, leading to valuation estimates that vary over a wide range.

Revised approach

3.15 Our revised approach to estimating the lump-sum value of 900 MHz and 1800 MHz spectrum in the UK involves the following steps:

- Derive auction prices by frequency band (800 MHz, 900 MHz, 1800 MHz and 2.6 GHz) for European countries, adjusted to UK equivalent terms, as described in Annex 7, paragraphs A7.21 to A7.36.
- Use these auction prices (in combination with our estimates of the UK market value of 800 MHz and 2.6 GHz) to derive benchmarks for the value of 900 MHz and for the value of 1800 MHz in the UK (we have focused on a specific relative benchmark type for each band, with each European country generating one benchmark evidence point for 900 MHz and one benchmark evidence point for 1800 MHz if the relevant auction data is available for that country); and
- Use the resulting set of benchmarks to make an assessment of the lump-sum value of 900 MHz and 1800 MHz in the UK.

Auction prices in other countries

3.16 As in our October 2013 consultation, we consider auctions of 800 MHz, 900 MHz, 1800 MHz and 2.6 GHz licences in Europe since the start of 2010. We have updated our data set to cover European awards since October 2013 which included one or more of the relevant spectrum bands, and for which we have been able to identify band-specific prices. That is: Austria, Czech Republic and Slovakia. We invited stakeholders to comment on these more recent auctions.[50]

3.17 The auction prices we considered are set out in Table 3.1. In converting these prices to UK-equivalent terms, we make the following adjustments (as in the October 2013 consultation):

- Add the present value of any annual spectrum fees (where relevant) to the lump-sum auction price.
- Adjust for differences between the benchmark country and the UK as regards (i) population and (ii) licence duration.
- Adjust for inflation, using UK CPI monthly figures (from the ONS).

[50] See *Update on European auctions since Ofcom's consultation on Annual licence fees for 900 MHz and 1800 MHz spectrum*, available at: http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees/update-note/

- Where spectrum in one or more bands was subject to delayed availability, apply an adjustment to allow for this (depending on the affected bands, this may impact on relative values as well as absolute values).

Table 3.1: Results of European auctions 2010-2013

£m/MHz (UK equivalent)	800 MHz	900 MHz	1800 MHz	2.6 GHz
Austria (2010; 2013)[51]	72.2	79.4	48.6	1.9
Czech Republic (2013)	44.1		6.0	3.0
Denmark (2010; 2012)[52]	16.2	2.9	1.2	10.3
Germany (2010)	52.9		1.9	1.6
Greece (2011)		32.8	14.5	
Ireland (2012)[53]	63.5	39.6	25.2	
Italy (2011)	52.1		16.7	3.8
Netherlands (2012)	*Not known*			
Norway (2013)	*Not known*			
Portugal (2011)	37.3	24.9	3.2	2.5
Romania (2012)	43.9	47.3	19.0	10.6
Slovak Republic (2013)	38.5		7.1	4.6
Slovenia (2014)	*Not known*			
Spain (2011)[54]	40.4	26.4		3.3
Sweden (2011)	21.2		9.7	
Switzerland (2012)	*Not known*			

Using prices from other countries to derive benchmarks for UK values

3.18 We now summarise the approach we have taken to deriving benchmarks for the values of 900 MHz and 1800 MHz in the UK from the auction prices in other countries in Table 3.1 above. We address in turn:

- The potential relevance of differences in circumstances between benchmark countries and the UK and, aligned to this, the case for focusing on relative values between auction bands rather than on the absolute values of 900 MHz and 1800 MHz in the benchmark country concerned.

[51] 2.6 GHz awarded in October 2010; 800/900/1800 MHz in October 2013.

[52] 2.6 GHz awarded in May 2010; 900/1800 MHz in September 2010; 800 MHz in June 2012.

[53] Results based on information from Comreg.

[54] A multiband auction took place in in July 2011. One lot of unsold 900 MHz spectrum was re-auctioned in November 2011. The 900 MHz price shown is from November 2011.

- The measures of relative value that we use to derive benchmarks for the value of 900 MHz and the value of 1800 MHz in the UK respectively.

- The way we take account of potential differences between the UK and the benchmark country in the expected DTT co-existence costs and coverage obligations associated with the 800 MHz band.

Country-specific factors influencing auction prices

3.19 Some stakeholders argued that we should adjust the auction prices to take account of country-specific factors (in addition to those set out in paragraph 3.17 above). We have considered the potential role of a range of country-specific factors in determining auction prices, in particular differences in market profitability, demand for 2G spectrum and urbanisation. For each of these factors, we have considered both the strength of arguments for considering that, in principle, the value of a spectrum band (or relative values between bands) in other countries risks being understated or overstated as an indicator of the value of spectrum in the UK, and whether such arguments are supported by the available evidence. In doing so we recognise the limitations of this evidence, particularly given the limited number of available data points (i.e. prices for each band in each country).

3.20 We do not consider that the evidence supports reliable quantified adjustments to the auction prices when converting them into UK equivalents. However, in view of the considerable scope for country-specific factors to influence differences in absolute values of spectrum between countries, our analysis now focuses primarily on benchmarks that are derived using *relative* values between bands (see Annex 7 paragraphs A7.37 to A7.41). This is because the impact of most country-specific factors is likely to be reduced when looking at the relative value of different bands in the country concerned (in the same way the ratio between the value of 900 MHz and 800 MHz in the country in question is not affected by whether we use contemporaneous exchange rates or purchasing power parity to convert the auction prices into £ sterling, for example). Our assessment considers (in qualitative terms) the extent to which benchmarks that are derived from relative values might be affected by country-specific factors (see paragraphs 3.36 and 3.43 to 3.44 below).

3.21 We continue to consider the implications of the *absolute* values (i.e. the European auction prices of 900 MHz and 1800 MHz bands themselves) – but only as one of the cross-checks we make on our assessment of the lump-sum values from the relative benchmarks.

Use of evidence points to derive relative benchmarks

3.22 Our revised approach is to focus on relative benchmarks, derived from the international auction prices. We therefore derive benchmark evidence points for UK values based on the measure of relativity which we consider to be the most appropriate for each of the 900 MHz and 1800 MHz bands in turn.

3.23 For the 900 MHz band, we have focused on the relative value of 900 MHz to 800 MHz licences. We consider this is likely to be the most informative benchmark evidence for the value of 900 MHz in the UK, particularly in light of the similar underlying technical characteristics of these two bands. Therefore, for example, in Ireland we estimate the value of 900 MHz spectrum at £39.6m/MHz and the value of 800 MHz at £63.5m/MHz, so the 900 MHz value is just over 62% of the 800 MHz value. Applying this ratio to our estimate of the value of 800 MHz in the UK net of co-

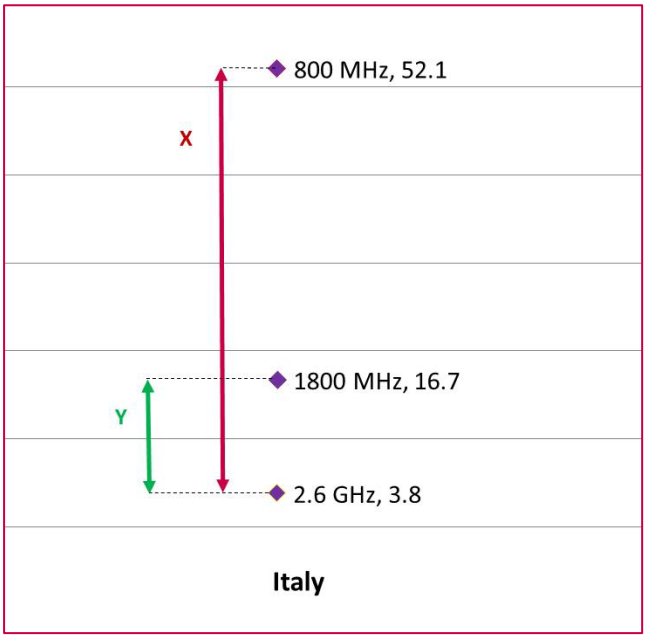
existence costs and without coverage obligations (£32.63m/MHz) suggests a UK value of 900 MHz spectrum of £20.3m/MHz (i.e. 62% of £32.63m).

3.24 Turning to 1800 MHz, we consider that, in view of its technical and commercial characteristics, the market value of this band is likely to be between the values of 800 MHz and 2.6 GHz spectrum. We have focused on the "distance method" proposed by AM&A on behalf of EE and H3G. Benchmarks for the value of 1800 MHz are calculated as follows, where 800_{UK} is our estimate of the value of 800 MHz in the UK, 800_{BC} is the value of 800 MHz in the benchmark country etc.

$$1800_{UK} = \frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}} \; x \; (800_{UK} - 2.6_{UK}) + 2.6_{UK}$$

3.25 An example of this method is shown in Figure 3.1 below for Italy.

Figure 3.1: Illustration of the distance method (Italy)



3.26 In Italy, the price of 1800 MHz spectrum is £12.9m/MHz higher than the price of 2.6 GHz ("Y" in the figure), and the price of 800 MHz is £48.3m/MHz higher than the price of 2.6 GHz ("X" in the figure), giving a ratio (Y / X) of 27%. Given our estimates of values of 800 MHz (£32.63m/MHz without coverage obligations plus £3m/MHz of co-existence costs) and 2.6 GHz (£5.5m/MHz), the Italy distance method benchmark is £13.5m/MHz, because this gives the same ratio of Y to X in the UK as in Italy.

3.27 We consider this distance method to be more appropriate than the use of ratios of 1800 MHz to 800 MHz and 1800 MHz to 2.6 GHz (as in the October 2013 consultation). It focuses on the question of where the value of 1800 MHz lies between the values of 800 MHz and 2.6 GHz. We consider this to be more relevant than the ratio of 1800 MHz to either 800 MHz or to 2.6 GHz on their own. It generates a benchmark for each country using all of the information on spectrum values in these bands to do so, and it produces one (and only one) benchmark for each country.

DTT co-existence costs and coverage obligations associated with 800MHz

3.28 The interpretation of the market value of 800 MHz from auction prices needs to take account of the expected costs associated with DTT co-existence and the presence, or otherwise, of coverage obligations in the 800 MHz licences being auctioned. Where there are expected DTT co-existence costs, we refer to the observed 800 MHz auction price as being "net" of co-existence costs. Where the expected DTT co-existence costs are added to the value of 800 MHz revealed through the auction, we refer to the 800 MHz value as "gross" of expected DTT co-existence costs. Observed 800 MHz auction prices may also reflect the value with or without a coverage obligation.

3.29 The implications for the UK 800 MHz value of each factor is considered in Annex 7, paragraphs A6.139 to A6.142 and shown in Table 3.2 below.

Table 3.2: Implications of expected DTT co-existence costs and coverage obligation on UK 800 MHz value

	Without coverage obligation	With coverage obligation
Net of expected DTT co-existence costs	£32.63m	£31.08m
Gross of expected DTT co-existence costs	£35.63m	£34.08m

3.30 For example, the UK value of 800 MHz, gross of expected DTT co-existence costs and without coverage obligation, is shown as £35.63m per MHz; this is £3m per MHz above the equivalent value net of DTT co-existence costs of £32.63m per MHz (note that this preferred value is stated in Section 2 net of expected DTT co-existence costs).

3.31 The methods for deriving benchmark evidence points for the UK value of 900 MHz and 1800 MHz (described above) use the values of 800 MHz in both the UK and in the benchmark country. It is important that the values of 800MHz (in UK and in the benchmark country) used to derive a benchmark evidence point are consistent with respect to expected DTT co-existence costs and coverage obligations. To do this, we characterise the value of 800 MHz in the benchmark country as to whether or not it is net or gross of expected DTT co-existence costs and whether or not it has a coverage obligation (which we consider will require more extensive roll-out than would take place commercially). We then use the corresponding value in Table 3.2 above to ensure that the benchmark evidence point is derived on a consistent basis.

