An Coimisiún um
Rialáil Cumarsáide
Commission for
Communications Regulation

DotEcon Limited on the Award of Licences for the use of Radio Frequencies in the 400 MHz band

A report for ComReg

Reference: ComReg 18/92a

Date: 24/10/2018

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Award of licences for the use of radio frequencies in the 400 MHz band

Prepared for ComReg

October 2018

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1 Introduction

ComReg is preparing the award of licences for the use of radio frequencies in the range 410 – 415.5 MHz paired with 420 – 425.5 MHz (a sub-band of the 400 MHz band). It has appointed DotEcon as its advisor for the design of the award.

In this report we consider the key issues for this award and recommend an appropriate approach to assigning licences for the use of these frequencies in line with ComReg's statutory objectives.

ComReg published a consultation on the proposed release of the 400 MHz band in July 2017 (hereafter 'the Consultation'), which explored possible uses for the available spectrum.[1] The responses to this Consultation suggested that the optimal use and assignment of the frequencies available is uncertain at present, with interested parties presenting a variety of views about the likely uses and appropriate licence bandwidth.

ComReg has also recently commissioned a study by Plum Consulting (hereafter 'the Plum report[2]') to look at potential uses of the 400 MHz spectrum. This report takes into account both the responses to the Consultation and the Plum report.

The Plum report highlights a number of potential uses for this spectrum, but singles out smart grids as the prime candidate. Smart grids are dedicated, high reliability and low latency networks for monitoring and control of utility networks. A smart grid could provide a more flexible

[1] ComReg, 'Consultation on Proposed Release of the 410-415.5 / 420-425.5 MHz sub-band', ComReg 17/67, 31 July 2017

[2] ComReg Document 18/92b Plum Consulting London LLP - Potential use of the 400 MHz band in Ireland

alternative to running fixed network infrastructure to remote sites needing links back to central control and monitoring facilities.

Summary of recommendations

Most importantly, Plum concludes that there is no other suitable spectrum available in the medium term for smart grid, whereas the other potential uses identified for this band do have alternative options. However, smart grid deployment does not require all of the available spectrum, with 2x3 MHz likely to be sufficient. Therefore, smart grid could potentially coexist with other uses referred to in the Plum report. For these reasons, we recommend using an auction process for the assignment of spectrum, reserving some of the spectrum for smart grid but assigning the remaining spectrum with as much flexibility as possible given the potential uses. This should facilitate an outcome where qualifying smart grid operators have access to sufficient spectrum, with the remaining frequencies assigned to those users who value them most.

We consider there is benefit to awarding the spectrum in two sequential auctions, starting with the frequencies reserved for smart grid, with a follow-up auction for the remaining spectrum (including the smart grid spectrum if not assigned in the first award) offered in duplex blocks suitable for NB-IoT users. This means that it is possible to resolve the demand for the smart grid spectrum before determining winners for the remainder. This approach is simple, and also helps to avoid any risk that a smart grid operator could use the spectrum reservation to leverage an advantage on winning additional frequencies.

Given the likely uncertainty over the value of the spectrum and the lack of experience with auctions of some of likely participants, we believe there would be a risk of an inefficient award outcome if a sealed-bid format were to be used. We therefore recommend an auction format with an open stage that allows bidders to respond to the bids of others and revise their valuations during the process. An open format means that a bidder who is outbid can choose whether to accept the current outcome or continue to compete in response to the demand from other bidders. In contrast, a sealed bid auction does not provide any opportunity to respond to the bids submitted by other and runs the risk that inexperienced bidders could make errors in determining their bidding strategy from which they would not be able to recover.

Finally, on the basis that some (or all) participants in the award are likely to have very limited experience with spectrum auctions, we propose keeping the auction rules as simple as possible, subject to avoiding any detriment to the efficiency of the award process.

In light of the above points, our recommendation is to award the spectrum via **two sequential clock auctions**:

- the first clock auction would include a single 2x3 MHz block reserved for smart grid;
- the second clock auction would include all of the remaining spectrum offered in 2x100 kHz lots (including the smart grid spectrum if it goes unsold in the first auction, broken down into these smaller blocks).

In the first auction, bidders would need to indicate whether or not they bid for the single lot at the price posted by the auctioneer; once a bidder had dropped out, it could not bid again for that portion of the band. In the second auction, bidders would indicate how many lots they wanted at a price per lot posted by the auctioneer; as this price rose, the number of lots demanded by a bidder could not be increased.

We recommend the use of exit bids to help minimise the risk of an inefficient outcome due to overshoot (where prices are increased beyond the market clearing level and some spectrum is left inefficiently unsold) and to give better options for packing winning bids into the available spectrum to reduce unsold lots. Exit bids give an option for bidders to make bids at price levels intermediate between round prices when they reduce demand.

After the two auctions, a follow-up assignment stage would be run to establish the specific frequencies to be awarded to winning bidders. For this we recommend using a process of random selection, on the basis that we are not aware of any material value differences across the frequencies available and any winner of the reserved portion would be assigned lots contiguous with lots won in the second auction.

Structure of this report

The report is structured as follows:

- Section 2 sets out the background to the award, how the spectrum might be used and the current market situation;
- Section 3 discusses the proposal to reserve some of the spectrum for a smart grid network and whether there is any need for measures to safeguard competition, such as competition caps on the number of blocks that can be acquired by any one bidder;
- Section 4 briefly discusses non-technical aspects of licence conditions, including the licence duration and the need for any usage restrictions;
- Section 5 considers sets out our proposals for how to define the lots offered in the award;
- Section 6 provides our recommendations on spectrum fees and the application of minimum prices;
- Section 7 assesses alternative designs for the award process; and

- Section 8 provides a brief summary of our recommendations.

2 Background

Spectrum available for the award

ComReg is proposing to award licences for a total of 2x5.5 MHz of paired spectrum, in the duplex frequency range 410–415.5 MHz / 420–425.5 MHz (hereafter "400 MHz spectrum"). These frequencies are currently unused.

ComReg's objectives

ComReg's primary objectives in carrying out its statutory functions in the context of electronic communications are to:

- promote competition;
- contribute to the development of the internal market;
- promote the interests of users within the Community;
- ensure the efficient management and use of the radio frequency spectrum in Ireland; and
- unless otherwise provided for in Regulation 17 of the Framework Regulations, take the utmost account of the desirability of technological neutrality in complying with the requirements of the Specific Regulations, in particular those designed to ensure effective competition.

Specifically, with regard to the assignment of licences for the use of radio spectrum, ComReg's key objectives are:

- to achieve an efficient allocation and to ensure that the spectrum is subsequently used efficiently;
- to grant licences on the basis of selection criteria that are objective, transparent, non-discriminatory and proportionate; and
- where a competitive procedure is to be used, to ensure that such a procedure is fair, reasonable, open and transparent to all interested parties.

Potential uses and demand for the spectrum

The 400 MHz spectrum has good propagation characteristics and is potentially useful for a wide range of applications. It is currently not subject to any EU Harmonisation Decision for a particular service or technology. From the responses to Consultation, there is some diversity in views about the potential users of the spectrum in Ireland (see Box 1 below).

ComReg intends to award the spectrum on a technology-neutral basis, with the least restrictive possible technical conditions. In its consultation on the proposed release of the 400 MHz spectrum, ComReg set out its preliminary views on the likely uses, including:

- Smart metering;
- Smart grid;
- Broadband Public Protection and Disaster Relief (BB-PPDR); and
- other potential uses such as DMR / TETRA Enhanced Data Services (TEDS).

Responses suggest that there is widespread support for using the band for smart grids, but there are diverging views on the potential use case for TETRA, PPDR, smart metering, other IoT applications and mobile communications.[3] A few responses also expressed the view that the band should not be made available exclusively for a single use.

Box 1: Summary of responses in relation to potential use of the frequencies

Smart grids

None of the respondents disagreed with ComReg that the spectrum proposed for award is suitable for the use of smart grids. However, several respondents pointed out that making the band exclusively available to the use of smart energy grids/meters is not appropriate.

Smart metering

Most respondents agreed with ComReg that the 400 MHz band is suitable for smart metering. However, two respondents pointed out that other bands might be more suitable for this. One respondent stated that, compared to the 400 MHz band, the 800 MHz band has

[3] See the responses to the Consultation, as set out in ComReg Document 17/105s.

significantly higher site density, allowing greater performance and making it more cost effective.

PPDR

The 410-430 MHz band was, amongst other frequencies, considered by the ECC Report 218[4] as a candidate band for the harmonization of BB-PPDR services. ECC Decision (16)02[5] subsequently sets out the parts of the 400 MHz and 700 MHz bands the ECC ultimately considered should be used for BB-PPDR. It highlights that while the 400 MHz range does not offer enough available spectrum to provide a standalone solution, it can offer national flexibility (alongside 700 MHz and other bands) In particular, the Decision specifies that in CEPT countries that wish to introduce BB-PPDR in the 400 MHz band, this should be with channelling arrangements 1.4 MHz, 3 MHz or 5 MHz in the paired frequency ranges:

- 450.5-456.0 MHz (uplink) / 460.5-466.0 MHz (downlink); and
- 452.0-457.5 MHz (uplink) / 462.0-467.5 MHz (downlink).

This ECC Decision explicitly excludes the frequencies that ComReg is seeking to award, on the basis that (at the time) the technical studies on the 410 – 430 MHz sub-band were incomplete.

The ECC highlights:

- potential issues with compatibility with existing radar systems operating in 420-430 MHz;
- potential compatibility issues between BB-PPDR and radio astronomy stations operating in the 406.1 – 410 MHz band; and
- a lack of corresponding standardisation activities in other organisations (such as 3GPP and ETSI).

ComReg indicated in the consultation document that, although there may be interest in using this band for BB-PPDR, it does not consider spectrum in the 410 – 430 MHz range to be suitable for such services.

[4] ECC Report 218, 'Harmonised conditions and spectrum bands for the implementation of future European Broadband Public Protection and Disaster Relief (BB-PPDR) systems', October 2015

[5] ECC Decision (16)02, 'Harmonised technical conditions and frequency bands for the implementation of Broadband Public Protection and Disaster Relief (BB-PPDR) systems', 17 June 2016

Several respondents disagreed with ComReg's view on the use of PPDR in the 400 MHz band. It was put forward that the band is used for public safety applications in several member states.

