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DS3 System Services auction design report

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Executive Summary

The SEM-Committee's Decision 14-108 ('the SEM-C Decision') sets out a high-level auction design framework for system services. The proposed auction design has been developed in the context of the Integrated Single Electricity Market (I-SEM), which is anticipated to be operational and replace the current SEM in Q4 of 2017[1]. It aims to encourage greater supply of system services to support system security by providing a degree of revenue certainty for new investment.

In this report we develop proposals for how these auctions might work, outlining reasons for specific design features and giving alternatives where appropriate. The proposals have been informed and benefited from extensive discussions with the TSOs, but form our independent view of a practical approach to the auction design. As far as possible, we develop our proposals *within the framework set out in the SEM-C Decision.*

SEM-C high-level framework

Key aspects of this framework are that:

- payments to providers of system services should be on the basis of availability, rather than whether the TSOs actually draw upon those services (e.g. by calling for reserve);
- long-term contracts should be available to provide revenue certainty to encourage investment, but only for new system services providers;
- existing capability should contract to supply system services for a year (thereby requiring annual auctions);
- bids should allow for the possibility of supplying a bundle or 'package' of different system services (as some providers will be able to jointly supply a number of system services);
- a clearing price should be established for each system service that applies uniformly to all auction winners.

There are some aspects of the SEM-C's proposed approach that may be problematic for the design of such an auction. As a result, our proposals make limited adjustments to the SEM-C Decision where we consider that an alternative approach would better achieve SEM-C's objectives; such adjustments are clearly signposted and justified.

[1] SEM Committee, October 2015, I-SEM Project Plan Quarterly Update: October 2015, 1.2.

Contractual obligations

The auction needs a clear definition of the contractual commitments that auction winners take on and the payment basis that applies to providers of system services. Furthermore, it is possible that auction losers could in some circumstances be called upon to provide system services; these circumstances and the associated payment terms need to be defined in order for winners to evaluate the *relative* benefits of winning against losing in the DS3 System Services auction ('the SS auction').

Payment basis

Under our proposed auction design (and consistent with the SEM-C Decision), winners of a DS3 System Services contract ('SS contract') are paid for system services whenever they are available, that is, whenever the relevant system services are technically realisable either at the market position or at the dispatch position. It should be noted that uncertainty is inherent to this payment basis for both providers and the TSOs, as availability is determined in real time and can only be estimated at the time of the SS auction.

In order to provide appropriate bidding incentives in the auction, providers without a SS contract should expect to receive strictly lower payments than winners of the SS auction when constrained on or down by the TSOs. Winners and losers cannot be in the same situation after the auction if bidding is to be meaningful.

Throughout this report, we simplify by assuming that losers do not receive any system services payments through the DS3 System Services mechanism, though may participate in the balancing market and are subject to Grid Code obligations. Therefore, there is an implicit assumption that the volume of system services procured through the auction is sufficient that it would not typically be necessary to call upon auction losers to provide system services (especially reserve) other than in exceptional circumstances.

Contractual obligations

Under our proposals, winners would take on a degree of commitment to be available for the services contracted for, when needed by the TSOs, in addition to existing commitments (e.g. Grid Code requirements). Without some commitment, SS contracts could give winners a valuable option to supply system services only when they choose, without any corresponding downside; this would not create an incentive to place cost-reflective bids, the auction may be largely meaningless and awarding SS contracts might have little tangible impact in practice. Furthermore, with an approach based on no commitment on SS contract holders, some technologies may be favoured and alternative technologies could be disadvantaged.

Different approaches are possible for defining the contractual obligations falling on winners. We propose some options that should strike a reasonable balance, resulting in a degree of commitment that is stringent enough for an auction to be meaningful, without being excessively onerous for providers by exposing them to excessive risk that would ultimately need to be reflected in the cost of awarding SS contracts.

We note that firm commitments on SS contract holders to make system services available to the TSOs at all times might work well in combination with more frequent auctions, but less well with an annual auction that procures system services well in advance of the TSOs' actual demand for system services being realised; this could create risks for bidders that may complicate their decisions about how to bid and possibly raise the costs of SS contracts.

Proposed commitments for SS auction winners

For reserve services, we propose that SS auction winners must:

- either take up a market position such that the contracted volumes of system services are technically realisable from that position;
- or, in the event that the volumes of system services that are technically realisable from the market position falls short of the contracted volumes, submit Balancing Mechanism (BM) offers that allow the TSOs to increase the volume of system services available from that provider through non-energy actions, including up to but not exceeding the contracted volumes. The price at which these BM offers are made is subject to conditions stipulated in the system services contract (but does not require any modification of the BM rules).