3.32 Table 3.3 summarises the relevant 800 MHz UK comparators for the different benchmark countries.

Table 3.3: Relevant UK comparators for 800 MHz

	Without coverage obligation	With coverage obligation
Net of expected DTT co-existence costs	Czech Republic, Ireland, Portugal, Slovak Republic	Romania
Gross of expected DTT co-existence costs	Austria, Germany, Greece, Italy, Spain, Sweden	Denmark

Framework for using benchmarks to assess UK market value

3.33 Having derived a set of country benchmarks based on relative values as described above, next we develop proposals for UK market value in light of this set of benchmarks. To do so, we:

- First, group the benchmarks into tiers, according to the extent to which we consider them to be informative of UK market values. We place more weight on benchmarks in a higher tier as we regard them as providing better quality evidence as a basis for ALF.
- Second, assess the risk that individual benchmarks may be understated or overstated estimates of market value in the UK and characterise the nature of that risk in terms of extent, scale and direction of any potential understatement or overstatement. This assessment affects our interpretation of the benchmark.
- Third, reach a view as to the lump-sum value of 900 MHz and 1800 MHz in the UK, in light of these benchmarks, taking account of the quality and nature of each benchmark evidence point (reflecting, respectively, the tier of the evidence point and its risk of understatement or overstatement referred to above).
- Fourth, apply cross-checks to our estimates of the lump sum values for 900 MHz and 1800 MHz in UK, including calculation of an illustrative weighted average and consideration of absolute benchmarks. We also consider the 1800 MHz / 900 MHz ratio.

3.34 There are some specific types of auction circumstances and/or country-specific factors which are relevant to the first step of grouping benchmarks into tiers. These may also be relevant to the second step of assessing the risk that benchmarks may be understated or overstated estimates of market value in the UK, alongside a wider range of other auction circumstances or country-specific factors. We explain further below the nature of the distinction between these first two steps.

Quality of benchmarks (tiers)

3.35 We categorise the available benchmarks into three tiers which reflect their relative quality according to the extent to which we consider them to be informative of UK market values. Given the requirement for us to set ALFs that reflect full market value, our main criterion for doing so relates to the extent to which the auction prices in the

country concerned appear to have been determined by bidding in the auction or auctions.[55] In particular:

- Where the auction prices appear to have been primarily determined by bidding in the auctions we consider that auction prices are more likely to reflect the relative values between the different bands and so be more informative for the purposes of deriving market values in the UK. This is therefore a key consideration for placing a benchmark in Tier 1.

- Where some or all relevant auction prices are the reserve price, we consider that benchmarks based on these prices are less informative of relative value in the country concerned. This is a key consideration for placing a benchmark in Tiers 2 or 3 rather than Tier 1. However, benchmarks from some auctions in which spectrum sold at reserve prices can still provide some useful information, depending on the circumstances of the auction. This is therefore a key consideration when judging whether to place a benchmark in Tier 2 or Tier 3.

3.36 In addition to this main criterion, we also consider factors which relate to the circumstances of the award in the country concerned, particularly the timing of the award, the amount and packaging of available spectrum, whether relative values arise from a single multiband award, and certain other country-specific factors. Taken individually, or together, these may represent a set of circumstances which were so different from circumstances in the UK today in terms of the drivers of spectrum value that it is appropriate to recognise this in the choice of tier. In some cases, we have put benchmarks in a lower tier largely on the basis of such factors – either Tier 2 or Tier 3 depending on the circumstances. For example:

- The price of the 900 MHz band in the Romanian auction was higher than the price of the 800 MHz band. This reflected the relativity of the reserve prices that were set by the regulator. Moreover, despite having a lower reserve price, there was unsold 800 MHz spectrum in Romania, but no unsold 900 MHz spectrum. The evidence indicates that the higher price of 900 MHz compared to 800 MHz was driven to a large extent by the much greater importance of 2G in Romania compared with the UK. We regard this as so different to the key drivers of the relative value of these bands in the UK that we consider Romania to be a third-tier benchmark for 900 MHz.

- The multiband auction in Germany, which included the 1800 MHz, 800 MHz and 2.6 GHz bands, took place in May 2010, well before important developments in the ecosystem for LTE1800. This is likely to have had a substantial effect on the

[55] A related issue is whether the auction generates band-specific prices or package prices. AM&A presented an analysis in which they automatically treated all results from CCAs as less important evidence, on the basis that band-specific prices cannot be directly observed inferred in these auctions. We recognise that there can be a degree of uncertainty in estimating band-specific prices in these auctions. However, we do not consider an automatic downgrading of the resulting evidence points as being less informative of UK market value is appropriate. Rather, in our view, the assessment depends on the specific circumstances, and the price information available in each case. We have therefore assessed the inclusion and tiering of individual benchmarks on a case-by-case basis, whether they came from an SMRA or a CCA.

In the cases of Austria and Ireland, the auction prices are derived from information we have obtained from the national regulators and which was not previously in the public domain. However, we do not consider that this is a reason to place these benchmarks in a lower tier, as discussed in footnote 2 to paragraph A7.9.

relative value of these bands in the German auction. In addition, unlike the 800 MHz and 2.6 GHz bands, only a minority of the spectrum in the 1800 MHz band was available in the auction, and two of the five available 2x5 MHz lots of 1800 MHz spectrum were non-contiguous. For these reasons we consider Germany to be a second-tier benchmark for 1800 MHz.

3.37 Where circumstances were different from the UK, but to a lesser degree than in these examples, we consider these circumstances when interpreting benchmarks, as discussed below, but do not change the tier for the benchmark on these grounds alone.

3.38 When using benchmarks to inform our judgement on the value of 900 MHz and of 1800 MHz in the UK, we consider that we should place most weight on benchmarks which are in the first tier and that benchmarks that are in the third tier should be considered as having very little informative value for these purposes.

Interpretation of benchmarks (risk of understatement or overstatement)

3.39 In some cases there is a risk that the international benchmark is an understated or overstated estimate of the UK value of the relevant band. We characterise the nature of the risks according to the:

i) Extent of the risk of understatement or overstatement (irrespective of its scale in point (ii) below): we categorise this as a smaller risk, a larger risk, or as an "unknown" risk if we consider that we cannot sensibly judge whether the risk is smaller or larger.

ii) Scale of the potential understatement or overstatement: smaller, larger, or an "unknown" scale if we consider that we cannot sensibly judge whether the scale of the potential understatement or overstatement is smaller or larger.

iii) Direction of potential effect: whether an understatement or overstatement, or "unknown" if we consider that we cannot sensibly judge the direction of the potential effect.

3.40 In doing this we consider whether the auction outcomes are likely to reflect market value in the country concerned, and whether there are other factors that might influence our interpretation of what a benchmark says about market value in the UK.

Whether auction outcomes reflect market value in the country concerned

3.41 Auction outcomes may not reflect the market value of spectrum in the relevant country for a number of reasons, for example due to:

i) Design of the auction: tight spectrum caps may mean there was limited competition in the auction, so that prices may understate market value;

ii) Reserve prices may have been set above market value, so that lots were either unsold, or sold for the reserve price. In these cases the auction price may overstate market value;

iii) Strategic bidding: bidders may bid above their intrinsic value of spectrum to foreclose rivals or to raise rivals' costs. Alternatively they may seek to understate their demand for spectrum in order to acquire it at a lower price. Alternative types of strategic bidding are described in Annex 7, paragraph A7.87.

Whether other factors influence the interpretation of benchmarks

3.42 As noted above, we have considered whether country-specific factors might lead a benchmark to be at risk of overstating or understating the market value of 900 MHz and 1800 MHz spectrum in the UK (even though we do not consider there is a reliable basis for making quantified adjustments to the auction values in Table 3.1). In the current context, the relevant consideration is whether country-specific factors might affect the values of benchmarks that are derived on the basis of the relative values of different frequency bands.

3.43 As explained in Annex 7 paragraphs A7.58 to A7.91, our view of the risk that country-specific factors may affect relative values is that:

i) There are possible reasons for considering that differences in urbanisation between countries may drive differences in bands, particularly leading to higher relative values for 800 MHz and 900 MHz spectrum in less urbanised countries compared to higher-frequency spectrum. The available empirical evidence provides some support for this view, and we have taken account of this in interpreting evidence from countries which are considerably less urbanised than the UK.

ii) There may be reasons for considering that large differences in the proportion of traffic that is 2G drive differences in values, particularly higher values of 900 MHz spectrum relative to other bands. However, the available empirical evidence does not provide clear support for such a relationship, and we have not generally taken such differences as a basis for considering there to be a risk of understatement or overstatement.

iii) The case for other country-specific factors (for example, average margin per user or AMPU) driving differences in relative values is unclear, and does not appear to be supported by the empirical evidence as a systematic driver of auction prices, and we have not taken differences in these other factors as a basis for considering a risk of understatement or overstatement.

3.44 We also note that the interest in 1800 MHz for LTE has increased in recent years.[56] There is therefore a risk that, if the award of 1800 MHz took place in 2011, then the country benchmark in question may be understating the more recent market value of 1800 MHz relative to 800 MHz and 2.6 GHz bands. For auctions of 1800 MHz before 2011, we consider that the extent and scale of the risk of understatement are of sufficient importance that we should take it into account in our judgement on the relevant tier for the benchmark (as discussed above for Germany).

3.45 The rest of this section now sets out our analysis for the 900 MHz and 1800 MHz bands in turn.

Lump-sum value of 900 MHz in UK

3.46 We have derived relative value benchmarks (900 MHz to 800 MHz paired ratios) from six countries where spectrum has been auctioned in both bands since 2010 – Austria, Denmark, Ireland, Portugal, Romania and Spain. Table A8.1 in Annex 8 shows the 900/800 MHz ratio for each country, together with the corresponding lump-sum benchmark value for 900 MHz in the UK (calculated on the basis of the UK

[56] See Annex 7 (A7.83 to A7.85).

market value for 800 MHz set out in Section 2). The table also shows the tier in which we have categorised the benchmark, along with our interpretation of the risk that the benchmark might either understate or overstate the market value of 900 MHz in the UK.

3.47 The resulting benchmarks are shown in Figure 3.2 below. Our assessment of these individual benchmarks is set out in further detail in Annex 7 and 8 and summarised below.

Tiering of international benchmarks

3.48 We consider that the Austrian and Irish auctions are more informative of the value of 900 MHz spectrum in the UK, and the benchmarks from these countries should be in our first tier. Prices were above reserve, reflecting bidding in these auctions. As such we consider these prices are more likely to be reflective of market value than if the spectrum had sold at reserve price. We have not identified country-specific differences which would lead us to modify our view that these benchmarks are more informative of the relative values of these spectrum bands in the UK.

3.49 We consider that the Portugal and Spain auctions provide less information about the value of 900 MHz spectrum in the UK, and that the benchmarks from these countries should be in our second tier. In Portugal, spectrum sold at reserve price and so the benchmarks reflect the relative value of reserve prices set by the regulator for 900 MHz and 800 MHz spectrum. In addition, only 2x10 MHz of the 900 MHz band was available in the auction in non-contiguous lots of which 2x5 MHz was unsold. In Spain, the benchmark relates to the price of 800 MHz in the July 2011 auction, and the reserve price of 900 MHz spectrum in the November 2011 auction. In each of the July 2011 and November 2011 auctions the reserve price of 900 MHz was the same and only 2x5 MHz of spectrum was sold at this price (2x5 MHz was unsold in the former). Whilst there is a case for these benchmarks to be categorised in the third tier, on balance, we consider they are more informative than other benchmarks we have included in the third tier. For this reason we include them in the second tier.

3.50 Finally, we consider that the Romania and Denmark auctions provide very little information about the value of 900 MHz spectrum in the UK, and benchmarks from these countries should be in our third tier. In Denmark, the three incumbent operators were prevented from bidding for the single available lot of 900 MHz spectrum. Our reasons for judging Romania as providing a third-tier benchmark are explained above (see paragraph 3.36).