However, there were an equal number of respondents who agreed with ComReg's view that PPDR might be best served by other bands, as in other EU countries. In particular spare frequencies the 380-390 MHz band can be used to expand the current system, whilst a new PPDR allocation would be best in frequencies more likely to be harmonised internationally. Some respondents indicated that higher bandwidth PPDR applications will in the future be supported by LTE based technologies, such as ESN networks in the UK.

TETRA/PMR/ DMR

Almost all respondents agreed with ComReg's view that TETRA, PMR and DMR do not represent the best use of the proposed frequencies. It was put forward that enabling TETRA/DMR and PMR in this band is not necessary, as PPDR and other industries are looking to move away from these legacy technologies. However, one respondent argued that it is not necessary to limit use and that TETRA is being used in the 400 MHz band in other countries.

Other IoT applications

Some respondents have noted that Smart Energy is only one of the possible IoT applications. Respondents suggested that focussing on Smart Energy in this band may lead to inefficient allocation. Instead other potential IoT uses should be considered, as it is likely that NB-IoT will be widely adopted in this band. One respondent goes further and proposes a dedicated National IoT network to support critical applications in industries such as health, industrial and energy.

LTE deployment

Several respondents indicated that there will be need for deployment of LTE in wider spectrum bands for greater efficiency. In particular for Smart Energy or other IoT applications this is considered by one respondent to bring economic benefits.

Other possible uses had also been proposed in the responses to ComReg's Draft Radio Spectrum Management Strategy[6]:

[6] ComReg Document 15/131 Consultation on Radio Spectrum Management Strategy 2016 to 2018 - published 14 December 2015

- Motorola proposed that the spectrum could be used for transition from analogue to Digital Mobile Radio (DMR) and TETRA platforms for professional voice and data communication services, and for introducing TETRA Enhanced Data Services (TETRA-TEDS).
- Sigma Wireless has asked ComReg to make the spectrum available for services such as PMR Radio, DMR Radio and Trunked DMR radio, and TETRA-TEDS (as well as smart metering and/or smart grid).

Key findings by Plum Consulting

A study for ComReg by Plum Consulting supports the general view that there are multiple potential uses, but clearly identifies smart grid as the most likely and suitable candidate:

- Plum considers that there is a clear potential and rationale for using the spectrum for a smart grid network, and there is currently no alternative spectrum that could be used for this in the medium term.
- Whilst in theory it might be possible to run a smart grid network on the existing network of an MNO, a dedicated network is likely to be more suitable as mobile networks may not be able to meet the availability, reliability and coverage requirements.
- There is support in the responses to the ComReg consultation for using the 400 MHz spectrum for electricity smart grids, and Plum believes that other utilities (such as gas and water) may also find the prospect of such a network attractive.
- Depending on the demand from other utilities, the spectrum could be used for a specific smart grid network, a more general network for all utilities, or a very general network for utilities plus other entities (such as PPDR). However, they currently find little evidence of any demand outside of the utilities for the

sort of dedicated, feature-rich, high reliability network that would be required for smart grid.

- Depending on the technology used (most likely LTE), a smart grid network would likely require 2x3 MHz of the spectrum. A smart grid network may be operated by the electricity companies, all utilities, or a third party.
- Alternative frequencies in other bands are available for smart metering and general purpose IoT networks, in particular in bands used for this in other countries (such as 800 MHz and 868 MHz) which would therefore offer benefits from economies of scale and better roaming capabilities. Smart metering solutions have already been deployed in Ireland (NB-IoT in licensed bands, and Sigfox in unlicensed bands) and there is no current indication of the need for further options. For these reasons, Plum does not believe there will be significant demand for the 400 MHz spectrum for such uses, although demand from NB-IoT applications may depend somewhat on how the offerings of existing options develop and the emergence (or not) of compatible terminal equipment.
- Demand for PMR licences is unlikely to increase beyond what can be met with the currently available spectrum.
- Demand from emergency services for PPDR is unlikely as alternative solutions have been (or are being) identified, with spare frequencies available in the 380-400 MHz band for expanding current systems, and the 700 MHz centre-band more likely to be suitable for deployment of a next-generation system.
- It is unlikely that MNOs will be interested in the spectrum for commercial mobile services or FWA, but they may wish to use it for the provision of other networks.

Previous/current use of the band

In 2005, ComReg offered two 2x2 MHz licences for the use of frequencies in the range 410–414 MHz / 420–424 MHz, alongside a single licence for the use of 2x4 MHz in the 900 MHz band. The licences were allocated on a national basis for the provision of Wideband Digital Mobile Data Services (WDMDS) with a licence term of 10 years.[7]

There was excess demand for all three licences on application, so the licences were awarded via auction (using a sealed bid auction). The winners in the 400 MHz band were Wirefree Communications and Mobisof,[8] and in the 900 MHz band Digiweb.

However, no commercial services were provided using these licences, which expired in December 2015. Since then, the 410–414 MHz / 420-424 MHz spectrum has remained unallocated.

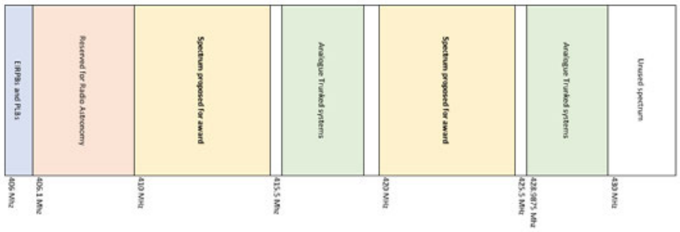
Currently, the closest spectrum allocations to the frequencies proposed for the award are:

- the range 406-406.1 MHz, used for Emergency Position Indicator Radio Beacon (EPIRBs) and Personal Locator Beacons (PLBs) services;
- the range 406.1–410 MHz, reserved for Radio Astronomy; and
- the range 415.7750–418.9875 MHz / 425.7750–428.9875 MHz, used for Analogue Trunked Systems.

[7] S. I. No. 642 of 2005

[8] The Mobisof licence was subsequently transferred to Wirefree Communications in 2006, when Wirefree was acquired by Nordisk Mobiltelefon AB.

Figure 1: Current frequency assignments in the 400 MHz band



3 Smart grid reservation

3.1 The case for a smart grid reservation

The Plum Report provides strong evidence that it would be efficient for at least part of the available spectrum to be used for deployment of a smart grid.

Justification for a smart grid reservation

Both the consultation responses and the Plum report highlight smart grid as a key potential use of the spectrum, with Plum stating that smart grid "*might be a best use of part or all of the band.*" A smart grid is likely to have a high social value relative to alternative uses of this band. In part, these benefits arise by creating efficiencies within the deployment of energy grids, lowering cost and providing greater flexibility as compared with alternative means of providing monitoring and control of infrastructure. These benefits should be reflected in a smart grid provider's willingness to pay for spectrum. However, there are also likely to be significant external benefits, as smart grids may be an enabler for greater use of renewable generation and energy storage technologies that are important for decarbonisation. There are no alternative frequencies that could be used for smart grid in the medium-term. Therefore, this band is the only opportunity in the foreseeable future to establish a wireless smart grid network in Ireland.

Other potential uses have been identified, although there would seem to be limited demand from these for the 400 MHz spectrum. Most importantly, these all have alternative frequencies available in different bands. Therefore, it is reasonable to conclude that it is likely to be efficient for at least part of this band to be used for smart grid.

The question then arises whether it is better to:

- design an award process in which there could be competition for spectrum between various potential users on a neutral basis; or
- make a reservation of spectrum for smart grid.

ComReg has made wide use of market mechanisms in other award processes. Uncertainty about the efficient allocation of spectrum means that, even if a leading candidate use has been identified, it is usually desirable to provide flexibility for bidders with various different uses to compete for spectrum. However, the particular circumstances of this award create significant risks from this typical approach.

Need for restricting potential users

There is only sufficient spectrum in this band for one smart grid deployment. According to the Plum report, the minimum amount of spectrum required for a smart grid network is likely to be 2x3 MHz, with 2x5.5 MHz available in total. Given the findings of the Plum report that there does not appear to be any effective alternative spectrum for smart grid provision, opening up this spectrum to all-comers risks monopolisation, as whoever buys the spectrum would be sole provider of smart grid services to the likely users (i.e. the utilities).

Such an outcome would be contrary to the objection of ensuring efficient allocation and use of the spectrum. This would distort any auction, as there would effectively then be competition to secure such a monopoly supply position and spectrum prices could be artificially inflated by competition for monopoly rents. To the extent that the available spectrum could be shared between smart grid and other users, this might also lead to inefficient exclusion of other users.

Therefore, we recommend that reserved spectrum for smart grid is made available only to a qualifying utility. This does not necessarily preclude others from using the spectrum to deploy a smart grid network. The Plum report suggests that it would be possible for a third party to operate a smart grid network on behalf of the utilities. For example, a particular third party could deploy a high-reliability network for the utilities and potentially other sharers. However, the spectrum usage rights underpinning a smart grid service would remain in the hands of a qualifying utility, who could then procure or self-provide the necessary network infrastructure, or even lease the spectrum to a third party.

We note that it would not be sufficient to simply restrict use of the part of the spectrum to smart grid provision (with the spectrum available to any award participant). This would still create the problem of creating a monopoly provider of smart grid services.

3.2 Scale of any reservation for smart grid

2x3 MHz seems an appropriate bandwidth to reserve

Plum has identified 2x3 MHz as being the minimum requirement for a smart grid network. Although we see a good case for reserving sufficient spectrum for qualifying utilities for smart grid deployment, the whole band does not need to be reserved.

The remaining spectrum can be service and technology neutral

The remaining 2x2.5 MHz could be made available for other uses in a service and technology neutral manner. We discuss packaging of this open spectrum to support the most likely potential uses in Section 5 below. This approach would allow a winner of the smart grid reservation to acquire additional open spectrum, but the smart grid winner would need to compete with other bidders.

In the event that there was no interest from any qualifying bidder for the smart grid reservation, then the full 2x5.5 MHz could be made available as open spectrum in a service and technology neutral manner.

3.3 Downstream competition and competition caps

Most award processes require consideration of how spectrum holdings may affect downstream market structure, and of whether any competition caps or other forms of competition-promoting measures are appropriate.