Interpretation of international benchmarks

3.51 In interpreting the Austrian and Irish evidence points, we note that some stakeholders suggested that strategic behaviour by bidders may have taken place, which could introduce an overstatement to our 900 MHz / 800 MHz benchmarks. We discuss these suggestions in more detail in Annex 8. As regards the direction of any potential overstatement or understatement, we consider that the strategic behaviour alleged in Ireland might lead this benchmark to be overstated, while in the Austrian case the direction of any understatement or overstatement is less clear. In our view, the available evidence is inconclusive about strategic bidding in either of these awards, and we consider that our assessment should treat the risk and scale of any such understatement of overstatement as being unknown in each case.

3.52 In interpreting the Portugal and Spain evidence points there are reasons for considering that they might overstate market value – namely that in Portugal some

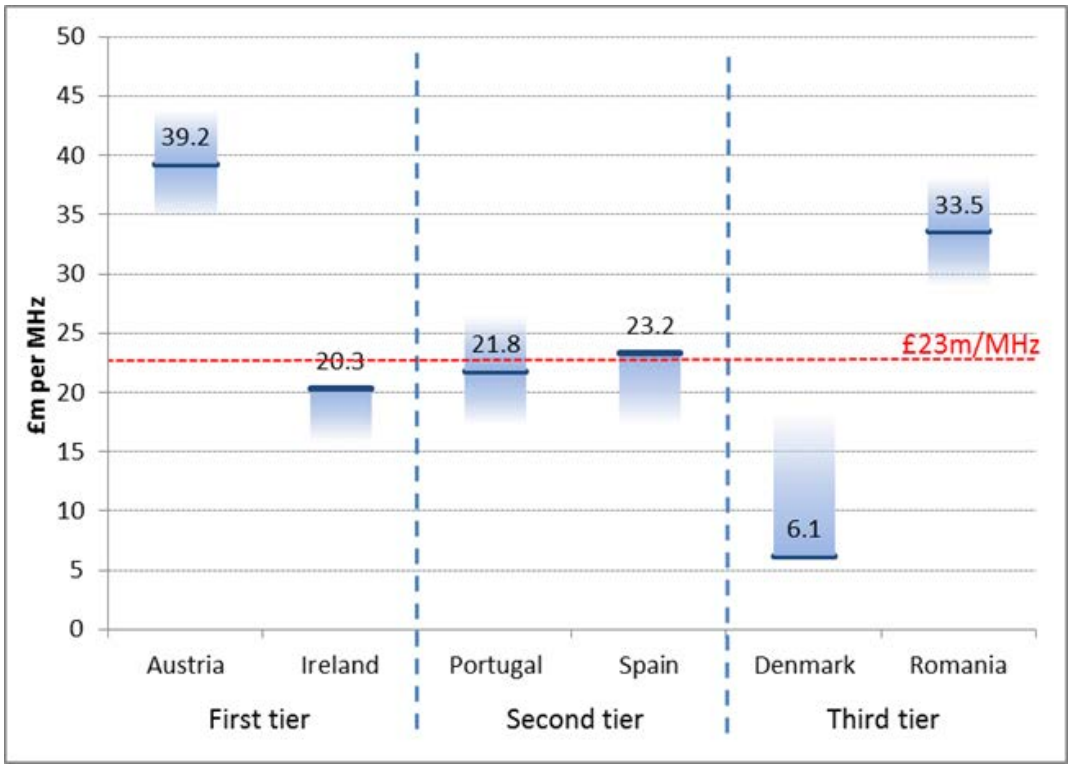
900 MHz was unsold at reserve price, while in Spain 800 MHz spectrum sold above the reserve price.[57] However, in Portugal there are also factors pointing in the opposite direction (non-contiguity of the 900 MHz lots may have reduced their value). Our view is that there is a larger risk of overstatement in the case of Spain; and that the risk of understatement or overstatement in Portugal is unknown and could be in either direction. In both cases our view is that our assessment should treat the scale of any such understatement or overstatement as unknown.

3.53 In Denmark, we consider there is a larger risk that the benchmark is a larger understatement, due to the exclusion of the three incumbent operators as noted above. In Romania we consider there is a risk of understatement or overstatement, but that the risk and scale of any such understatement or overstatement should be treated as unknown.

Estimate of market value

3.54 The shaded areas in Figure 3.2 illustrate our assessment of the risk, scale and direction of potential understatement or overstatement associated with each benchmark. The length of these shaded areas reflects a combination of the risk and scale of potential understatement or overstatement (with a larger risk of a larger understatement or overstatement being represented by a longer shaded area etc, although the resulting length of the shaded areas is not drawn to a specific scale and so is only illustrative).

Figure 3.2: 900 MHz paired ratio benchmarks



[57] This may mean that the 900 MHz / 800 MHz benchmark is overstated because it suggests that the 900 MHz price at the reserve price may be above market value, whereas the 800 MHz price may be at market value as it was driven by auction bids.

3.55 We have two first-tier benchmarks (Austria and Ireland), of which the higher is almost double that of the lower. The average of these benchmarks is around £29.8m per MHz.

3.56 We consider that an appropriate estimate for UK market value should be towards the lower end of the range of first-tier benchmarks because:

- We consider that we should adopt a conservative approach when interpreting the evidence; and
- There is a risk that the Irish benchmark overstates the UK market value, although we treat the level of risk and the scale of potential overstatement as unknown.

3.57 On this basis, we consider that an appropriate estimate of UK market value would be between the average of the first tier benchmarks, and the lower of these two benchmarks, i.e. between around £20m and £30m per MHz. A figure of around £25m per MHz could be appropriate if we were solely considering first-tier benchmarks.

3.58 We next consider second-tier benchmarks. The average of the first-tier and second-tier benchmarks is about £26m per MHz. This average includes both the Spain benchmark of £23.2m per MHz (which reflects the sale of a single block of 900 MHz spectrum sold at reserve price, and is likely to be an overstatement) and the Portugal benchmark of around £22m per MHz (for which there is a risk of understatement or overstatement - see paragraph 3.52). Adding in these benchmarks suggests that our estimate should be lower than the £25m mentioned above.

3.59 Considering the third tier of evidence, the low Denmark benchmark is well below the Irish benchmark, while Romania is closer to the Austria benchmark. However we place considerably less weight on these third tier benchmarks for the reasons given above, and explained in Annex 8.

3.60 On balance, we consider that **£23m per MHz** is an appropriate estimate of the market value of 900 MHz spectrum in UK for the purpose of setting ALF, adopting a conservative approach to interpreting the benchmark evidence It is significantly lower than the average of the first-tier benchmarks and reflects a downward revision adjustment to take account of the second-tier benchmarks.[58] It is close to (though above) the lowest first-tier benchmark. .

Cross checks

Illustrative weighted average of benchmarks

3.61 Stakeholders put forward their own assessment of benchmark evidence in their responses using weighted averages in which benchmarks are weighted according to the quality of the evidence. For example, AM&A calculated a weighted average by giving “more important” benchmarks twice as much weight as “less important” benchmarks.[59] As a cross-check, we have compared the proposed value of £23m per MHz set out above with the results of applying this weighting approach to our

[58] The value of £23m/MHz is 77% of the average of the first-tier benchmarks, and 88% of the average of the first- and second-tier benchmarks.

[59] AM&A used these weights in the context of the 1800MHz band; AM&A did not look at weights for the 900 MHz band.

revised benchmarks. Table 3.4 calculates a weighted average reflecting the weights proposed by AM&A, by giving first-tier evidence twice as much weight as second-tier evidence (for this exercise we have weighted third-tier evidence at zero[60]). The resulting weighted average is £27.3m/MHz. Our proposed value of £23m per MHz is 84% of this weighted average.

Table 3.4: Illustrative weights for 900 MHz benchmarks

	900 MHz
First-tier weighting	2
Second-tier weighting	1
Third-tier weighting	0
Illustrative weighted average value in £m/MHz	27.3

Absolute values of 900 MHz

3.62 We can cross check our estimate of the value of 900 MHz spectrum against the absolute values of this spectrum in our benchmark countries, repeated below in ascending order.

Table 3.5: Absolute value of 900 MHz spectrum (£m/MHz UK equivalent)

Country	Denmark	Portugal	Spain	Greece[61]	Ireland	Romania	Austria
Absolute value (£m)	2.9	24.9	26.4	32.8	39.6	47.3	79.4

3.63 Seven countries in our sample have auctioned 900 MHz lots since 2010. The average absolute value in these countries was £36.2m per MHz, while the average among the first tier countries (Austria and Ireland) was £59.5m per MHz.

3.64 Our proposal is lower than all but one of the absolute values in these countries (Denmark, in which the price is likely to be an understatement). Austria, Ireland, Greece, Romania and Portugal are less urbanised than the UK. This might be relevant to the extent that differences in urbanisation between countries drive differences in value of bands, particularly leading to higher values for sub-1 GHz spectrum in less urbanised countries. This will tend to affect the absolute value of 900 MHz, although not necessarily the relative value of 900 MHz to 800 MHz.

3.65 More generally, we are not minded to amend our figure from the relative value benchmarks on the basis of the evidence of absolute values of 900 MHz spectrum . There is significant dispersion in the values (a range of £76.5m between the highest and lowest absolute benchmark in Table 3.6 above, or £54.5m if we exclude

[60] Applying positive weights to the third-tier benchmarks will tend to bring down the average. For example, with weights of 0.5, the weighted average would be £26.3m/MHz.

[61] There is not a relative value for Greece in Figure 3.2 above because the 800 MHz band was not auctioned.

Denmark). As discussed earlier, this reflects the fact that there is much greater potential for absolute benchmarks to be affected by factors (such as urbanisation) which vary widely between countries and are difficult to control for. This weakens their relevance to a UK market value for 900 MHz.

Comparison with stakeholder proposals

3.66 The following table summarises stakeholders' alternative 900 MHz value proposals which were presented in their responses to our October 2013 consultation. This table expresses these proposals in terms of the relative value of 900 MHz to 800 MHz, given this reflects the implications of the international benchmark analysis on which this section has focused. As can be seen, these are broadly consistent with our revised proposals (although Vodafone and Telefónica both used estimates of the UK 800 MHz market value that are significantly below those that we propose in Section 2).

Table 3.6: Summary of implied ratios of 900 MHz to 800 MHz from different proposals

	900 MHz / 800 MHz ratio	Comments
October 2013 consultation	84%	Based on value of 800 MHz in UK, gross of co-existence costs and without coverage obligation.
Vodafone	61% to 81%	Excluded results which were above or below the upper or lower bounds of UK market value (Denmark is below UK 2.6 GHz value), leaving Ireland, Portugal, Spain and Romania. Took Ireland and Spain as the two most important evidence points to create a range of ratios. Applied the resulting range of 900/800 MHz relative values to the midpoint of Vodafone's UK 800 MHz market value estimate (£19.7m) to produce a 900 MHz value range.
Telefónica	63%	The average of the 5 relative values (Denmark, Ireland, Portugal, Romania and Spain) was 69%. The average of 4 of these relative values (excluding Romania) was 57%. The midpoint of these bounds was 63%. Applied the ratio of 900/800 MHz of 63% to Telefónica's suggested UK 800 MHz market value (£24.16m).
Our revised proposals	65%	Based on value of 800 MHz in UK, gross of co-existence costs and without coverage obligation. (The ratio based on 800 MHz net of co-existence costs and without coverage obligation would be 70%.)

Lump-sum value of 1800 MHz in UK

3.67 In deriving an estimate of the value of 1800 MHz spectrum in the UK, we focus on the distance method proposed by AM&A on behalf of EE and H3G, as described above. We have derived nine distance method benchmarks from countries where spectrum has been auctioned in relevant bands – Austria, Czech Republic, Germany, Ireland, Italy, Portugal, Romania, Slovak Republic, and Sweden. The UK 1800 MHz lump-sum value that is generated by each benchmark is shown in Table 8.2 in Annex 8. The table also shows the tier in which we have categorised each benchmark, along with our interpretation of the risk that the benchmark might either overstate or understate the market value of 1800 MHz in the UK.

3.68 The resulting benchmarks as shown in Figure 3.3 below. Our assessment of these individual benchmarks is set out in further detail in Annex 8 and summarised below.