Only one smart grid operators feasible

Smart grid requires 2x3 MHz, so there is insufficient spectrum within the award to set competition caps that would promote multiple smart grid operators in the downstream market and alternative spectrum does not appear to be available. For this reason, we have proposed the exceptional step of reserving spectrum for qualifying utilities to avoid creating severe future competition problems.

No need for spectrum competition caps

Open spectrum not reserved for smart grid could be used for a variety of applications and with a range of alternative technologies, each with varying spectrum requirements. However, Plum considers that there is likely to be limited demand for the spectrum available in this award for these applications, whilst there are frequencies available in other bands offering (likely preferable) alternatives for each of them. For these reasons it there appears to be little reason for concern over how the open spectrum might be awarded causing problems for competition in any of the potential downstream markets that might be served.

Even without specific concerns about downstream competition being undermined by a winner taking too great a share of a spectrum band, sometimes prudential spectrum competition caps may be set to ensure that one operator cannot acquire all of the available frequencies. However, we see no role for such competition caps in this case. The potential uses of the spectrum have a wide range of bandwidth requirements, and Plum have identified use cases that would require the majority (or all) of the open spectrum.

Even in the event that there is no interest from a qualified utility for smart grid and all of the spectrum is made available on a service and technology neutral basis, the different minimum bandwidth requirements of the various potential uses could still span the majority of the available 2x5.5 MHz. Therefore, it is not feasible to set such a spectrum competition cap in this award without precluding some potential uses.

Furthermore, we see no competition grounds for preventing a winner of the smart grid reserved spectrum from also acquiring open spectrum. For example, a smart grid operator may wish to expand into the unreserved spectrum to support deployment of other applications in the future, such as video surveillance.

3.4 Summary of recommendations

Summary recommendation

There are strong arguments to suggest that a portion of the spectrum should be used for the provision of a smart grid network. We propose a reservation of 2x3 MHz for that specific use that would be available only to a qualifying utility. We have not identified any significant concerns about competition in the downstream market and propose that the spectrum is offered without spectrum competition caps so as to avoid unduly precluding some potential uses.

4 Licence conditions

4.1 Licence duration

15-year licence terms seem appropriate

The Plum report highlights that potential use cases and networks have an expected life cycle of 15 years or more (noting that scanning telemetry was installed in the UK for the utilities 20 years ago). In addition, it notes that PPDR and smart grid networks have high deployment costs, which would suggest a reasonable licence duration is required to allow for sufficient return on investment. Plum is of the view that licences should be for at least 15 years.

A 15-year licence term would be consistent with other licences issued by ComReg, and is supported by most respondents to the Consultation who believe that a 15-year licence would be in line with the asset life of infrastructure, and would be appropriate to support the required investments. Some respondents believe that the life cycle of required assets could be less or more than fifteen years, with approximately the same number of responses on either side.

In light of the findings of Plum and the responses, we consider that a licence duration of fifteen years appears appropriate and is aligned with expected life cycle of assets.

4.2 Usage restrictions

Usage restrictions required for the smart grid spectrum

As discussed above, we would recommend that 2x3 MHz of the spectrum made available only for the operation of a smart grid network, and awarded only to a qualifying utility (if there is demand). This will require specific conditions to be attached to the smart grid licence regarding the services to be provided and the users by whom the spectrum usage right may be held.

In the event of any proposed transfer of the smart grid licence, these restrictions would need to continue to apply. In the event of any leasing of the spectrum, a smart grid network could be provided by the leaseholder, but the restriction on the usage of the spectrum for smart grid would need to be maintained by the licence holder.

Usage restrictions for the open spectrum

The remaining spectrum may feasibly be used for provision of a variety of services (more so if there is no demand for the smart grid spectrum and this is made openly available), although the most likely (based on the Plum report) would seem to be NB-IoT. There is sufficient spectrum to support multiple NB-IoT providers, and there would be no need for guard bands if NB-IoT were to be deployed alongside a LTE based smart grid network. Making spectrum available in small enough blocks to allow NB-IoT use (which needs 2x200 kHz channels) would in any case allow bidders to put multiple lots together to meet uses with greater bandwidth requirements, subject to the use of an auction process that would (i) award multiple lots as contiguous duplex spectrum and (ii) not face bidders aggregating multiple lots with risks of getting some, but not all, of the lots they need.

In the Consultation, ComReg proposed to make the licences available on a technology neutral basis. We understand that ComReg does not intend to set any guard bands amongst users, and proposed instead that adjacent operators should negotiate arrangements to minimise interference.

Several respondents to the Consultation have indicated that it is important that ComReg establish clear Block Edge Masks for the licences. We agree that such restrictions would be useful as the default framework that would apply if negotiation between adjacent users fails. In particular, there may need to be sufficient default measures in place to prevent interference with the smart grid network or unduly precluding use of the spectrum for NB-IoT.

4.3 Access requirements

Given that there is only sufficient spectrum to support a single smart grid licensee and there is no alternative spectrum available in the mid-term, the winner of the smart grid spectrum will have monopoly power over the use of those frequencies. However, there may be more than one entity that would have an interest in making use of a smart grid network. The Plum report highlights that there was strong support in the responses to the Consultation for a smart grid network for electricity but notes that gas and water are also likely potential users.

It may, therefore, be important to ensure that awarding the smart grid spectrum to one particular entity does not unduly preclude one or more of the utilities from being able to benefit from smart grid services or allow the license holder to abuse its monopoly power.

However, we believe that this is likely to be more appropriately achieved via ex post application of competition powers than by attaching any ex ante obligations to the spectrum. This is because it is difficult at this point to determine how shared use of a smart grid might practically be best organised and there is a risk that inappropriate access obligations could impair some of the functionality of such a grid.

In particular, we consider that ex ante obligations for providing wholesale access to spectrum are unlikely to be appropriate in this case. Smart grid networks may have stringent requirements on reliability, security and latency, and it is important to not impose any ex-ante obligations that might put that in jeopardy. Although operators may naturally come to a spectrum sharing arrangement, enforcing this through access obligations on the underlying spectrum would be inappropriate due to the risk of interference with the proper functioning of the network to the required standards.

It is possible that sharing of network resources (rather than underlying spectrum) might be a better model. However, it is difficult to see how access requirements might be set *ex ante* for smart grid services that do not currently exist.

If it turns out subsequently that certain users – such as network utilities – find that there are no alternatives available for smart grid, a network deployed using the 400 MHz spectrum would then have the characteristics of an essential facility. If access to the network for other users was technically possible, but not forthcoming at a reasonable price, then this could lead to a complaint under competition law. However, any eventual conclusion to mandate access would depend on an analysis of the alternatives available to such users at the time, the definition of a relevant market and a finding of dominance in supply to that market. Therefore, DotEcon is of the view that the possibility of a subsequent ex-post competition complaint by an alternative utility operator against the winning bidder should provide a sufficient restraint on the winning bidder denying reasonable access.

5 Definition of lots

In the Consultation, ComReg proposed offering the available frequencies in 2x500 kHz lots, on a national basis. This proposal was aimed at providing flexibility for different users to express their bandwidth requirements, and for alternative splits of the spectrum.

Additional information has since become available through the responses to the ComReg Consultation as well as the report by Plum. We now have a more informed view of the likely services and technologies that might utilise the spectrum and their spectrum requirements.

5.1 Spectrum reserved for smart grid

Spectrum packaging for reserved spectrum

As discussed above, we recommend reserving 2x3 MHz of the spectrum for smart grid. Since this is the minimum requirement for smart grid, as set out by Plum, if ComReg were to implement such a reservation, there would seem to be no reason for awarding it in lots smaller than 2x3 MHz.

Equally, there is no reason to make this lot larger than 2x3 MHz. In the event that a qualifying utility wanted more than the minimum amount of spectrum necessary for smart grid, then it should have to compete for this additional spectrum with alternative users. Given the reservation being made for smart grid, it would be unfair to other potential users if this reservation were largely than necessary.

Location of the reserved spectrum within the band

We recommend that the smart grid spectrum is assigned specific frequencies in advance of the auction, and that this is located at the lower end of the available frequencies (410 – 413 MHz).

The frequencies immediately below the available spectrum are not currently used (although are reserved for radio astronomy) and so there are no interference concerns from putting smart grid at the lower end of the band. The adjacent frequencies at the top, however, are used (albeit lightly) for analogue Private Business Radio (PBR) – the potential for interference to PBR from LTE (considered by Plum to be the most likely technology) is greater than normal due to the duplex direction applied varying across PBR users. However, Plum highlight that the risk is still fairly low, and if necessary PBR users could easily be assigned alternative channels to address the issue. For these reasons we do not consider there to be any particular concern over potential interference with PBR. However, for the sake of prudence we would suggest that the smart grid spectrum is located at the bottom end of the available frequencies. This view is in line with the recommendations set out in the Plum report, which suggests that the lower part of the band would be more suitable for smart grid in order to avoid the risk of interference with existing services at the upper end of the band. Note that if we preassign specific frequencies for smart grid, this should be at one end or the other (not in the middle) to avoid splitting the spectrum and restricting the options for other users to be assigned contiguous spectrum.

5.2 Spectrum available to all bidders

Lot size for open spectrum

Allocation of the remaining spectrum (whether 2x2.5 MHz or the full 2x5.5 MHz if the smart grid reservation is not taken up) needs to take into account the wide range of uses identified in the responses to the ComReg consultation and the Plum report. In that regard, it is important not to preclude the use cases described by Plum from participating in the award simply because of the way lots have been defined.

ComReg's proposal to allocate the spectrum in blocks of 2x500 kHz had support from five respondents to the Consultation, whilst other respondents argued for lots with greater bandwidth on the grounds of the minimum bandwidth necessary for deploying services (some proposing 2x1.5 MHz lots, some 2x3 MHz lots and others 2x5 MHz or a single lot including all of the 2x5.5 MHz available).

The Plum report suggests that an even finer granularity might be more appropriate, indicating a minimum bandwidth requirement for PMR of 2x100 kHz, and 2x200 kHz channels being suitable for NB-IoT.

Given the wide range of requirements from different users, it seems appropriate that the maximum degree of flexibility should be provided, as this makes little difference to the complexity of the proposed auction. This would suggest that, on the basis of Plum's findings, lots offered in 2x100 kHz blocks would be suitable, as this would provide the maximum required flexibility to potential users for acquiring bandwidths based on their individual requirements.