Tiering of international benchmarks

3.69 Interpreting these benchmarks requires an assessment of the interplay of different auction and country factors for the three bands involved in the distance method calculation: 800 MHz, 1800 MHz and 2.6 GHz.

3.70 In Italy, there was a single multiband award including the relevant bands. In Austria and Ireland 800 MHz and 1800 MHz were included in the same multiband auction but 2.6 GHz was auctioned in 2010 in Austria and has not yet been auctioned in Ireland, where we have used a proxy measure for 2.6 GHz. Prices of the relevant spectrum bands were above reserve, reflecting bidding in these auctions. We have not identified country-specific differences which would lead us to modify our view that the relevance of these benchmarks for the purposes of informing the relative values of these spectrum bands in the UK. We consider that the Austria, and Ireland auctions are more informative of the value of 1800 MHz spectrum in the UK, and that these benchmarks should be in our first tier. In Italy, only 2x15 MHz of 1800 MHz spectrum was auctioned, in 2x5 MHz lots (although these were generic lots) which were won by different operators. We consider there is potentially a case for including Italy in our second tier. However, on balance due to the factors considered above we have included Italy in our first tier.

3.71 We consider that the Germany and Sweden auctions provide less information about the value of 1800 MHz spectrum in the UK:

- Our reasons for considering that Germany should be in the second tier are explained above (see paragraph 3.36).

- In the case of Sweden, 800 MHz and 1800 MHz were sold in separate awards in March 2011 and October 2011 respectively.[62] Two operators bid jointly in both awards; in total there were five bidders in the 800 MHz award but only three bidders in the 1800 MHz award, which may have resulted in less competition for 1800 MHz than 800 MHz spectrum. We consider there is potentially a case for treating Sweden as a first-tier country. However, on balance due to the auction circumstances described above we have included Sweden in the second tier, rather than the first tier.

[62] In Sweden, a 2.6 GHz award took place in 2008. In view of the early date of this award, we have used a proxy measure for the value of 2.6 GHz.

3.72 Finally, we consider that the Portugal, Romania, Czech Republic and Slovak Republic auctions provide very little information about the value of 1800 MHz spectrum in the UK, and that the benchmarks from these countries should be in our third tier. In particular:

- In the Czech Republic, 1800 MHz spectrum was auctioned in very small (2x1 MHz) lots, and incumbents were unable to bid on the only block which was large enough to be suitable for LTE. Significant amounts of 1800 MHz and 2.6 GHz spectrum were unsold.

- In Portugal there was some unsold spectrum in 1800 MHz and 2.6 GHz. The fourth bidder made a zero bid in the first round, leaving more 1800 MHz spectrum than the three active bidders could acquire under the spectrum caps. A 2.6 GHz cap was also binding on the three active bidders. No spectrum in any band sold significantly above reserve price.

- In Romania no spectrum in any band sold significantly above reserve price, and there was some unsold spectrum in 800 MHz and 2x40 MHz of unsold 2.6 GHz – i.e. the two other bands that are used to generate the distance method benchmark for 1800 MHz.

- In the Slovak Republic, incumbents were unable to bid on the only block which was large enough to be suitable for LTE.

Interpretation of international benchmarks

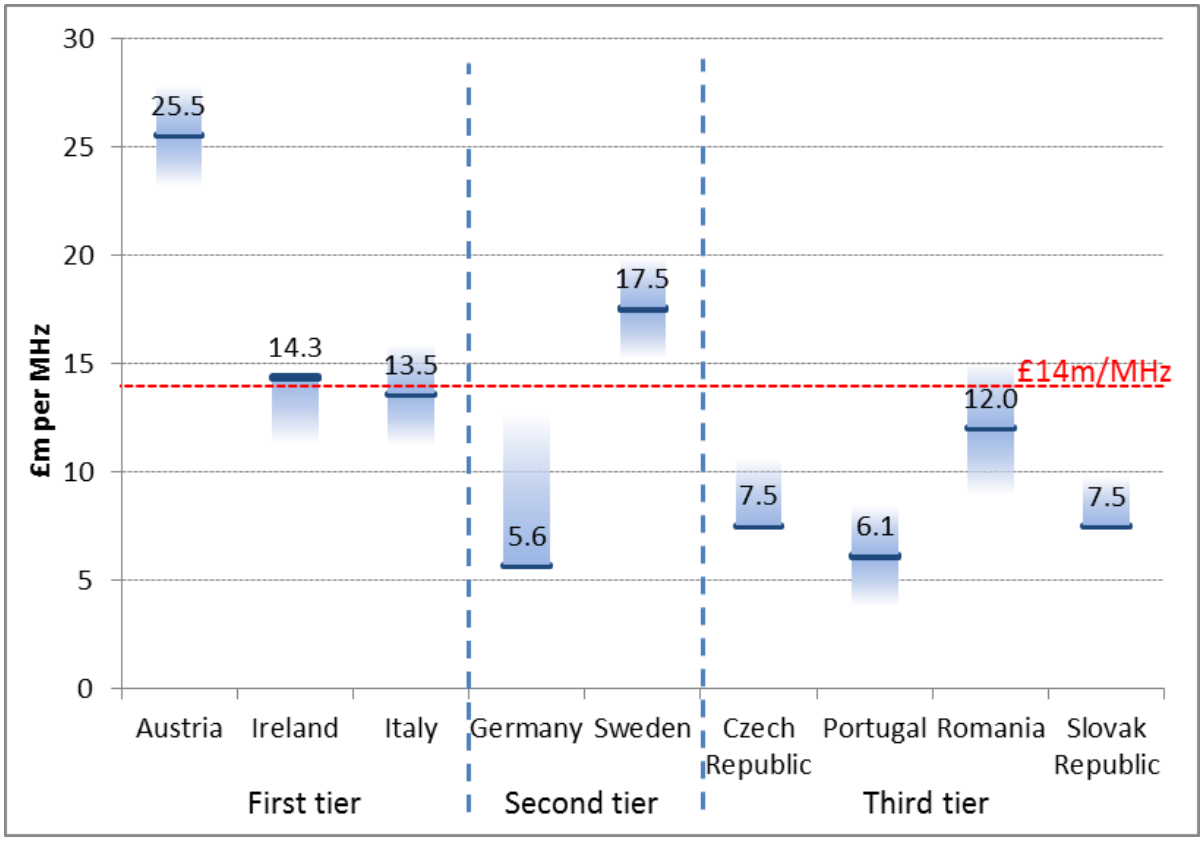
3.73 In interpreting the first-tier benchmarks, we note that there is a potential risk of understatement or overstatement in the Austria and Italy benchmarks, arising from possible strategic behaviour in the auction and, in the case of Italy, the relatively early date of the award in September 2011. However, for both of these countries we treat the direction, risk and scale of any understatement or overstatement as unknown because there are possible sources of either understatement or overstatement. In the case of Ireland, we consider that there is a risk of overstatement of the value of 1800 MHz spectrum since the 2.6 GHz spectrum is not (yet) available for mobile use.

3.74 As regards the benchmarks in other tiers, in Germany we consider there is a larger risk of a larger understatement, particularly due to the early date of the award in 2010. For Czech Republic we consider there is a larger risk of understatement, for Slovak Republic we consider there is an unknown risk of understatement; in each case, we treat the scale of understatement as unknown. For other second- and third-tier countries we treat the direction of any understatement or overstatement as unknown.

Estimate of market value

3.75 The benchmarks are shown as a diagram in Figure 3.3. As with Figure 3.2, the shaded areas illustrate our assessment of the risk, scale and direction of potential understatement or overstatement associated with each benchmark.

Figure 3.3: 1800 MHz distance method benchmarks



3.76 We have three first-tier benchmarks, in Austria, Ireland and Italy. The highest, Austria, is around 90% higher than the lowest, Italy, while Ireland is much closer to Italy than Austria. The average of the Austria, Ireland and Italy benchmarks is £17.8m per MHz.

3.77 We consider that an appropriate estimate for the UK market value of 1800 MHz should be towards the lower end of the range of first-tier benchmarks because:

- We consider that we should adopt a conservative approach when interpreting the evidence;
- Two of the three benchmarks are at the lower end of the range, while only one is at the top;
- There is a risk that the Irish benchmark overstates the UK market value, and we have categorised this as a larger risk, although the scale of potential overstatement is unknown.

3.78 We consider that there are stronger reasons for preferring a figure towards the lower end of the first-tier range than in the case of 900 MHz (as set out in paragraph 3.57 above), since there are two benchmarks around the lower end of the range, and there is a larger risk, rather than an unknown risk, of overstatement in Ireland.

3.79 We consider that an appropriate estimate of UK market value would be between the average of the first tier benchmarks and the lowest benchmarks, i.e. between around

£13.5m and £17.5m per MHz. We consider that a figure of around £14m per MHz could be appropriate if we were solely considering first-tier benchmarks.

3.80 We next consider second-tier benchmarks. We note there is less consistency in the second-tier benchmarks than in the case of 900 MHz. The average of the first-tier and second-tier benchmarks is about £15m per MHz. The German benchmark is at larger risk of being a larger understatement, but it is substantially lower than £14m per MHz. The Sweden benchmark could be seen as indicating a higher value than £14m per MHz. However, the two benchmarks in the second tier have implications in different directions. Their inclusion in the second tier also indicates that we consider these benchmarks to be less informative of the UK value than the benchmarks in the first tier. Therefore, on the basis of the second-tier evidence we do not consider it appropriate to adjust the £14m per MHz figure suggested by a conservative interpretation of the first-tier benchmarks.

3.81 All four of the third-tier benchmarks are materially lower than £14m. However, we place considerably less weight on these benchmarks for the reasons given in paragraph 3.72 above, and further explained in Annex 8.

3.82 On balance, we consider that **£14m per MHz** is an appropriate estimate of the market value of 1800 MHz spectrum in the UK for the purpose of setting ALF, adopting a conservative approach to interpreting the benchmark evidence. . It is significantly lower than the average of the first-tier benchmarks and we do not consider that the second- or third-tier benchmarks provide a strong reason for a higher or lower estimate.[63] It is close to (though slightly above) the lowest first-tier benchmark.

Cross checks

3.83 We have looked at two cross-checks for the UK 1800 MHz lump-sum value (as for 900 MHz).

Illustrative weighted average of benchmarks

3.84 As with the 900 MHz case, we have looked at a weighted average of the benchmarks. Table 3.7 calculates a weighted average using similar weighting factors to those used by AM&A (on behalf of EE and H3G), by giving first tier evidence twice as much weight as second tier evidence.[64]

3.85 The resulting weighted average is £16.2m per MHz. Our proposed value of £14m per MHz is 86% of this weighted average. We consider these percentage comparisons (of our proposed value to the straight, or weighted, averages of the benchmarks) are broadly consistent with similar comparisons for 900 MHz (see paragraph 3.61).

[63] This value of £14m/MHz is 79% of the average of the first tier benchmarks, and 92% of the average of the first and second tier benchmarks

[64] As is the case for 900 MHz, applying positive weights to third-tier benchmarks will tend to bring down the weighted average. For example, with weights of 0.5, the weighted average would be £14.6m/MHz.

Table 3.7: Illustrative weights for 1800 MHz benchmarks

	1800 MHz
First-tier weighting	2
Second-tier weighting	1
Third-tier weighting	0
Illustrative weighted average value in £m/MHz	16.2

Absolute values

3.86 Our proposed value of 1800 MHz falls in the middle of the ranking of absolute value benchmarks, with six of these benchmarks lower than £14m and five of them higher than £14m. All the distance method benchmarks we have considered above are, by construction, above the UK 2.6 GHz price of £5.5m and they range up to £25.5m. In contrast, absolute benchmarks range from around £1m to almost £50m. Three of these benchmarks are below the estimated UK value of 2.6 GHz.

Table 3.8: Absolute value of 1800 MHz spectrum (£m/MHz UK equivalent)

Denmark	Germany	Portuga	Czech Re	Slovak Rep.	Sweden	Greece	Italy	Romania	Ireland	Austria
1.2	1.9	3.2	6.0	7.1	9.7	14.5	16.7	19.0	25.2	48.6

3.87 In light of their wide variation, and the risk that they are affected by country-specific factors, we do not consider that the evidence of absolute values provides a strong reason for revising our estimate of 1800 MHz value from the relative value benchmarks.

Comparison with stakeholder proposals

3.88 The following table summarises stakeholders' alternative 1800 MHz proposals. As can be seen, these are generally lower than the market value by our analysis of the evidence points.

Table 3.9: Summary of stakeholder proposals on 1800 MHz lump-sum value

Stakeholder	1800 MHz value	Summary of methodology
October 2013 consultation	£15m per MHz	Around 50% of value of 800 MHz gross of co-existence costs and without coverage obligation. When expressed in terms of the distance method, 40% of the distance from the 2.6 GHz value to the 800 MHz value ("Y/X ratio" of 40%).
Vodafone	£6.3m - £12.5m per MHz	Excluded results which are above or below Vodafone's estimates of the upper and lower bounds of UK market value. This left 9 out of 16 benchmarks in the sample. Considered that relative valuations of 1800/800 MHz derived from Sweden, Ireland and Italy defined the boundaries of the appropriate range for the value of 1800 MHz in the UK (32%

		to 64%). Applied these ratios to the midpoint of Vodafone's estimate of UK 800 MHz market value (£19.7m) to produce a range.
Telefónica	£8.93m per MHz	Considered simple average of absolute values at £8.9m. Applied average ratio of 37% to Telefónica's estimate of UK 800 MHz value (i.e. £24.16m per MHz), which resulted in £8.93m per MHz. Applied average ratio of 212% to Telefónica's's estimate of UK 2.6 GHz value (i.e. £4.21m per MHz), which (coincidentally) also resulted in £8.93m per MHz
AM&A for H3G and EE	£9.0m per MHz	Around 18% of the distance from the 2.6 GHz value to the 800 MHz value (using the values of £29.95m/MHz and £5m/MHz from the October 2013 consultation). Set out criteria for inclusion and categorisation of importance of a country. Calculated weighted average of included countries.
Our revised proposals	£14m per MHz	31% of the distance from the 2.6 GHz value (of £5.5m / MHz) to the 800 MHz value (of £32.63m / MHz, net of co-existence costs and without coverage obligation). Resulting ratio of 1800 MHz to 800 MHz is 43%.

3.89 A large part of the reason why the MNOs' estimates of the UK 1800 MHz value are significantly below our proposed value is because their estimates are based on lower values for 800 MHz and 2.6 GHz. However, the focus of the analysis in this section is on the value of 1800 MHz relative to 800 MHz and 2.6 GHz. Our observations below therefore compare the estimates of relative value.

3.90 Vodafone and Telefónica based their analysis on the ratio of 1800 MHz to 800 MHz. Our proposed 1800 MHz value of £14m is 43% of our estimate of our UK 800 MHz value. This is reasonably close to Telefónica's average ratio of 37% and within the 32% to 64% range proposed by Vodafone.

3.91 EE and H3G (drawing on AM&A) base their proposals on the distance method, using our October 2013 consultation estimates for values of 800 MHz and 2.6 GHz. Their estimate of UK 1800 MHz value is 18% of the distance from the 2.6 GHz value (of £5m / MHz) to the 800 MHz value (of £29.95m / MHz). This compares with the distance of 28% under our revised proposals.

Comparison of 900 MHz to 1800 MHz

3.92 As a further check we can also compare the ratio of 1800 MHz to 900MHz implied by our proposals against the ratios in our benchmark sample where both 900 MHz and 1800 MHz have been auctioned (as shown in the following table).

Table 3.10: Value of 1800 MHz as a proportion of 900 MHz

Austria	Ireland	Portugal	Greece	Romania	Denmark
61%	64%	13%	44%	40%	43%

3.93 Our proposals suggest a value for 1800 MHz that is around 61% of the value of 900 MHz spectrum (£14m/MHz compared to £23m/MHz). This is at the higher end of the within-country relative values of 900 MHz and 1800 MHz shown above. However the two countries (Austria and Ireland) which are in the first tier for both 900 MHz and 1800 MHz both have a similar ratio to our proposals.[65] In the other four countries, either one or both of the 900 MHz and 1800 MHz benchmarks are in the third tier which means that we place very little weight on them.

3.94 On the basis of this cross-check, we are not minded to change either of our proposed values derived from the relative value benchmark evidence.

Summary of our revised proposals for lump-sum values of 900 MHz and 1800 MHz spectrum

3.95 Our proposed lump-sum values are summarised in Table 3.11.

Table 3.11: Lump-sum values for 900 MHz and 1800 MHz

900 MHz	1800 MHz
£23m/MHz	£14m/MHz

Question 2. Do you have any comments on our revised assessment of the lump sum values of 900 MHz spectrum and 1800 MHz spectrum?

[65] In the case of Ireland, we have identified an unknown risk of overstatement in 900 MHz but a larger risk of overstatement in 1800 MHz due to the non-availability of 2.6 GHz. If 1800 MHz in Ireland were in fact overstated, and to a greater extent than any overstatement in 900 MHz values, this would imply a lower ratio of true values than presented above. However, in both cases we consider the scale of potential overstatement is unknown.

Section 4

Deriving annual licence fees from lump-sum values

Introduction

4.1 This section sets out our approach to converting our estimate of the lump-sum value of the spectrum into annual fees and corresponds to step 3 in the analytical framework we set out in Section 1. Supporting material for this section is set out in Annex 10.

Our October 2013 proposals and stakeholder responses

4.2 Our October 2013 proposals were to:

- spread the lump-sum value of spectrum over 20 years, using an ALF profile that is flat in real terms, that is a 20-year annuity;
- apply a post-tax WACC of 4.2% when deriving the annuity payment;
- take into account the differential tax benefits of the lump-sum value and the ALF in calculating the ALF; and
- use the RPI index to adjust the base year ALF level each year when the licence fee comes due for payment.

Spreading the lump-sum value

4.3 Stakeholders broadly agreed with our proposals to spread the lump-sum value over 20 years using a constant real profile. We are therefore minded to continue to adopt this approach.

4.4 We note that some respondents argued for an adjustment for the terminal value of the auctioned licences. For the reasons we set out in our October 2013 consultation we remain of the view that we should not make an adjustment for terminal value.

Inflation index

4.5 In the October 2013 consultation we proposed to use RPI for the purpose of revising ALF, but acknowledged that there was an argument for using CPI instead. Stakeholders responded arguing for the use of CPI, and having considered the matter further, we consequently issued a further consultation in April 2014 (“the CPI consultation”) setting out how we would adjust the discount rate were we to favour moving to CPI.

4.6 In response to the CPI consultation, stakeholders reiterated that they favoured CPI, but had some specific concerns with our proposals, largely in relation to the

perception that we were inappropriately updating only some of the WACC parameters,[66] and also with the inflation parameters we were proposing to use.

4.7 We are now minded to use CPI as the measure of inflation in calculating ALFs, both for the purposes of (i) the discount rate that we adopt at various stages of our ALF methodology (in estimating the lump-sum value of spectrum and also in annualising such lump sums into ALF), and (ii) the way we derive the change in ALF each year in line with this measure of inflation.

4.8 For the purposes of calculating the discount rate, we are minded to use a CPI assumption of 2% and a RPI assumption of 3.3%. The reasoning and evidence behind these assumptions, including that presented by stakeholders, is set out in Annex 10.

Discount rate

4.9 Stakeholders argued that the discount rate we use should not be the WACC but should instead be the cost of debt (or, in some cases, the risk free rate). We use a discount rate for a number of calculations in deriving ALFs:

- In converting our lump-sum valuations into annual fees, we need a discount rate to reflect the time value of money in spreading out the lump-sum value over time;
- In our international benchmarking, some of the auctions involved spectrum licences with different licence durations. In order to derive a value on a comparable basis to the UK auction licences, we need to adjust the auction prices to estimate the value for a licence duration of twenty years; and
- Some of the international auctions involved licences on which ALFs were payable. In order to derive a value on a comparable basis to the UK auction licences, we need to incorporate the value of these fees into the present values of the auction revenues.

4.10 These three exercises have slightly different purposes and so, for reasons explained below, we consider that it is appropriate to apply a different discount rate for each. In summary, we propose to apply:

- The cost of debt for the purposes of deriving ALFs. This is a change from our October 2013 consultation in which we proposed to use a WACC for these purposes;
- The 2011 MCT WACC, converted to a CPI-adjusted real WACC, for the purposes of adjusting licence duration. This is the same approach as in the October 2013 consultation, aside from the change in the inflation index used; and
- The 2011 MCT cost of debt, converted to a CPI-adjusted real cost of debt, for adjusting benchmark auction results for the presence of annual fees. This is a change from our October 2013 consultation in which we proposed to use a WACC for these purposes.

[66] See paragraphs 4.26-4.29 below, where we discuss adjusting the 2011 WACC and cost of debt estimates for CPI, which sets out that we do not propose to change the RPI inflation assumption used in deriving those figures. For the discount rate used to annualise our lump sum values, we are proposing to update all of the parameters and so this issue does not arise.

Discount rate for annualisation

4.11 In coming to our estimates of lump-sum values, we have used data from bids in auctions. It is likely MNOs will have decided what to bid based on the present value of the expected cash flows they would derive from the spectrum. We assume these cash flows would have been discounted at the MNO's WACC to produce present values.

4.12 However, the nature of our annualisation exercise is not to reproduce the original cash flows on which the lump-sum value is based. Rather, we are seeking to spread the lump-sum value over the period covered by the ALFs to calculate a constant real annual payment from the MNOs to the Government, the ultimate recipient of revenue from ALF payments. In principle, an average efficient MNO (on which our estimation of the discount rate is based) and the Government should be indifferent between payment for the spectrum in the form of a lump-sum payment or ALF. This means that the discount rate used to annualise the lump-sum value should reflect the risk of the cash flows coming from MNOs to the Government through the ALF, rather than the risk to the MNOs of the cash flows associated with using the spectrum.

4.13 Exactly what the nature of this risk is depends on the nature of the ALF obligation. We have considered two polar cases, which would imply very different discount rates:

- If the ALF payment were set up such that the risk of the ALF payment were the same as the risk of the future after-tax free cash flows (e.g. through some form of net revenue sharing arrangement between the MNOs and the Government), the correct discount rate to use would be the rate used to convert the expected cashflows from using the spectrum into the bid value. This may be approximated by the MNOs' WACC.

- If the ALF payment were set up so that they were completely fixed regardless of circumstances, and MNOs had no option but to pay this level of fee, the ALF would effectively be akin to a form of highly secured debt and the correct discount rate would be the corresponding interest rate for such a debt instrument.

4.14 We note that even where the ALF payments are completely fixed, there is still a risk that the Government does not receive the payments due to the risk that the licence holder may default on its payments. Therefore the appropriate discount rate would be some form of cost of debt (which incorporates a debt premium to reflect such a risk) rather than the risk-free rate, as argued by some stakeholders.

4.15 We set out our analysis of the appropriate rate in each of these polar cases in Annex 10. Based on this analysis, we now consider that:

- If the ALF was closely correlated with the underlying spectrum value (the 'WACC' case) a rate of 5.1% may be reasonable; and

- If the ALF was completely uncorrelated with the underlying spectrum value a rate of 2.6% may be reasonable (the 'debt rate' case).

4.16 We recognise that there is no solution that perfectly fits the case we are addressing here. We have therefore sought to identify what we consider to be the best available proxy rate to use for the purposes of setting ALFs, given our conservative approach to interpreting the available evidence set out in Section 1.