Typically, there are two potential downsides from offering the spectrum in very small blocks:

- it could potentially increase the complexity of the award if this allows for an extremely large number of options for bidders, or alternative outcomes;
- it may expose bidders who require a larger bandwidth to risks, if they are required to bid for individual lots separately without a guarantee that they may win the required bandwidth or nothing at all.

2x100 kHz lots does not create complexity problems

The first issue does not apply for this award, given the limited bandwidth available. If 2x3 MHz were to be reserved for smart grid and sold as a single lot, offering the remaining 2x2.5 MHz in 2x100 kHz blocks results in a total of 25 identical lots, which is manageable. Even if the full 2x5.5 MHz were to be awarded as 2x100 kHz blocks there would only be 55 identical lots, which would still not be of concern in terms of either complexity for bidders deciding how to bid or the overall complexity of the award.

The second issue can be resolved through the auction design. In this context, we identify two important sources of risk:

- the risk that a bidder who bids for a number of lots could be awarded some but not all of the lots it bid for, which could lead to outcomes where the bidder does not obtain the minimum bandwidth it requires or which underpins its bids; and
- the risk that a bidder seeking a contiguous block of greater bandwidth could be assigned non-contiguous 100 kHz blocks.

Package bidding can mitigate aggregation risk

The first of these issues can be resolved by using an award mechanism that supports package bidding, which allows bidders to make offers for a combination of lots (the package) rather than for individual lots. We address this in Section 7.

Frequency-generic or frequency specific lots?

The second issue can be resolved by initially offering the spectrum in frequency-generic lots (blocks with a given bandwidth that do not have specific frequencies assigned) and only determining the frequency assignments after determining the total bandwidth to be assigned to each bidder, so that each winner can be guaranteed to be assigned contiguous blocks. This approach has been used successfully in a number of previous awards by ComReg.

The drawback of offering the spectrum initially as frequency-generic lots is that if some specific frequency blocks are more valuable than others, then bidders would want to know beforehand the specific frequencies that correspond to the lots they are bidding for. Therefore, this approach is only appropriate if the benefits from ensuring that bidders receive contiguous assignments are greater than any benefits from allowing bidders to bid for specific frequencies.

At present we are not aware of any material, systematic differences in the value of the different 2x100 kHz blocks available. Therefore, we recommend that the approach of offering the open spectrum initially as frequency-generic lots is also adopted for this award.

5.3 Summary of recommendations

Summary recommendation

If spectrum is reserved for smart grid, we would recommend offering this as a single 2x3 MHz block of spectrum at the lower end of the available frequencies (410 – 413 MHz). For all other frequencies, we would recommend offering the spectrum in lots of 2x100 kHz on a frequency generic basis, ensuring that any risks for bidders who require greater bandwidth are mitigated through the design of the award mechanism. Once these lots have been assigned to bidders, the specific (contiguous) frequencies for each winner would be determined. If the winner of the smart grid lot were to win additional spectrum, this would be automatically positioned contiguous to the smart grid frequencies (410 – 413 MHz).

6 Spectrum fees and minimum prices

Structure of spectrum fees

ComReg typically splits the fees that apply to spectrum licences between:

- a **spectrum access fee** (SAF) – a one-of fee established during the award process (e.g. determined by auction) payable soon after the allocation of licences; and
- ongoing **spectrum usage fees** (SUFs), paid annually during the licence term.

We do not see any particular need to deviate from this approach.

Need for minimum prices

The **minimum price** comprises both the minimum possible SAF (set by the reserve price for the auction) and the ongoing SUFs (indexed by inflation) that licensees can anticipate paying.

There are good reasons for setting minimum prices in an auction, as these reduce incentives for:

- **strategic behaviour** within an auction aimed at decreasing the price paid (including both tacit collusion within an auction and also arrangements entered into prior to an auction aimed at decreasing competition within the subsequent auction); and
- **speculative bidding** e.g. attempting to acquire the spectrum at a low price without a genuine business plan for using the frequencies but in the hopes that the value will increase in the future and the spectrum can be sold on at a profit.

These arguments are applicable for the open spectrum not reserved for smart grid, and for these reasons we recommend that ComReg applies a minimum price in this award for those frequencies.

For the smart grid reservation, concerns over strategic behaviour or speculative bidding are less relevant. There is only one lot available so there is no 'collusive split' of the spectrum between competing parties, and the risks of speculative bidding are removed by restricting the potential licensees to qualified utilities and imposing usage conditions (i.e. the strict qualifying restrictions prevent participation from any non-credible bidders, and the usage restrictions in any case significantly limit the scope for trading the spectrum for a profit at a later date).

However, there is a fairness argument to suggest that a smart grid operator should face the same minimum price as those competing for the open spectrum. Furthermore, applying at least part of a minimum price as ongoing annual licence fees provides incentives to return unused spectrum to ComReg which can potentially then be reassigned to a more efficient user. For these reasons, we recommend that the minimum price also applies to the smart grid spectrum.

Level of minimum prices

The minimum price would typically be set based on a conservative estimate of the market value of the spectrum, established using a benchmarking exercise taking account of comparable international awards. However, a lack of data or other information about the market value of a smart grid network or any of the other potential uses means that benchmarking (or another form of valuation exercise) is not possible, and that it is very difficult to set the reserve price and annual licence fees in a way that reflects the likely value of the spectrum, but does not risk leaving this spectrum inefficiently unsold (if set too high). Since there are no alternative frequency options for smart grid, we consider it particularly important to avoid the risk of setting the minimum fees for the reserved 2x3 MHz too high and making it too expensive for a smart grid operator to acquire.

Therefore, we believe that the primary goals for determining the minimum fees in this particular award are:

- to avoid setting the minimum price too high and choking off demand from one or more of the potential uses identified in the Plum report (in particular for the smart grid spectrum where the minimum price has less relevance for preventing frivolous or strategic bidding);
- to set a minimum SAF (reserve price) that is sufficiently high so as to deter frivolous or vexatious participation in the award of the open spectrum; and
- to set SUFs at a level that provides at least some incentives for winning bidders to return spectrum rights of use to ComReg if left unused.

In relation to the second point, splitting the minimum price between upfront fee and ongoing SAFs helps to ensure the spectrum can be reallocated to another user if it is not being efficiently used, but also serves to protect bidders where there is a degree of uncertainty over the future value of the spectrum e.g. the spectrum can be returned if the spectrum is being unused, in which case the licensee would not be liable for paying any future annual usage fees. We note that in the previous award of the available spectrum, the licence fee was paid in a single upfront transaction, but the spectrum was subsequently not used. In this case, the licensees would have paid the full amount of the fees for no return on their investment, but because the cost was sunk would have no reason to return the spectrum to ComReg so it could be reassigned.

We consider that a minimum price – including the SAF and ongoing SUFs on a discounted basis - in the order of €500-600k for the 2x3 MHz block and €15-20k for a 2x100 kHz lot is probably sufficiently high to discourage frivolous or vexatious bidders. At these levels, there is little risk of leaving spectrum inefficiently unallocated.

Split of minimum price between SAF and SUF

ComReg has typically applied a 50/50 split of the minimum price between the minimum SAF (reserve price) and the SUFs (for example, in the 2012 MBSA). However, given the likely uncertainty over the future development and value of the potential services, we consider that there may be some merit in deviating from this approach and putting a slightly greater weight on the ongoing annual fees. We consider that putting approximately 40% of the minimum price in the SAF would help to reduce the risks for bidders with uncertainty over their revenue streams but maintain a sufficiently high upfront fee so as to discourage frivolous or vexatious bidding.

On this basis, we propose the fees set out in Table 1, noting that:

- the SUFs would be paid annually for each year of the licence term (i.e. 15 payments in total, assuming a 15-year licence duration); and
- the SUFs would be adjusted yearly in line with inflation.

Table 1: Proposed licence fees

Spectrum block	Minimum SAF per block	Annual SUF per block	Minimum price per block (Discounted at 8.63% pa)
2x3 MHz (smart grid reservation)	€240,000	€39,000	€590,000
2x100 kHz	€8,000	€1,300	€19,600

7 Award mechanism

7.1 Administrative assignment or auction

The frequencies available could be assigned through an administrative process, where interested parties apply for the lots offered and ComReg determines how to assign lots amongst applicants, or through an auction process, where bidders make offers for the lots available (bids) and ComReg assigns the spectrum to those bidders who made the highest bids (the exact process for selecting winning bids depends on the specific auction rules).

Auctions are more transparent and efficient

It is widely accepted that auctions provide a more transparent and efficient mechanism for assigning spectrum, and ComReg has favoured this approach in recent awards. Indeed, we would only recommend an administrative process if there were a clear and convincing reason for doing so arising from the likely failure of a market mechanism.

Based on the evidence provided in the Plum report and the consultation responses, it is very likely that smart grid represents the best use of at least some of the spectrum. However, the value of this is uncertain, and there could potentially be multiple parties interested in operating a smart grid network with sufficient spectrum for only one.

In the event that there is excess demand for the smart grid spectrum, leaving it to the regulator to establish which user to assign the spectrum to risks an inefficient outcome. The regulator would have to decide based on very limited information about the users. It would be advisable in that case to use a competitive process (an auction) to determine the allocation, which would be likely to yield a more efficient outcome and would also remove the burden of administrative choice from the regulator.

Regarding open spectrum not reserved for smart grid, there is a high level of uncertainty about the value of the spectrum and also the potential uses. This makes it very difficult for ComReg to run an administrative process with any likelihood that it will yield an outcome that ensures an efficient use of the spectrum. Again, it is likely to be preferable to allow market mechanisms to establish the optimal allocation.

There was support for an auction process in responses to the Consultation

Furthermore, the responses to the Consultation suggest that there is greater support for an auction process, with four respondents indicating a preference for an auction (albeit some specifying that this was under the proviso that there should be measures to prevent telecommunications operators from acquiring all of the available frequencies), versus three who indicated a preference for an administrative award.

Given the considerations above, we recommend that ComReg uses an auction for the award.

7.2 Key auction design considerations

In this section we discuss key considerations that need to be taken into account when forming recommendations on the auction format.