4.17 The ALF obligation appears to us to have a number of features which means it is closer to the 'debt rate' case than the 'WACC' case as:

- The ALF payable is fixed in advance and does not vary depending on the return the MNOs actually earn from the spectrum; and
- The ALF payment is secured against an asset (i.e. the spectrum the licence entitles the MNO to use) which is returned to Ofcom if the ALF is not paid. We can then re-assign it to another licensee, which would yield revenue for the Government (either in the form of auction revenue or ALF payments)

4.18 We recognise however that the ALF regime is not exactly aligned with the debt rate case:

- MNOs can avoid paying the ALF by handing back the spectrum. This seems to provide the option of 'defaulting' on this debt with no effect on the rest of its financial operations. This is in contrast to most debt, where default can have significant negative implications (e.g. cross default clauses). This would seem likely to increase the probability of default relative to these other forms of debt.
- The level of ALF could be revised either up or down. To the extent such revisions reflect changes in the market value of the spectrum, this transfers some of the risk of the underlying cash flows back to Government. This would make the ALF regime lie between the 'debt rate' case and the 'WACC' case.

4.19 In practice, these two factors are likely to be closely linked. For example, if the underlying value of the spectrum fell below the level of ALFs such that MNOs were considering handing back the spectrum, it is likely that they would first petition Ofcom to review the level of ALF to bring it back into line with the market value. Such a review could lower the level of ALFs, thus reducing the returns to Government in line with the reduction in the market returns.

4.20 The ability for ALF to be revised up or down[67] alters the balance of risk between the Government and MNOs compared to a situation where ALFs are set 'once and forever'. At the extreme, if ALFs were revised so frequently that changes in market value were reflected in the fee levels in real time, the ALF would essentially reflect the underlying expected cash flows from the spectrum. This would transfer all of the risk of these cash flows to the Government (since any reduction (increase) in expected cash flows would be reflected in a decrease (increase) in market value of the spectrum, which would immediately feed through to lower (higher) ALFs). As such, the ALF obligation would be much closer to the 'WACC' case described above.

4.21 In practice, our approach to fee reviews is somewhere between these two extremes. While we are setting the level of ALFs by annualising the lump-sum value over a twenty-year period, we are not proposing that twenty years is a fixed period during which no review can take place. We comment on our approach to reviews in Section 6. We currently are not minded to review ALF within the next five years, and thereafter we would be likely to review ALF only if there were grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum.

[67] Given that ALFs should reflect market value, there is likely to be a rationale to revise fees where evidence suggests ALFs are too high or too low, and so we consider it reasonable to assume a symmetric probability of revisions up or down.

4.22 This suggests that the Government could in practice be left sharing the underlying risks of the business for which the spectrum is employed. The discount rate which should be applied to calculate the ALF should therefore reflect the extent to which the Government is sharing this risk. If the WACC represents the discount rate where the Government effectively takes on all risks, and the debt rate represents the discount rate where the operator bears all of the operating risks, other than those normally borne by a lender, the appropriate discount rate could be derived by interpolating between the two polar cases, according to the percentage of risk borne by the Government. Thus the discount rate could be computed as:

$$ALF\ discount\ rate = Debt\ rate + Government\ share\ of\ operating\ risk * (WACC - Debt\ rate)$$

4.23 We illustrate the potential effect this could have on the discount rate in Table 4.1 below, assuming different proportions of risk borne by the Government.

Table 4.1: Illustrative discount rates assuming different levels of risk sharing

Government share of risk	Discount rate
0%	2.6%
20%	3.1%
40%	3.6%
60%	4.1%
80%	4.6%
100%	5.1%

4.24 This suggests that using the debt rate could understate the discount rate it would be appropriate to use if the review regime were significantly to transfer risk from the licensees to the Government. However, there is considerable difficulty in estimating the extent of such a transfer of risk, as this is influenced by the exact mechanism through which fee reviews are instigated,[68] the extent to which a change in value is completely captured by resetting the ALF (particularly given the inherent uncertainty in determining the underlying value) and the symmetry of revisions.

4.25 For the reasons set out above, we recognise that it is possible that the appropriate discount rate lies above the cost of debt. However, for the reasons set out in Section 1 we consider it appropriate to take a conservative approach when interpreting the evidence to derive ALFs. We therefore propose to use the cost of debt rate for the purposes of deriving ALFs, and so use a discount rate of **2.6%** (real, after-tax) in deriving annual fees from our lump-sum value.

[68] For example, a system where reviews are undertaken at fixed intervals regardless of changes in value would have different implications to a system where reviews were only instigated in response to variance in the underlying value. Capturing the implications for risk sharing from this latter system in particular is not straightforward.

Discount rate for benchmark adjustments

4.26 As noted above, a different discount rate is, in our view, appropriate for the other adjustments we make in the context of our international benchmarks. In estimating an adjustment to an auction price for licence duration, we are adjusting for the difference in value an operator would place on having access to spectrum for a shorter (or longer) period. This will reflect the difference in cash flows they expect to earn over (for example) 15 years compared to 20 years. The risk of these expected cash flows should be reflected in this adjustment, and so we consider it is appropriate to use the WACC in adjusting for licence duration.[69]

4.27 The appropriate WACC to use will reflect expectations at the time of the auction (and ideally for each bidder). We have information on a number of different auctions which took place at different times which are affected by this adjustment, and it is not practical to estimate the cost of capital which would have been appropriate for each individual auction and bidder. We set out in the October 2013 consultation that the WACC calculated for the 2011 MCT charge control was a reasonable proxy capturing the systematic risks which would apply to the licences covered by the annual licence fees. This reflected a forward-looking view of the WACC for the MCT charge control which runs from April 2011 to the end of March 2015.

4.28 We also noted that we found no material change in circumstances, for the majority of parameters, from those estimated in March 2011 and the WACC estimated prior to bidder applications being submitted in December 2012 (see paragraphs 5.66-5.74 of the October 2013 consultation). We note that more of the auctions affected by this adjustment were closer in time to 2011 than 2014, and we therefore intend to use the 2011 MCT WACC in adjusting the international benchmarks for licence duration. However, we propose to convert this to a CPI-adjusted real WACC to ensure we are using a consistent measure of inflation throughout.[70] This gives a discount rate of **4.7%** (real, after-tax).

4.29 Incorporating the value of annual fees into the upfront bids for licences is essentially the reverse adjustment we make in annualising the lump sums into annual fees i.e. it converts a stream of fees into a lump-sum present value.[71] The correct discount rate

[69] We set out details of this adjustment in Annex 7.

[70] For the avoidance of doubt, we retain the RPI assumption used in the 2011 MCT WACC (i.e. 2.5%) to derive the nominal WACC, and then deflate this by our CPI assumption (2%). We therefore avoid the error highlighted by respondents to the CPI consultation of retrospectively changing the inflation assumptions. We note that, as a result, we are implicitly incorporating a different wedge assumption in the discount rates for benchmarking (where the difference between RPI and CPI is 0.5%) to that used for annualisation (where the wedge assumed is 1.3%). A wedge of 0.5% was in line with historical averages of the wedge at the time the rates used for the benchmark adjustments were set – the 2011 OBR working paper calculated that between 1989 and 2011 the average wedge was around 0.7 percentage points, and between 2005 and 2011 it was 0.5% (Miller, R (2011), "The long-run difference between RPI and CPI inflation", OBR Working Paper No. 2 http://cdn.budgetresponsibility.independent.gov.uk/Working-paper-No2-The-long-run-difference-between-RPI-and-CPI-inflation.pdf). At this point in time the change in the formula effect which contributes to the wedge was also fairly recent and so it may not have been clear what the long-run effect of this would be. However, there is now greater information as to the size of the wedge in future, not least from the Bank of England's estimate which we use to derive the RPI assumption for the annualisation discount rate (as set out in Annex 10). It therefore seems to us reasonable in the circumstances to incorporate different wedge expectations in the discount rates, given the difference in the time at which they were estimated and the information available at those times.

[71] We set out details of this adjustment in Annex 7.

would therefore be the same as that used for annualisation, although it may reflect expectations from a different point in time. Specifically, as with the licence duration, the summing of annual fees should reflect the view of the discount rate as at the time of the relevant auction. This adjustment affects a number of our benchmark auctions, many of them closer in time to 2011 than 2014. We consider we should be consistent between the dates of the calculation for the discount rates for the two benchmark adjustments. Therefore, as above, we consider the 2011 MCT market review to be a useful point of reference for this purpose. We therefore intend to use the cost of debt derived for the 2011 MCT WACC (but again, as proposed, adjusted for CPI inflation) to adjust benchmark auction results for the presence of annual fees.[72] This gives a discount rate of **2.4%** (real, after-tax).

Tax adjustment

4.30 In our October 2013 consultation we proposed to make a tax adjustment to ensure we levy an appropriate pre-tax ALF, taking into account any difference in the tax treatment of a lump-sum payment and an ALF payment. We noted that the tax treatment of a lump sum and an annual payment would be broadly consistent, but that the tax treatment of annual fees would be more favourable than that of a lump-sum payment due to the ALF incorporating an allowance for the time value of money and adjusting for inflation.

4.31 In response to our October 2013 proposals, stakeholders broadly agreed in principle that we should ensure consistency in the tax position between ALF and a lump-sum payment. However, they argued that we had not considered all of the tax benefits associated with a lump-sum payment. More specifically, stakeholders argued that an equivalent lump-sum payment would be financed with debt, and so would attract a tax deduction for the interest payments on that debt. They argued that this tax deduction should also be included in our adjustment.

4.32 We now consider that for these purposes, the ALF is close to being a form of debt instrument (although it may not exactly reflect the same risk as debt, as discussed above). This implies that the ALF payments displace 100% debt capacity.[73] An equivalent treatment of a lump-sum payment would therefore also assume that the lump-sum payment displaced 100% debt capacity. This does imply that the tax deduction on interest payments for such a lump sum payment needs to be captured. We do this by using the after-tax debt rate to discount the ALF. That is, the tax deduction for interest payments is embedded in the after-tax debt rate, so it is not necessary to make an additional adjustment to the tax adjustment factor (TAF) to allow for this as suggested by stakeholders.

4.33 We have made a number of adjustments to our modelling of the TAF. Rather than using the latest forecasts for corporation tax for each year between 2013/14 and 2015/16 then a constant rate of 20% thereafter, we use a flat rate of 20%. This simplifies the calculation and makes a very small difference only to the resulting ALF. We assume a CPI inflation rate of 2% (as discussed above) and (as before) amortise the lump-sum payment over 20 years. The tax adjustment is calculated from the difference in tax benefits from ALF payments compared to the amortisation tax deductions available through a lump-sum payment, converted to present values

[72] We adopt a simplifying assumption that such fees are fixed and will not be revised, and so the cost of debt is a reasonable discount rate.

[73] Were we to adjust the discount rate so that it was higher than the cost of debt, this would also involve assuming the ALF displaced somewhat less than 100% debt capacity.

using the after-tax discount rate of 2.6% (as discussed above). The TAF is thus calculated as:

$$TAF = 1 + \left[\frac{(PV\ of\ \ tax\ benefits\ of\ ALF\ -\ PV\ of\ \ tax\ benefits\ of\ the\ amortisation\ of\ LSV)}{LSV}\right]$$

4.34 We calculate that the impact of the tax adjustment is equivalent to an increase of 8% in the lump-sum value (compared to 11% in the October 2013 consultation). The full derivation of our ALF proposals incorporates a TAF of this amount.

4.35 We are still considering whether the TAF appropriately captures the tax effects of levying ALFs, and whether there are simpler and more transparent ways of capturing such effects. An alternative, equivalent approach would be to treat the ALF as a standard leasing arrangement and calculate the break-even lease rate where the average efficient operator would be indifferent between buying the asset (i.e. an upfront payment) and leasing (i.e. paying annual fees). The break-even lease payments are determined by:

$$PV\ of\ after\ tax\ lease\ payments + PV\ of\ amortisation\ tax\ benefits = purchase\ price\ of\ asset\ i.e.\ LSV$$

4.36 In such a calculation, all discounting is done at the after-tax debt rate. If a rate higher than the debt rate were used it would similarly be an after-tax rate that would be used to discount the incremental after-tax cash flows arising from switching from a lump sum to ALF.[74] As can be seen from the two equations, the TAF and the standard lease approach both incorporate the same elements (PV of tax benefits of lease payments, PV of amortisation tax benefits, lump-sum value, discounting at the after-tax rate). Our current judgment is therefore that this would not give a different answer than that given by the current approach, but it would show how the TAF arises in a standard discounted cash flow analysis.

Summary of our revised proposals on deriving annual licence fees from lump-sum values

4.37 In summary, in deriving an annual fee from the lump-sum value we propose to:

- spread the lump-sum value of spectrum over 20 years, using an ALF profile that is flat in real terms, that is a 20-year annuity;
- apply a post-tax discount rate of 2.6%;
- take into account the differential tax benefits of the lump-sum value and the ALF; and
- use the CPI index to adjust base year ALF level each year when the licence fee comes due for payment.

4.38 We use the following formula for calculating the base level of ALF from the lump-sum value of spectrum and updating it for inflation. This formula assumes an annuity

[74] Discounting the after-tax cash flows at the after-tax rate is the standard approach to such analysis, as set out in Brearley, Myers and Allen (2014), "Principles of Corporate Finance", 11th Ed., p.648-650.

payment with the payments made at the beginning of the year (as in the October 2013 consultation).

$$ALF_t = LSV * TAF * \left[\frac{r}{1-(1+r)^{-t*}}\right] * \left[\frac{1}{(1+r)}\right] * \left[\frac{CPI_t}{CPI_{t0}}\right]$$

4.39 Where:

- ALF_t is the value of ALF in year t;
- LSV is the lump-sum value of spectrum;
- TAF is an adjustment factor that reflects the tax advantages of ALF over lump-sum payments (equal to 1.08 in this case);
- r is the real post-tax discount rate, i.e. 2.6%;
- t* is the length of period over which we spread the LSV for the purposes of calculating ALF, which is equal to the initial term of the licence, i.e. 20 years;
- CPI_{t0} is the level of the CPI (all items) index in March 2013 and CPI_t is the latest available figure for the same index published in the Consumers Price Inflation Reference Tables by the ONS (further detail as to the exact method of implementing this is set out in Section 6).

Question 3. Do you have any comments on our revised approach to converting our estimate of the lump-sum value of the spectrum into annual fees using a discount rate based on the cost of debt?

Section 5

Our revised proposals on the base level of ALFs

Introduction

5.1 In the previous three sections we set out our assessment of the first three steps of our analytical approach, which we have revised significantly in light of the responses to the October 2013 consultation. In this section we show step 4, setting out our revised proposals for ALFs at full market value using our updated analysis of steps 1, 2 and 3. These estimates form our proposals on the base level of ALFs, i.e. in March 2013 prices. We discuss in Section 6 how the ALFs should be implemented (including indexation for inflation since March 2013).

5.2 The rest of this section:

- Sets out our revised proposals for base level of ALFs.
- Provides a comparison to the earlier proposals in the October 2013 consultation.

Our revised proposals for base level of ALFs

5.3 Using the revised proposals set out above for each of steps 1, 2 and 3 provides the following base levels of ALFs (where these are expressed in March 2013 prices):

- 900 MHz: £1.57m/MHz; and
- 1800 MHz: £0.96m/MHz.

5.4 We consider that the annual fee rate above for each of 900 MHz and 1800 MHz is a reasonable estimate of full market value for the purpose of ALF. These annual fees therefore constitute our revised proposals for the base level of ALFs.

Comparison to proposals in the October 2013 consultation

5.5 To assist understanding in how our estimates have changed since the October 2013 consultation, we show in Table 5.1 a comparison between our estimates for each of steps 1-4 as published in the October 2013 consultation and our revised proposals in this document.

Table 5.1: Comparison of estimates between October 2013 consultation and our revised proposals

	Step 1 (£m per MHz)		Step 2 (£m per MHz)		Step 3 (%)	Step 4 (£m per MHz pa)	
	800MHz	2.6GHz	900MHz	1800MHz		900MHz	1800MHz
October 2013 consultation	£26.85m[75]	£4.95m	£25m	£15m	4.2%	£1.99m	£1.19m
Revised proposals	**£32.63m**	**£5.5m**	**£23m**	**£14m**	**2.6%**	**£1.57m**	**£0.96m**
Effect on ALFs compared to October 2013 consultation	+22%	+11%	-8%	-7%	-14%	-21%	-19%

5.6 Note that, since step 2 uses the results of step 1 as inputs, the percentage changes for step 2 compared to the October 2013 consultation shown in Table 5.1 reflect the combined effect of the revisions to our analysis in both steps 1 and 2. The separate impact of the changes in our preferred values for 800 MHz and 2.6 GHz in the UK (in Section 2) and of the revisions to our analysis of relativities using international benchmarks (in Section 3) is shown in Table 5.2.

Table 5.2: Breakdown of the change in Lump Sum Values

	Lump-sum values in October 2013 consultation	Effect of changes in:			Revised lump-sum values
		UK values of 800 MHz and 2.6 GHz	Benchmark analysis	Both factors together	
900 MHz	£25m / MHz	+22% (x 1.22)	-24% (x0.76)	-8% (x 0.92)	£23m / MHz
1800 MHz	£15m / MHz	+18% (x 1.18)	-21% (x 0.79)	-7% (x 0.93)	£14m / MHz

5.7 Note also that the step 3 comparison shown in Table 5.1 is not an entirely like-for-like comparison of our revised proposals with the October 2013 consultation, and this also affects the step 4 comparisons in the final two columns. The reason is that one of the sources of change between the proposed discount rates in the October 2013 consultation and in this document is the move from the use of RPI to CPI as the measure of inflation for indexation purposes. This change affects the profile of ALF payments over time since, with CPI, they start from a higher base level of ALFs but then increase over time with inflation at a slower rate (because CPI inflation is generally lower than RPI inflation). But, by construction, the move from RPI to CPI is expected to lead to no change in the present value of ALF payments by licensees over twenty years.

[75] In the October 2013 consultation we proposed a figure of £29.85m/MHz, which was gross of expected DTT co-existence costs of £3m/MHz. In this table, to ensure direct comparability of figures, we set out figures for step 1 that are net of expected DTT co-existence costs (i.e. as reflected in bids in the auction) – the corresponding net figure for the October 2013 consultation proposal was £26.85m/MHz as shown above.

5.8 Therefore, in Table 5.3 we show a more direct, like-for-like comparison for steps 3 and 4, by amending the figures shown in the row for the revised proposals purely for the purpose of this comparison. Specifically, in Table 5.3 we show a discount rate for our revised proposals of 1.3%. This is the cost of debt of 2.6% as used in step 3 in this document, but adjusted to reflect RPI, not CPI inflation. The effect of the RPI-based discount rate of 1.3% can then be directly compared to the effect of the RPI-based discount rate in the October 2013 consultation of 4.2%. This allows us to isolate the effect on ALF rates of the other sources of change in the discount rate from the October 2013 consultation (aside from the move from RPI to CPI). These relate to: (i) the change from a WACC to a cost of debt; and (ii) the update of the discount rate from 2011 to 2014. Table 5.3 shows that these changes would, taken on their own, have the effect of reducing ALF rates by 23% (rather than by 14% as in Table 5.1).

Table 5.3: Adjusted comparison of estimates between October 2013 consultation and our revised proposals

	Step 1 (£m per MHz)		Step 2 (£m per MHz)		Step 3 (%)	Step 4 (£m per MHz pa)	
	800MHz	2.6GHz	900MHz	1800MHz		900MHz	1800MHz
October 2013 consultation	£26.85m	£4.95m	£25m	£15m	4.2%	£1.99m	£1.19m
Revised proposals, re-calculated for comparison (discount rate based on RPI not CPI)	£32.63m	£5.5m	£23m	£14m	[1.3%]	[£1.41m]	[£0.86m]
Effect on ALFs compared to October 2013 consultation	+22%	+11%	-8%	-7%	**-23%**	**-29%**	**-28%**

5.9 In the final two columns we show what the base levels of ALFs would have been under the revised proposals if the discount rate had been based on RPI rather than CPI. We reiterate that the re-calculated base levels of ALFs in Table 5.3 are purely for the purpose of comparison with the October 2013 consultation figures, and the base levels of ALFs we are proposing in this document to be paid by the licensees are as set out in paragraph 5.3 and Table 5.1 above. However, Table 5.3 shows that the like-for-like reduction in ALF payments by licensees for the 900 MHz and 1800 MHz spectrum for the revised proposals in this document would be 29% and 28% (respectively) compared to the proposals in the October 2013 consultation.

5.10 In Table 5.4 we show the effects of our revised proposals, as set out in paragraph 5.3 and Table 5.1 above, on the level of payments by licensee.[76] We also include, for comparison, the current level of payments. The reduction in base level ALF payments would be between 19% and 21% compared to the base level ALF payments in the October 2013 consultation. As above, the reduction in the payments of each licensee on a like-for-like basis would be greater at around 28% to 29% compared to the proposals in the October 2013 consultation (allowing for the fact that under the revised proposals the base ALF levels would be increased over time in line

[76] For the purpose of this table we assume that H3G would be paying ALF for 2x15 MHz of 1800 MHz spectrum and EE would be paying ALF for 2x45 MHz of 1800 MHz spectrum.

with CPI inflation whereas, under the proposals in the October 2013 consultation, the base ALF levels would be increased at a higher rate in line with RPI inflation).

Table 5.4: Revised proposals for base level of ALF payments for 900 MHz and 1800 MHz by licensee, compared to current and proposed base payments in the October 2013 consultation (in £m per annum)

	Vodafone	Telefónica	EE	H3G	Total
Current	£15.6m	£15.6m	£24.9m	£8.3m	£64.4m
Proposals in October 2013 consultation	£83.1m	£83.1m	£107.1m	£35.7m	£308.9m
Revised proposals in this document	**£65.8m**	**£65.8m**	**£86.4m**	**£28.8m**	**£246.7m**
Ratio to Current	4.2	4.2	3.5	3.5	3.8
% change vs October 2013 consultation proposals	-21%	-21%	-19%	-19%	-20%

Section 6

Implementation

Introduction

6.1 This section sets out how we are minded to implement the revised fees, including:

- having a common date for introduction of revised ALF;
- the choice of common effective date and phasing-in revised ALF;
- calculating the first year's payment of revised ALF following the common effective date; and
- implementation of inflation indexation.

6.2 We also set out our current position on future reviews of the level of ALF.

Having a common date for introduction of revised ALF

6.3 In the October 2013 consultation we noted that the licences have different fee payment dates, reflecting the difference in the dates on which the licences were initially granted (28 February for EE, 31 July for Vodafone and Telefónica and 31 October for H3G). We considered whether for reasons of fairness as between the licensees the revised ALF should be introduced on a date that was common to all of the licensees, rather than an introduction that produced a 'staggered' effect because of the different fee payment dates. We identified two ways in which we could implement a common date:

- change the payment dates applying to the licences so that they are identical ("common actual payment date"); or
- adjust the size of fee payment in the first year following the common date, so that each licensee makes payments over a period of time that are effectively equivalent ("common effective date").

6.4 We proposed to use a common effective date to achieve a common implementation across the licensees, by adjusting the payment in the first year following the common date so that each licensee's first payment following the common date would be made up of two sums:

- the revised ALF applied to the licensee's spectrum holdings; plus
- a sum equal to the difference between the revised ALF and current ALF, pro-rated in relation to the number of months between the common effective date for the introduction of the revised ALF and the licensee's payment date (referred to in this section as the "deferral component").

6.5 In their responses, the MNOs agreed with the proposal that the new ALF rates should take effect at the same point in time. They also made a number of points raising legal arguments on the options we set out in the October 2013 consultation for achieving a common implementation date.

6.6 In relation to our proposal to have a common effective date, a number of the responses challenged the legal basis for what we describe above as the deferral component. They argued, variously, that it would be inconsistent with the respondents' claim that licence fees are "paid in arrears"; that it amounted to charging for more than one year of fees; that it required operators to pay twice for one payment period; and that it would be disproportionate. We discuss these points below.