7.2.1 Sequencing of the award process

Proposal for two sequential auctions

We believe that there may be some benefits in running two sequential auctions to award the spectrum:

- the first auction would determine the assignment of the 2x3 MHz reserved for smart grid; and

- the second auction would be used to assign the remaining spectrum – if there were no demand for the smart grid spectrum in the first auction, then this could be included in the second (broken down into 2x100 kHz blocks).

This approach would be problematic if a bidder was dependent on winning more than 2x3 MHz for deployment of a smart grid network to be feasible. That bidder would then be at risk in the first auction as it would not know whether or not it was likely to acquire the additional spectrum needed in the second. However, based on the Plum report and the responses to consultation, this does not appear to be the case. 2x3 MHz should be sufficient for running a smart grid network. Plum highlight that there is currently no requirement from smart grid for more than 2x3 MHz, although there may be some use cases in the future.

On this basis, we consider it reasonable to proceed on the basis that the value of 2x3 MHz to a smart grid operator is unlikely to be dependent on whether or not the operator wins additional spectrum. Moreover, to the extent that a smart grid operator might want more than 2x3 MHz, it should not benefit from a reservation, but rather compete for incremental spectrum above the minimum. Therefore, given this situation, running two sequential awards should not materially affect the efficiency of the outcome.

Running two separate awards for the reserved spectrum and the open spectrum means that:

- it is possible to resolve the demand for the smart grid spectrum before determining winners for the rest; and
- it helps to avoid the risk of a smart grid operator leveraging the reservation it is given on the 2x3 MHz lot to acquire additional spectrum, which would be

distorting to the award outcome and unfair to other bidders that cannot bid for the reservation.

Resolving the demand for smart grid before awarding the rest of the spectrum means that (non-smart grid) bidders know in advance what spectrum is available to them to bid for; this is likely to make it easier to prepare for the auction, and potentially to determine whether they participate in the award at all i.e. a potential user needing more than 2x2.5 MHz but not wishing to operate a smart grid network would only want to participate if there were no demand for the smart grid reservation).

The more important reason for two separate auctions is the potential for distortions in the auction outcome due to the reservation for smart grid. If all of the spectrum were to be included in a single auction process that allowed for package bidding (as recommended above), there is a risk that a smart grid operator could use the reservation to leverage an unfair advantage over winning additional spectrum. For example, the smart grid bidder could bid only for packages containing the smart grid lot *and* additional spectrum (without placing a bid for the smart grid lot on its own). To compete for the non-reserved spectrum, the other bidders would have to then outbid the smart grid bidder on both the reserved spectrum and the additional spectrum, which may require a bid with a significantly higher than the value of the non-reserved spectrum alone. This could then lead to an outcome where the smart grid operator wins spectrum in excess of 2x3 MHz that could have been more efficiently awarded to another user.

It is of course possible that a smart grid operator might like to have additional spectrum[9], but it is desirable that it should have to compete for it with other bidders on a neutral basis, which sequential auctions would achieve.

To keep things simple for bidders, we suggest that where possible the same auction format is used for both auctions. This avoids the need for potential smart grid operators to prepare for two different types of auction.

7.2.2 Risks associated with awarding small spectrum blocks

As discussed in the previous section, a drawback from offering the available frequencies in small blocks is that, depending on the auction format and rules adopted, bidders who are seeking a greater bandwidth (through bidding for multiple lots), who may have minimum bandwidth requirements or strong complementarities across the lots they bid for, could be exposed to a two main risks.

- **Aggregation risks** – the risk that a bidder who is bidding for a number of lots might win some but not all of these lots. This is problematic for bidders who have a minimum bandwidth requirement that is only achieved with several lots, or for bidders with strong complementarities across different lots (i.e. if the value of X lots is greater than X times the value of one lot).
- **Fragmentation risks** – the risk that a bidder who is bidding for a number of lots might win non-contiguous lots. This is problematic for bidders who seek contiguous bandwidth, for instance in order to

[9] The Plum report suggests that a smart grid operator might have demand for spectrum in excess of 2x3 MHz for future applications such as video surveillance.

be able to use wider channels, or to minimise the scope for interference problems with adjacent users.

Whether these risks exist, and their materiality, depends on the structure of demand, the lots offered in the auction and the specific auction rules.

Aggregation risk

Aggregation risks arise when there are synergies across lots (the value of the lots together is greater than the sum of the individual value of the lots). For example, a bidder might need to acquire a minimum bandwidth (in excess of the lot size) for its business case to be viable, in which case winning fewer than that number of lots would result in the bidder paying for something that is worth nothing.

Aggregation risks can be resolved by accepting 'package bids', where bidders can specify a bid amount for a package of lots rather than for individual lots. If the bid is selected as a winning bid, the bidder will be assigned all of the lots in the package. This means that a bidder will not be exposed to win a subset of the lots it bids for (unless it separately bids for such a subset). The drawback of this approach is that, depending on how bids are collected and assessed, it could lead to some lots remaining inefficiently unsold if bidders have strong complementarities. We discuss this when describing the clock auction format below.

Regarding the spectrum available in this award, we do not consider aggregation risk to be an issue in relation to the spectrum reserved for smart grid. The amount to be reserved (2x3 MHz) is, to the best of our understanding, sufficient for the operation of a smart grid network, and our recommendation to make this available in a single block of spectrum means there is no risk that a potential smart grid operator would end up with less spectrum than it needed.

Furthermore, the evidence in the Plum report suggests that there is currently no clear need for a smart grid operator to acquire additional spectrum, and anything it might acquire in excess of 2x3 MHz is unlikely to have any impact on the value of the reserved spectrum. Therefore, we consider any valuation interactions between the reserved 2x3 MHz and the remaining spectrum and likely to be one way only (i.e. that a smart grid operator needs to win the reserved block before having demand for additional spectrum, but the value of the reserved block does not materially depend on obtaining the additional spectrum).

However, aggregation risk is likely to be something that needs to be accounted for in relation to the unreserved spectrum. The proposed lot size for the open spectrum (2x100 kHz) is small in comparison to the potential minimum requirements expressed by some respondents to the Consultation (with some arguing that the minimum usable bandwidth for some services would be 2x1.4 MHz, 2x2 MHz, 2x3 MHz or even 2x5 MHz depending on the service). In this case it is feasible that a number of participants seeking to acquire open spectrum will need to win multiple lots, potentially in a particular multiple related to carrier bandwidth; measures to protect them from winning only a subset of their requirements are likely to be necessary.

Fragmentation risk

As mentioned above, fragmentation risk arises when bidders need to acquire contiguous frequencies but there is a possibility that spectrum they win is 'broken up' into multiple blocks.

Fragmentation risks can be resolved by initially offering lots as frequency-generic in a first stage, and then only determining the specific frequencies to be assigned to each winner in a follow-up stage, with a guarantee that all winners will receive a contiguous assignment corresponding to the total bandwidth of the frequency-generic lots they have won. A key requirement for this approach to work well is that the specific frequency blocks that may be assigned in correspondence with frequency-generic lots should be of similar value. Otherwise, the value of a frequency-generic lot offered in the first stage might crucially depend on the specific frequencies that the bidder might be assigned in relation to this lot in the follow-up stage, which would create uncertainty about the value of lots offered in the first stage. In this case it may be necessary to specify different categories of frequency-generic lots, so that lots within each category should have similar value but not necessarily across categories. However, in this case it may not be possible to guarantee contiguity of assignments to winners winning lots in different categories.

Our proposal to reserve 2x3 MHz for smart grid and make it available as a single frequency-specific lot means that any bidder winning (only) that lot will have no fragmentation risk as contiguity of the spectrum is guaranteed.

For the remainder of the spectrum, there are several use cases with differing bandwidth requirements (in excess of the proposed lot size). In this case, we consider that it might be appropriate to make the unreserved spectrum available initially as frequency-generic 2x100 kHz lots and to assign specific frequencies (guaranteed to be contiguous) at a later stage. This would only be a problem if there were significant value differences for frequencies across the band. However, we are not aware of any material differences in the value of different lots, and we therefore expect that all of the available 25 unreserved lots (55 lots if there is no demand for smart grid) could be offered as a single category of frequency-generic lots.

In the case that a winner of the reserved smart grid lot also wins additional lots, that bidder could be guaranteed that its additional spectrum will be located contiguous to the smart grid spectrum. This would not have any adverse effects on the award process (in particular it would not advantage the smart grid operator) if there are no value differences associated with winning spectrum in different parts of the band.

7.2.3 Open stage versus sealed bid

Sealed bid auctions are fairly simple and quick to run. However, they can expose bidders to a relatively high degree of uncertainty about the likely outcome, as they do not have an opportunity to gauge the degree of competition in the auction or to revise their bids if they are unhappy with the outcome.

Conversely, open (multi-round) auctions disclose some information about the level of competition, allowing bidders to update expectations and estimates of competitors' behaviour and to update their valuations and bids accordingly. Although open auctions are more complex to run, and take a longer time to resolve, the possibility to 'bid back' means that they are less prone to inefficient outcomes due to bidding errors. Open auctions do provide greater scope for tacit collusion or other gaming strategies, although this does depend on the specific rules used for the auction.

Common value uncertainty

Overall, it would seem likely that there will be a reasonable amount of uncertainty over the value of the available spectrum for this award. If there were competition for the smart grid spectrum (i.e. multiple qualifying utilities), we could expect there to be significant common value uncertainty. For the additional spectrum, it is possible that there could be a number of different types of uses competing, but the more likely scenario would seem to be competition for this spectrum to deploy NB-IoT, in which case there is again likely to be common value uncertainty. Therefore, the situation is rather different from other recent awards (such as the 26 GHz award) where ComReg has been able to use a sealed-bid approach due to modest common value uncertainty.

Potential for bidder error

Furthermore, given the potential importance of smart grid and the lack of alternative spectrum, there may be concerns about the risk of inefficient outcomes if a sealed-bid process were used with a high degree of valuation uncertainty. Under these circumstances it would be less risky to use an open process that allows bidders to bid again if their current bids are unsuccessful. An open process would also reduce the consequences of unsophisticated bidders unused to spectrum auctions making a bidding error; in a sealed bid auction, there would be no opportunity to recover from a bidding error.

For these reasons we recommend the use of an open auction format for this particular award.