6.7 We do not agree that payments under the Wireless Telegraphy (Licence Charges) Regulations 2011 (the "Fees Regulations") are made "in arrears". These payments are not characterised under the Fees Regulations as payments in advance or payments in arrears. The Fees Regulations require licensees to make payment of the amount specified in the Fees Regulations at 12-monthly intervals (following the first payment obligation at the time the licence was issued). This payment is due on the last day of each interval of 12 months, and is payable only if a licensee holds the licence on that specific date. In other words, the requirement to pay such fees does not depend on whether the person holding the licence on that day was entitled to use the relevant frequency bands in the previous year, or whether this person will have the right to do so for the following year.[77]

6.8 We also do not agree that the "deferral component" would amount to charging for more than one year of fees, or paying twice for one payment period. The deferral component, as set out in the October 2013 consultation, simply reflects the fact that (under this proposal) there would be a gap of time between the common effective date and each licensee's payment date.

6.9 In relation to our comment in the October 2013 consultation that we could achieve a common implementation date by changing licensees' actual payment dates, one respondent said that changing the licence fee payment date would be a licence variation which would require the consent of the licensee. We do not agree with this. The times at which licence fees must be paid to Ofcom are prescribed by regulations made under section 12 of the Wireless Telegraphy Act 2006, and the mechanism for changing these times is to make new regulations under that section.

6.10 We said in the October 2013 consultation that we recognised that changing the payment dates applying to the licences so that they are identical (i.e. having a common actual payment date) may be unnecessarily disruptive to licensees, recognising that arrangements for licence fee payments under these licences are of longstanding duration. However, since then we have considered further how we would implement our proposal to increase ALF each year in line with inflation (see further Section 4 of this document and paragraphs 6.22-6.25 below). We now consider that it would be better to move licensees to a common actual payment date as the way to ensure consistent treatment between the licensees. It would simplify the regulations and their implementation by comparison with the alternative of having to specify and implement different inflation adjustments across the year (to reflect different licensee payment dates). However, recognising that changing the fee payment date may cause some disruption to licensees, we don't think we should do this at the same time as we introduce revised ALF.

[77] For the avoidance of doubt, the relevant licences have an indefinite duration as they remain in force until revoked by Ofcom or surrendered by the licensees. Therefore, 12 months corresponds to the length of the payment interval (i.e. how often fees become payable), rather than being a "licensed period" or "term", as some respondents have characterised it.

6.11 We are therefore minded to have a common date for the introduction of revised ALF, and we think that it would be pragmatic, fair and reasonable to implement this common date by:

a) setting a common effective date for the introduction of revised ALF with each licensee's payment date remaining as it currently stands for payment of the first ALF following this common effective date; and

b) after the first payment of revised ALF, for subsequent ALF payments to be made on a common actual payment date (i.e. by changing each licensee's payment date so that they are all on the same date). We propose that the common actual payment date would be the first anniversary of the common effective date.

The choice of Common Effective Date ("CED") and phasing-in the revised ALF

6.12 We said in the October 2013 consultation that we proposed to set the common effective date to be the first day of the month following the new fees regulations coming into force, and that we did not propose to phase-in the revised ALF.

6.13 A number of respondents (including the MNOs and Prospect) argued in their responses to the October 2013 consultation that there was a case to phase in the new fee rates over time and that we should consider the impact of different lengths of phase-in on investment, notably the deployment of 4G networks. Some of the responses drew attention to other cases where increased fees have been phased in over time.

6.14 We have considered these arguments carefully. We are conscious that a significant period of time has passed since the Government direction was made in December 2010, and since the conclusion of the UK 4G auction in March 2013. Taking that into account, in light of these responses we think that a fair and reasonable approach for us to take is to set a common effective date as soon as practicable after the new fees regulations come into force, with a two-stage phase-in of revised ALF. This phase-in would consist of the following (abstracting from indexation for inflation for simplicity):

- one half of the increase (from the current ALF rate to the proposed new ALF rate coming into effect on the CED; and

- the second half of the increase becoming effective one year later (which as set out above would be the common actual payment date). From this date ALF rates would be at the proposed revised level.

Calculating the first year's payment of ALF following the CED

6.15 In this sub-section we set out how we propose to calculate the first year's payment of ALF following the CED, using for illustration 31 January 2015 as the CED and 31 January 2016 as the common actual payment date. (We do not deal in this section with adjusting for inflation; this is covered in the next section.)

6.16 We propose that each licensee's first year's payment of ALF following the CED would be made up of the following components:

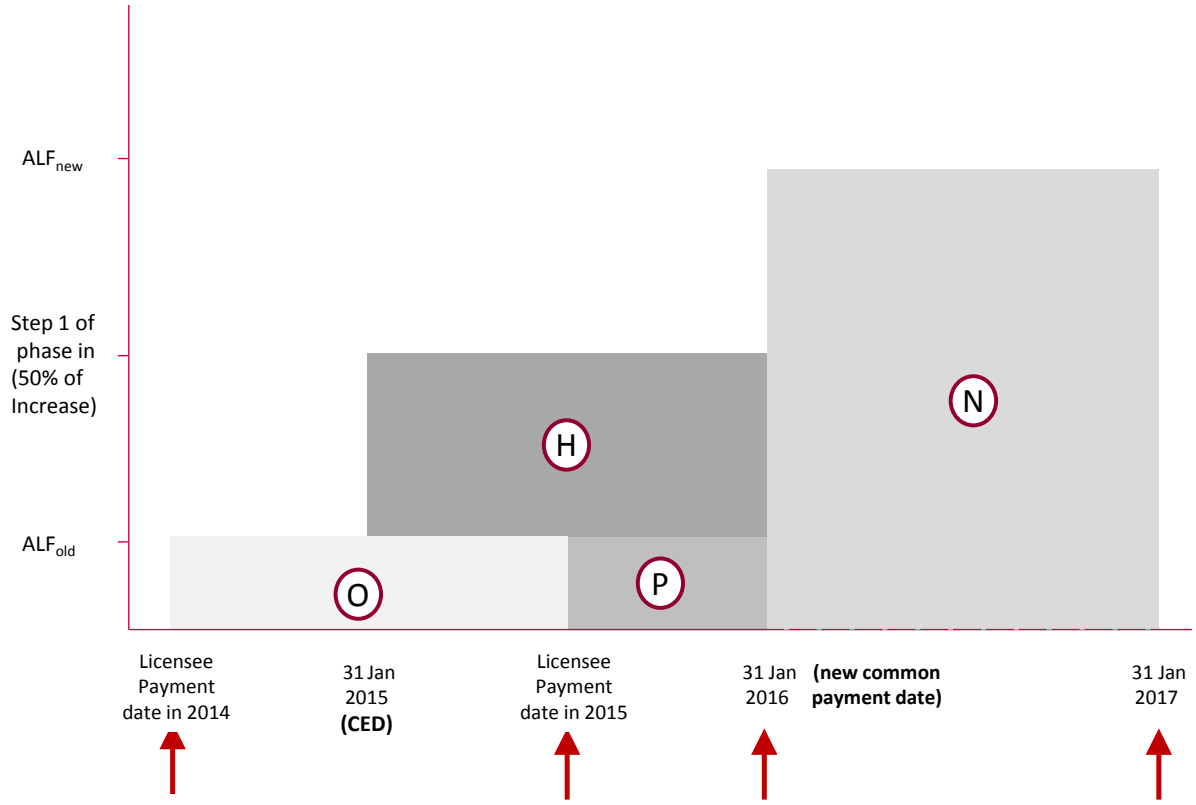
- a sum equal to 50% of the increase in ALF (i.e. half of the difference between the revised ALF and the current ALF) applied to the licensee's spectrum holdings; plus

- a sum equal to the current ALF, pro-rated in relation to the number of months between the licensee's payment date and the common payment date.

6.17 The reason for expressing the payment obligation in this way is explained below. It is essentially the same approach as we proposed in the October 2013 consultation[78], adjusted to reflect our new proposals to have a two-step phase-in of revised ALF over two years, and to move to a common actual payment date. This is the approach that we have adopted in the draft fees regulations in the Notice published alongside this consultation.

6.18 Figure 6.1 below illustrates how this proposal would apply. The arrows indicate the licensee's payment dates. The dates in 2014 and 2015 reflect the annual payment date under current arrangements. The payment date then moves to the new common actual payment date (31 January) from 2016.

Figure 6.1: Illustration of payment obligations (£m per MHz)



6.19 In this figure, the area "O" represents the amount of the licensee's ALF payment obligation that became due on its annual payment date in 2014 at the current (or "old") rate of ALF.

6.20 The area "N" represents full revised ALF, which would be applied at the new common payment date on 31 January 2016.

[78] Paragraphs 6.13 and 6.14 of the October 2013 consultation.

6.21 The licensees' first payment following the CED (due on the 2015 payment date) is represented as the combined area of "H" and "P". "H" represents 50% of the increase in ALF (from the "old" rate of ALF to the new revised rate), in line with our proposal to phase-in revised ALF over two years; this is the component in the first bullet in paragraph 6.16 above. "P" is the current ("old") rate of ALF, pro-rated on a monthly basis for the period between the licensees' payment date to the new common payment date; this is the component in the second bullet in paragraph 6.16 above.

Implementation of inflation indexation

6.22 We set out in Section 4 how we are minded to take account of inflation in setting ALF. Here we provide more detail on how we are minded to implement the inflation indexation.

6.23 The formula for calculating each year's ALF (ALF_t) at the end of Section 4 incorporates the proposal to increase ALF each year in line with inflation as measured by the CPI index. In particular, the nominal value of ALF is inflated by the ratio:

$$\left[\frac{CPI_t}{CPI_{t0}}\right]$$

Where CPI_{t0} is the level of the CPI (all items) index in March 2013 and CPI_t is the latest available figure for the same index published in the Consumers Price Inflation Reference Tables by the ONS.

6.24 In practice, the latest available CPI index figure at any time is likely to be two months old because inflation data related to each month is usually published by the ONS between the 15th and the 20th of the following month. For example, if the new regulations are made in January 2015, then the latest available CPI index that we could use at the time we make the regulations is likely to be the index for November 2014, which should be published by the ONS between 15 and 20 December 2014. Under our revised proposals, we would then use the November 2014 CPI index to adjust the base level of ALF (before deducting the current ALF rate and calculating the size of the 50% increase at the CED) in order to derive the amounts that will be specified in the new fee regulations for the first payment obligation of each licensee following the CED[79].

6.25 Similarly, the ALF rates for the 31 January 2016 payment date would be defined in the regulations by a formula which adjusts from March 2013 prices using the CPI index for November 2015 (with each subsequent 31 January payment date being inflated by the CPI index from the previous November).

[79] We recognise that this may produce the effect that licensees could, for their first payment following the CED, pay levels of ALF that are slightly different from each other when expressed in real terms (if the level of inflation is different between when ALF is set and the different dates for payment of ALF in the first year following the CED). An alternative which would mitigate the potential for this effect is to do a separate indexation adjustment for each licensee, calculated as near as possible to the licensee's payment date. However, taking account of the fact that this effect (were it to arise) would only affect the first year's payments, and noting that payments in the first year are at a reduced level under our phase-in approach, our view is that the approach set out above is reasonable and proportionate.

6.26 The draft fees regulations in the Notice published alongside the consultation set out the formula that would be used to derive inflation-adjusted ALF rates for the fees due on the CED and subsequently for the fees due on the common actual payment date.

Future Review of ALF

6.27 The October 2013 consultation proposed that the revised fees should be introduced for an indefinite period and should not be time limited. We invited views on the period during which we would not expect to carry out a further review of the ALF rates. The suggestions in response ranged from a minimum of 3 years (H3G), to a period of five to ten years (EE) and up to 20 years (Prospect). Vodafone did not suggest a specific length of time but suggested that there would be a benefit of setting spectrum fees for the longest possible time.

6.28 While we note that we cannot bind ourselves in advance as to the decisions we may take in the future on the exercise of our powers to revise spectrum fees, we consider that there would be a benefit in some period of certainty for licensees. We currently are not minded to review ALF within the next five years, and thereafter we would be likely to review ALF only if there were grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum, in keeping with our general policy on fee reviews as set out in the Strategic Review of Spectrum Pricing.