7.2.4 Summary of conclusions on key considerations

Summary recommendation

To summarise the conclusions from the discussions above:

- We propose the use of two auctions to run sequentially, the first to assign the smart grid spectrum as a single frequency-specific lot, with a second auction to assign the remaining frequencies (including the smart grid spectrum if unsold in the first auction) as multiple frequency-generic lots.
- The two auctions should ideally use the same format for simplicity, unless there are strong arguments for doing otherwise.
- The auction format used should have an open stage to allow for price discovery (alleviating common value uncertainty) and to mitigate the risk of inefficient outcomes due to bidder error.
- The auction format should support package bidding to avoid aggregation risk and initially assign

(unreserved) spectrum as frequency-generic lots (with a guarantee of contiguous assignments) to remove fragmentation risk.

7.3 Proposed auction mechanisms

On the basis of the considerations and recommendations above, our proposal is to use a clock auction format that allows for exit bids (to mitigate the risk of inefficiently unassigned spectrum). We discuss this in detail below, along with some discussion on other potential auction formats and our reasons for considering them less appropriate.

In this section we have assumed that the award will be sequential, as recommended, with the spectrum reserved for smart grid awarded first and the remainder made available in a later auction. The auction formats proposed could feasibly be implemented in a way that allowed for the reserved and unreserved spectrum to be awarded together. However, auction formats with package bidding across reserved and open spectrum would need additional rules in place to prevent leveraging of the reservation (as discussed above). Given that we do not see any need to award all of the spectrum together, we believe that the sequential approach is preferable as it much simpler for bidders and it is unlikely to lead to any efficiency loss relative to a more complex combined auction.

We first consider the auction formats that may be used to assign the single (frequency-specific) lot reserved for smart grid and the remaining open spectrum as frequency-generic lots. We then discuss the options for determining specific frequency assignments for winners of the open spectrum.

7.3.1 Clock auction with exit bids

Our proposed format is a clock auction with exit bids and a combinatorial closing rule. To explain how this format works, we proceed in steps, first explaining how a simple clock auction works without the additional features of exit bids and a combinatorial closuring rule. This illustrates why these additional features are useful.

Simple clock auction

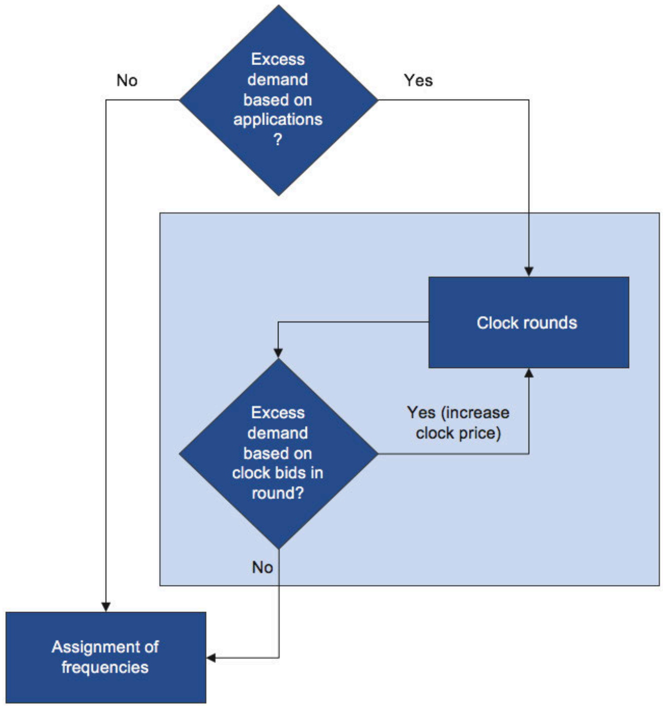
The clock auction is a simple dynamic auction format that supports package bidding. Clock auctions can resolve excess demand quickly when there are identical lots (although they will also work in the one lot case, as for the smart grid reservation), as price increments apply uniformly to all identical lots.

In the context of the current award, assuming that all lots in each auction can be offered in a single category, a basic clock auction would work as follows:

- the auction progresses in rounds, where the auctioneer announces the price per lot that applies in that round (the clock price) and bidders specify the number of lots they wish to acquire at the clock price;
- at the end of each round, the auctioneer calculates the total demand across all of the bids received in the round – if this exceeds the total supply of lots, then a further round is run, with a higher clock price; otherwise, the auction ends and each bidder wins the lots it bid for in the last round, and pays the clock price for each of these lots;
- there is an activity rule to ensure that bidding is progressive, which establishes that in any round after the first round, the number of lots for which a bidder

bids cannot exceed the number of lots for which it bid in the preceding round.

Figure 2: Flow of the simple clock auction



The simple clock auction meets the criteria identified above in that:

- it is an open auction format that supports price discovery and mitigates the risk of bidder error; and
- the format supports package bidding in the sense that a bidder will win all of the lots bid for in the final round, or nothing (there is no scope for a bidder to win just a subset of the lots it has expressed demand for at particular prices.

The clock auction also has the benefit of being very simple for bidders to understand and participate in. In particular, in the case of the spectrum reserved for smart grid, there would be a single lot and bidders would simply need to say whether or not they wished to purchase the lot at a given round price. The increase in complexity when dealing with the remaining spectrum split into multiple lots is likely to be very small, with bidders only needing to state how many lots they wish to acquire at a given price.

The simple clock auction can leave lots inefficiently unallocated

The main drawback of the simple clock auction is that it could lead to some lots remaining inefficiently unassigned. This is because there is a risk that demand might drop too abruptly from one round to another (e.g. if several bidders reduce demand in the same round, or if bidders reduce demand by several units in one step). Thus, in the course of one round we might go from a situation in which there is excess demand to a situation in which the auction ends with unsold lots. Such large drops in demand may be the result of price increments being too large (referred to as 'price overshoot'), but can also arise regardless of how small the price increments are due to the structure of bidders' valuations. This can happen where a bidder's value per lot is increasing in the number of lots over some range. As a result of these increasing marginal valuations for lots, the number of lots demanded by the bidder can drop by many lots – or the bidder might drop out altogether - as the price per lot increases slightly.

Exit bids and combinatorial closing

Exit bids can help to reduce the impact of overshoot

The risk of inefficiency due to overshoot can be reduced by allowing (or requiring) bidders to make *exit bids* when they reduce demand. These exit bids would be the best offer that a bidder makes for lots on which it ceases to bid. Exit bids specify a price (required to be between the round price in the preceding round and the current round price)[10] at which the bidder would be prepared to buy the lots it no longer demands at the current round price.

Exit bids give the auctioneer additional options for clearing the market. If a price increment resulted in unallocated lots, it might be possible to set a uniform clearing price for all bidders at a somewhat lower level, determined by one of the exit bids received in the final round. This would help if unsold lots had been caused by the previous price increment having been too large, in effect stepping past a market-clearing price per lot.

However, even this approach might leave lots inefficiently unsold, as there could be demand expressed in previous rounds for those unsold lots, but at a lower price per lot. For example, a bidder might be willing to take them in addition to whatever lots it is bidding for in the last round, but does not value the additional lots at the final price, otherwise it would have continued bidding for more lots.

Combinatorial closing

To overcome this issue, we propose a combinatorial closing rule. At the end of each round, we find the value maximising combination of bids, taking at most one from each bidder, subject to the number of allocated lots not exceeding supply based on *all* clock bids and exit bids submitted throughout the auction. This could then be accepted as the winning outcome, or it may be necessary to run a further round.

If a bidder who submitted a non-zero bid in the last round finds itself outside of this value maximising solution, then it would not be fair on that bidder to end the auction without giving it a chance to respond by increasing its bids.

[10] For example, suppose that at round prices of 10 per lot a bidder is bidding for three lots. In the following round, when the price increases to 11 per lot the bidder decides to bid for two lots. The bidder could then make an exit bid for a third lot at a price between 10 and 11.

Therefore, the auction will only close following a round in which the value maximising combination of bids includes a bid from *all* bidders active in the last round. Winners would then pay the amount of their winning bids.

With a single lot category (as for this award)[11], such a rule would always guarantee that if the auction were to close, all bidders still bidding in the final round would be included in the winning combination of bidders and would win at least as many lots as they bid for in the final round. This is because bidding is progressive, with the number of lots bid for by each bidder falling (or at least staying the same) as prices increase. A bidder that is still active in the final round may therefore win with one of its clock bids or exit bids submitted in a previous round, but this would give it more lots at a cheaper price per lot compared with winning its clock bid in the final round.

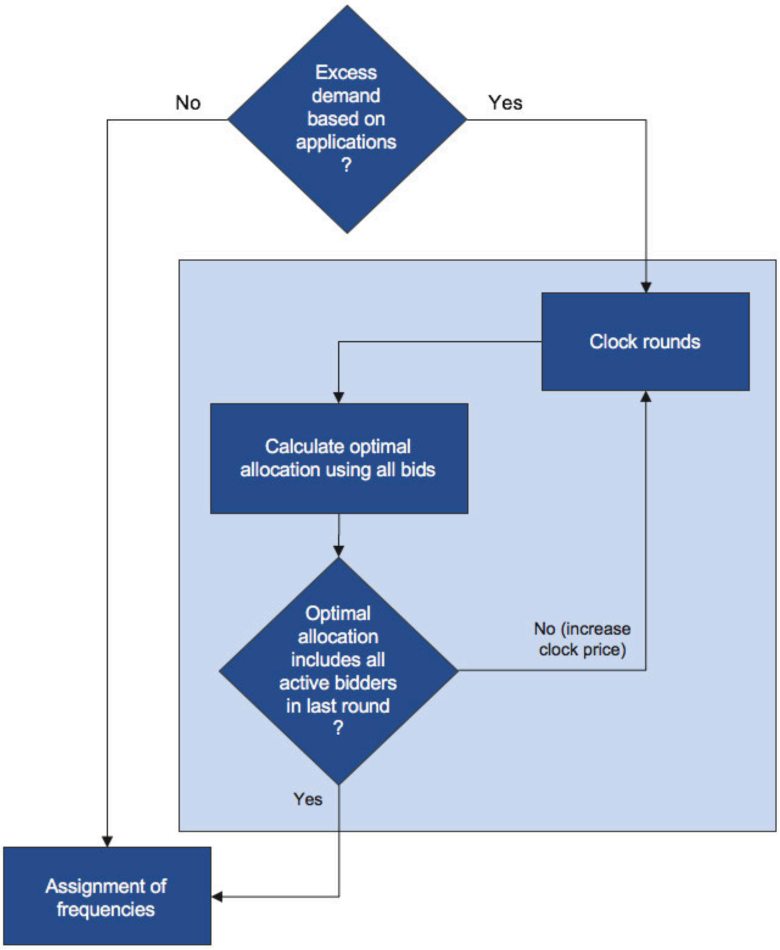
[11] Exit bids are likely to be a reasonably effective and simple way of helping to minimise the likelihood of unsold lots in the proposed single lot category scenarios. With a single lot category, it is fairly straightforward for a bidder to 'fill-in' any gaps in the bids it wishes to submit, as this only involves submitting exit bids for the different quantities of lots of interest between demand in the previous round and demand at current round prices. We note, however, that exit bids are less likely to work so easily in multi-category scenarios with package bidding. In these cases, when a bidder drops demand (in terms of eligibility points), there could be a very large number of packages the bidder could then feasibly submit exit bids for (i.e. packages with total eligibility points between the bidder's eligibility at the start of the round and its activity in the round), based on the large variety combinations of lots across different categories. This then becomes very difficult (or infeasible) for bidders to manage on a round by round basis. Under these circumstances, a full-scale combinatorial auction, such as a combinatorial clock auction, would be a better alternative.

The combinatorial closing rule, which looks back at previous bids, also helps to rectify inefficiencies that could otherwise result from one or more bidders having increasing marginal valuations (leading to discrete drops in demand), effectively discounting lots that would otherwise go unsold at the final clock price. However, where multiple lots are available the proposed clock auction does not necessarily allow bidders to express all relevant bids, as they might reduce demand discretely and, even with the provision for exit bids, not be able to make bids for certain number of lots due to the requirement that exit bids be above the previous round price.

This limitation of the clock auction (even with a combinatorial closing rule) could be avoided by moving to a more sophisticated combinatorial auction format (such as a CCA or CMRA, described below). However, such formats are more complex and the efficiency gains are unlikely to be sufficient to justify their use in this particular context.[12] Given that participants may have no previous experience of spectrum auctions, we also consider the benefits of simple rules and bidders always being able to bid again if not in the winning outcome.

[12] The limitations of the clock auction with exit bids discussed do not apply for the one-lot smart grid case since bidders will always be able to submit a bid for the single lot at the desired bid amount. We note also that the other potential users (of the open spectrum) will have alternative frequency options available in other bands, which would help to mitigate the risk of inefficiencies (and the impact on the downstream market) arising as a result of some bidders being unable to submit bids for all packages of interest.

Figure 3: Flow of the proposed clock auction with exit bids



Box 2: Example of combinatorial closing

Suppose there are four bidders (A, B, C and D) and seven frequency-generic lots in one lot category.

In round *n* there is excess supply at a price of €60 per lot. Bidder A submitted a bid for 5 lots (at a total bid amount of €300), no other bidders submitted a clock bid in that round. Bidders B, C and D have all submitted exit bids during the auction, giving the following set of bids to consider when establishing winners:

Bidder A: 5 lots @ €300

Bidder B: 7 lots @ €390

Bidder C: 2 lots @ €80

Bidder D: 3 lots @ €150

The efficient allocation, taking these as final bid amounts, would be to assign all seven lots to bidder B.

However, considering the award of seven lots to B to be the efficient outcome assumes that A's value for five lots is fixed at €300 (or to be more precise, is less than €310) and that it is not willing to accept fewer than five lots, one or both of which may not be true.

Ending the auction at this point and giving all lots to B would not be fair to A since A has not had the opportunity to fully express its demand. We therefore require a further round in which bidder A can respond to the competition from B by increasing its bid or reducing demand.

In the next round, suppose that the round price increases from €60 to €65 per lot, and consider the following example cases:-

Bidder A continues to bid for five lots:

If bidder A continues to bid for five lots at the new round price (with a total bid amount of €325), the optimal outcome now is to assign five lots to A and two lots to C (with a total value of €405). Since B, C and D cannot modify their bids (and presumably would not want to given they dropped demand to zero at lower prices), we know that this is the most efficient allocation and the auction can end.

Bidder A reduces demand to four lots:

Suppose that, in response to the price increase, bidder A reduces its demand to four lots with a bid amount of €260. The optimal allocation now is to assign four lots to A and three lots to D, for a total price of €410. Since the only active bidder in the final round is included in the set of winning bidders (and has clearly indicated it does not wish to compete further for more than the four lots it is winning) the auction can end.

Bidder A drops out of the auction:

Suppose instead that €65 per lot is too expensive for bidder A who wants either five lots or nothing. A drops its demand to zero, and submits an exit bid of €305 for five lots. The optimal allocation would be to give all seven lots to B. A has indicated that it is not willing to bid up to the level required to outbid B (individually or jointly with C) and does not want to win fewer than five lots, and so the auction can end.

Overall, the option to take account of all clock bids and exit bids submitted in the auction combined with combinatorial closing rule gives the best chance for establishing an efficient outcome and avoiding unnecessarily unallocated lots. Given that one of ComReg's key objectives for the award is efficiency, we consider this approach to be most suitable.

Summary

Summary assessment

The clock auction is an effective and very simple process for auctioning multiple lots. Being an open auction, it should support price discovery in a setting of common value uncertainty (in particular in relation to the spectrum reserved for smart grid) and mitigate the risk of an inefficient award due to bidder error. Allowing for exit bids with a combinatorial closing rule should help to support an efficient outcome by reducing the risk of unsold lots due to price overshoot, which may be particularly helpful given the uncertainty over the value of the spectrum.

With the proposed lot structure and sequential auction process, using a clock auction with exit bids will be straightforward for bidders. The first auction would be for just one single item meaning that bidders simply need to say 'yes or no' at a given round price. The possibility for an exit bid means a bidder will always be able to bid exactly the desired amount for the lot. With the second auction, there would be just a single lot category, and bidders would have to simply state the number of lots they wish to acquire at each round price. Exit bids can be used (but are not compulsory) to provide more precise information about a bidder's willingness to pay than is allowed via the clock bids.

We consider that the features of the clock auction (open stage and supportive of package bidding) balanced with the simplicity of the format make it a suitable and attractive option for this award.

7.3.2 Other candidate auction formats

In this section we look briefly at other candidate auction formats. As discussed above, we strongly recommend using a format with an open stage. We therefore do not consider sealed-bid auctions any further as we believe these to be inappropriate for this award.

SMRA

The simultaneous multiple round ascending (SMRA) auction is a commonly used format for spectrum auctions. It involves repeated rounds of bidding, with bidders being declared standing highest bids on particular lots until they are overbid at a higher price. All lots remain in play until the auction closes (the 'simultaneous' aspect of the auction). The SMRA is commonly implemented with frequency-specific lots, but there are variants that support frequency generic lots.

The SMRA exposes bidders to aggregation risk

The major problem with the SMRA is that is does not allow for package bids. It is possible that a bidder could be standing highest bidder on a number of lots, and then be outbid on some, but not all of these lots. This is clearly not an issue with regard to the spectrum reserved for smart grid, but is likely to be problematic for the auction of the remaining spectrum for which there is a range of potential uses with varying minimum spectrum requirements. Given the potential synergies across lots that are likely to exist for some bidders (in particular, the likely minimum requirements in excess of the bandwidth assigned to each lot for some uses), using a SMRA would face bidders with the risk of winning only a subset of the lots they need at a price above the value of those lots to the winner. This risks inefficient outcomes.

Although the problem of aggregation risk could be somewhat ameliorated by providing rules for limited withdrawals of standing high bids, it cannot be eliminated and risks creating significant additional complexity in the award process.

Fragmentation risk if frequency-specific lots

Fragmentation risk (the risk of winning spectrum in multiple non-contiguous blocks) can also be an issue in the SMRA when frequency-specific lots are used. Since we are proposing to award the (unreserved) spectrum as frequency-generic lots and the reserved spectrum as a single lot that cannot be broken up, this would not a be a problem.

The SMRA is not suitable for this award

However, given the likelihood of aggregation risk and the additional complexity required to mitigate (not eliminate) this risk, we do not consider the SMRA a good choice for this award. Furthermore, we do not see any benefit to using the SMRA over the clock auction proposed and do not consider the SMRA (either with frequency-specific or frequency-generic lots) a viable candidate format for this award.

Combinatorial Clock Auction (CCA)

Another choice of open auction format is the Combinatorial Clock Auction (CCA), which has been used by ComReg for other recent awards (the MBSA in 2012, and the more recent 3.6 GHz band award in 2017).

Overview of the CCA

Assignment of frequency-generic lots using a CCA would typically be a two-stage process. The first stage (the **clock rounds**) is essentially a clock auction - during the clock rounds, bidders would bid for packages of lots at prices set by the auctioneer. The price of a lot category would be increased for the next round in the event that there was excess demand for the lot at previous round prices. Following a clock round in which there was no excess demand for any lot at prevailing round prices, the clock rounds would end.

The second stage comprises a single **supplementary bids round**. Bidders can submit bids for multiple packages in a sealed bid process. Bid amounts are discretionary and set by the bidder, but subject to constraints that help to incentivise bidding to valuation. The supplementary bids round would allow bidders to:

- increase the bid amounts submitted for packages bid for in the clock rounds; and/or
- submit bids for additional packages not bid for in the clock rounds.

Bidders are therefore able to fully represent their valuations for packages of lots in which they might be interested but not bid in the clock rounds.

Activity rules in the CCA

The CCA uses activity rules that restrict what the bidder can bid for during the clock rounds and in the supplementary bids round based on bidding behaviour earlier in the auction. For example, the CCA used for the 3.6 GHz award in Ireland implemented revealed-preference based activity rules:

- During the clock rounds, bidders would only be allowed to increase the number of lots they bid for (relative to the package bid for in the previous round) if prices are such that doing so would be consistent with value differences across packages implied by the bidders bid decisions in previous rounds where it reduced the eligibility (number of lots bid for). Allowing for so-called relaxed bids (bids for packages larger than current eligibility) would be appropriate in this situation as it would allow bidders to bid according to valuation in a setting where (due to retuning costs) there may be a preference to reduce the number of lots bid for in a particular (preferred) part of the band before switching to larger packages located elsewhere in the band but where retuning costs are higher.
- Supplementary bid amounts would be constrained based on value differences implied by bidding behaviour in the clock rounds, applied through the use of relative caps with respect to packages bid for in rounds where the bidder reduced eligibility, and also with respect to the package bid for in the final clock round (the final price cap).

Winner determination and pricing

Following the supplementary bids round, the winning bids and bidders would be determined taking into account all bids submitted during the auction. The winning outcome would be that which maximised the total value of bids included subject to accepting at most one bid from each bidder and not assigning more lots than are available. Prices are determined using a second-price rule based on opportunity cost.

The activity rules in conjunction with the winner and price determination rules are designed to incentivise bidding straightforwardly according to valuations.

Assessment of the CCA for the current award

The CCA is particularly useful in the case that there are multiple lot categories that are complementary and/or substitutable. During the clock rounds bidders can switch easily between different packages as prices develop, helping them to bid for the most profitable package in each round, explore the demand of others and establish an estimate of which packages they might have a chance of winning. The supplementary bids round then gives an opportunity for bidders to express preferences over a much wider range of packages, increasing the chances that one of their bids will fit in to the optimal allocation given the demands of others.

With a single lot category, the benefits of the CCA are less pronounced as “switching” between packages in this case simply means dropping demand to bid for fewer lots, and there is no scope for moving backwards and forwards between different categories. In particular, the clock rounds of the CCA would be identical to the simple clock auction as there would be no use for the more complex rules such as relaxed bids. With a single lot, the CCA would essentially be the same as the clock auction with exit bids (since the supplementary bid for a single lot would be analogous to an exit bid). With multiple lots, the supplementary bids round would offer flexibility in terms of being able to submit bids for all packages of interest at bid amounts that represent valuations more accurately than clock bids. However, with a single lot category, bidders should to a large extent be able to bid for the majority of packages of interest during the clock rounds, as this would simply involve reducing demand in response to price increases. Where the price increments are sufficiently large for a bidder to drop demand by more than one lot even though it has a value for the intermediate packages, exit bids provide reasonable opportunities to express that demand.

Compared with the clock auction with exit bids, the CCA offers a little more flexibility over the range of valuation structures that can be represented (i.e. through supplementary bids). However, we consider that the clock auction with exit bids should be sufficient to support an efficient outcome in the simple setting with just a single lot category, and we see little benefit in adding complexity to the process by using a CCA. In particular, when we consider some or all bidders are likely to have little or no prior experience with spectrum auctions, it would seem prudent to adopt the simplest approach unless there are good reasons for doing otherwise.

Overall, although the CCA could be used for this award, we consider that the proposed clock auction with exit bids is likely to be more suitable.

Combinatorial Multiple Round Ascending Auction (CMRA)

Overview of the CMRA

The Combinatorial Multiple Round Ascending Auction (CMRA) follows a basic clock auction structure, but allows bidders to submit multiple mutually exclusive package bids each round. One of the bids (the 'headline bid') must be at clock prices, and will determine the eligibility of the bidder in the following round (the minimum of the bidder's eligibility in the round and the bidders' activity in the round). The headline bid can be zero if the bidder does not wish to make any bids at clock prices (and this is the default bid if the bidder does not make any bids in the round).

Bidding constraints in the CMRA

A bidder can submit bids for other packages of lots alongside its headline bid. However, all bids submitted in a round must satisfy the constraints that bid amounts:

- cannot exceed clock prices

- must be above any relevant reserve price; and
- must satisfy revealed preference constraints arising from rounds in which the bidder reduced eligibility (which are analogous to the relative caps used in a CCA).

Constraining bids to not exceed clock prices ensures that bids are increased progressively, if required in order to outbid competitors.

Closing rule

Unlike the clock stage of the CCA, the CMRA does not end when there is no excess demand at clock prices (from headline bids). This is important, because the CMRA does not include any further stages, and hence bidders must submit all of their bids during the clock rounds. Instead, the CMRA ends when it is possible to accept one bid from each bidder (which can be a bid for zero lots if the bidder made a zero headline bid, but not otherwise) and this achieves the maximum possible value (relative to accepting bids without necessarily including a bid from each bidder).

One implication of the closing rule is that bidders always have an opportunity to bid back if they are not winning with one of the bids they have submitted. Therefore, bidders have less pressure to make bids for all possible targets, and can instead introduce these progressively in response to changes in the clock prices. Another implication is that the auction might end even if there is excess demand at clock prices, if it were possible to achieve the maximum possible value by accepting a bid from each bidder without necessarily including all the headline bids. This is can help to resolve coordination problems where the headline bids from different bidders clash on the same lots, but where such bidders would be equally happy to acquire different lots instead in a way that would allow for accommodating demand from all bidders.

The closing rule also implies that the auction might continue even if there is no excess demand at clock prices i.e. in the case where bids at clock prices would be outbid by other bids, requiring some prices to increase. Therefore, determining whether any lots require a price increase (and hence whether or not the auction ends) does not simply rely on assessing excess demand at current clock prices. Instead, the CMRA determines which lots need a price increment by checking which bidders would be at risk of losing, and then determining the lots for which demand at clock prices from these bidders clashes with the bids from other bidders.

Assessment of the CMRA for this award

The CMRA is similar to the CCA in that it is effective in allowing bidders to flexibly represent in their bids a range of values for packages spanning different combinations of lots over a number of lot categories. A key difference between the CMRA and the CCA is that the CMRA has the desirable property that bidders pay the amount of their winning bids, though these amounts are determined by competition with other bidders. In constrast, with the CCA a bidder bidding straightforwardly could make a bid for a package of lots, but end up paying less than this due to the second price rule. Therefore, the CMRA may be more appropriate than the CCA if some bidders could be budget constrained.

With a single item, the CMRA is exactly the same as the proposed clock auction with exit bids (since an additional bid can only be submitted when dropping demand from one to zero, and the bid amount is restricted to be between the previous round price and the current round price). With multiple lots in a single category, the CMRA can offer additional flexibility over the bids that can be submitted for different numbers of lots. However, as with the CCA we do not consider the benefits of this flexibility to be sufficiently great to recommend the CMRA over the clock auction with exit bids.

Overall, we conclude that the CMRA would work for this award, but we do not consider the benefits of using it justify the additional complexity relative to the clock auction with exit bids.

7.3.3 Determining specific frequency assignments

The spectrum reserved for smart grid will be frequency-specific (410 – 413 MHz), and therefore the location of the spectrum in the band is predetermined before the auction. For the remainder of the spectrum, however, we are proposing to first award this as frequency-generic lots (using the clock auction outlined above). That is, winners will be awarded a specific number of lots, but they will not at that stage know where in the band their frequencies will be located. We therefore need a mechanism for determining the specific frequency assignments for winning bidders.

In recent previous auctions run by ComReg where spectrum is initially assigned as frequency-generic lots, ComReg has run a follow-up assignment stage in which bidders were able to submit bids for the different possible positions in the band they could be allocated (subject to some constraints). This is appropriate in settings where bidders may have value differences over being located in different parts of the band (e.g. to coordinate with the tuning range of existing equipment, or because certain frequencies have interference issues with adjacent users). In this case, bidders are able to express these preferences in their assignment stage bids and compete for the frequencies with other winners who might have conflicting preferences.

Where there is no difference in the value of different frequencies within the available spectrum, a competitive assignment process is not necessary. At present we are not aware of any material differences in the value of various locations within the (open) spectrum, and we therefore consider that specific frequencies could be assigned by ComReg through a random selection process (most likely determined algorithmically), subject to:

- all winning bidders being guaranteed a contiguous block of spectrum; and
- any additional spectrum being won in the second auction by the winner of the smart grid lot being automatically place next to the smart grid spectrum.

If there are valid reasons presented in the responses to the consultation to suggest that potential users might have material value differences across different frequencies within band, this recommended approach may be revised to incorporate an assignment bidding process.

8 Summary of recommendations

This section provides a consolidated list of our recommendations:

- 2x3 MHz of spectrum should be reserved for smart grid, for which only qualified utilities may apply. We suggest that this is positioned at the lower end of the available frequencies (410-413 MHz).
- The remaining (open) frequencies would be offered as 2x100 kHz lots. This would include the reserved 2x3 MHz if there is no demand for smart grid, meaning there would be either 25 or 55 2x100 kHz lots available in the award.
- We propose to allocate the open spectrum initially as frequency generic lots, and then determine the specific frequency assignments in a follow-up assignment process.
- A licence duration of 15 years would seem appropriate.
- The reserved spectrum should be subject to a usage condition that requires the licensee to use the spectrum for operating a smart grid network. The open spectrum can be offered on a service and technology neutral basis.
- Measures to ensure fair access to the smart grid network may be required, but this would be more appropriate via ex post application of competition law (if necessary) rather than by imposing ex ante obligations.
- Minimum prices should be aimed at reducing incentives for frivolous or vexatious bidding and covering ComReg's administrative costs in relation to the licences. We consider that €240,000 for the smart grid spectrum and €8,000 per lot for the open

spectrum would be suitable reserve prices for the auction. We propose annual spectrum fees of €39,000 for the smart grid spectrum and €1,300 per lot for the open spectrum.

- We do not see need for any spectrum competition caps in this award, given the wide range of minimum bandwidth requirements for the potential uses and the expected limited impact of the award on downstream competition.
- Assigning the spectrum using an auction mechanism would be more appropriate than an administrative assignment, given the uncertainty over the potential uses and value of the spectrum.
- We recommend running two sequential auctions; the first to award the reserved smart grid spectrum, and the second to assign the remaining open spectrum.
- The auction format should include an open stage (to allow for price discovery and mitigate the risk of an inefficient outcome due to bidder error) and support package bidding (to eliminate aggregation risk). It should also support the initial award of spectrum as frequency-generic lots.
- We recommend using a clock auction with exit bids and a combinatorial closing rule; this meets the criteria identified above and is a very simple format for bidders to understand. The CCA or CMRA would also be suitable for this award, but we do not believe that the benefits they would offer over the proposed format would be sufficient to justify the additional complexity.
- We are not aware of any material value differences across the frequencies within the available spectrum, meaning that a simple random assignment process can be used to establish frequency assignments for winners of the (frequency-generic) open lots. This

process should guarantee contiguous assignments to all winners.