For reserve services, some technologies face a trade-off between taking up a market position to earn reserve payments (i.e. part load) and taking up a market position to earn higher energy payments (e.g. full load). In such cases, a SS contract holder that takes up a full-load market position must make decrement (DEC) offers at a predetermined price level that allow the TSOs to constrain it down to provide additional reserve. We propose that the price level for the required DEC would be a suitable proxy for the real-time energy price (exactly how this proxy is defined would need to be determined by the TSOs and form part of the contract with the provider).

Additionally, for some technologies reserve is not technically realisable when the provider is out of the market schedule. In such cases, a SS contract holder would have to submit an increment (INC) offer up to its minimum generation level, allowing the TSOs to constrain it on to increase the volume of available reserve. We propose two alternative price levels at which winners could be required to make these INC offers:

- at the energy price (this would make the requirements symmetric to the DEC case, but might be onerous because units could be required to turn on at a substantial loss at that point); or

- at the provider's costs (assuming a suitable proxy for cost is available) minus the system services payments it would receive following the TSO action (this would give the provider a zero payoff if constrained on).

These alternatives lead to somewhat different allocations of risk between the TSOs and the contract holder.

With contractual obligations defined in this way, providers that can be available for the contracted amount of reserve even when not in the schedule, for example some alternative technologies, are not required to make any such INC offers.

For non-reserve services that are technically realisable whenever providers are exporting – regardless of the volume of energy being exported – there would be no requirement to make specific DEC bids. It would be possible to require INC offers at a predetermined level, as above, though similar questions arise as for reserve services about how onerous these obligations should be. Nevertheless, the broad principle that the providers would enter into contracts with certain defined obligations to supply these services would still apply.

Benefits of proposed approach

These proposals should allow different technologies to compete on a broadly equivalent basis and should mean that providers who are well placed to provide system services (e.g. those that are often 'marginal' in the energy market) are relatively competitive in the SS auction. The general principle is that, having assigned a contract for DS3 services by auction, the TSOs would expect to be able to draw on those services when needed at no (or at least at controlled) marginal cost, because the provider had already been compensated for the risk of being asked to supply those services through an availability-based payment. Furthermore, obligations on conventional providers to make certain balancing market bids would not require any change to the balancing market mechanism; this could be implemented entirely through contractual obligations on SS contract holders.

Volume requirement

In the simplest case, a single total volume requirement could be specified for each service. The volume requirement would be additive, in the sense that quantities from winning bidders can simply be added together in order to produce a total value that satisfies the volume requirement. Therefore, this approach would not take account of any constraints (for example transmission constraints) that would require specific providers or groups of providers to supply system services.

Flexibility

The volume requirement should allow some flexibility. In particular, rather than having to procure a certain target quantity regardless of cost, it may be possible to somewhat scale back requirements if this led to a much lower clearing price. This may be a useful countermeasure against market power.

Granularity

While the TSOs will ultimately decide on granularity based on their volumes analysis, there may be benefits from specifying more granular volume requirements, rather than a simple total requirement.

Two possible options for volume requirement granularity are:

- locational granularity (e.g. specify a volume requirement for Northern Ireland and one for Ireland prior to completion of the second North-South Interconnector); and
- technological granularity (e.g. specify a volume requirement for synchronous and one for non-synchronous generation).

Satisfying these more granular volume requirements could ensure that the volumes procured in the auction closely match the real-time requirements, avoiding undesirable outcomes – e.g. procuring disproportionately large volumes of a service from providers in Ireland, or from providers using synchronous generation.

A further refinement would be to specify volume requirements for different time periods (e.g. off-peak and on-peak, which could be defined in terms of season and time of day). This could have similar efficiency benefits, but only if the estimated worst-case scenario differs substantially across time periods. On the other hand, if the main factor underlying the worst-case scenario is the degree of non-synchronous penetration caused by factors (e.g. wind) that are largely unpredictable regardless of time period, then there is little benefit from time period granularity.

Whenever a granular volume requirement is set (e.g. Ireland/Northern Ireland), there are two options for the setting of clearing prices. One approach is to set a single clearing price, but this will mean that the less competitive category (e.g. Northern Ireland) will set the price for all categories. In the more competitive categories, there may be 'unhappy losers' that lose with bid amounts that were more competitive than the final clearing prices. Alternatively, separate clearing prices could be set for each category, which is likely to be more efficient but might be perceived as discriminatory.

Any benefits from volume requirement granularity should be weighed against the costs of increased auction complexity and the risk of producing an overly prescriptive outcome. Some constraints (e.g. transmission constraints) may be expected to diminish over time and it may not be necessary (or practical) to reflect the full complexity of real-world constraints within the auction. However, setting a very simple total volume requirement might lead to over-procurement of system services, in the sense that the failure to consider real-world constraints would require a higher volume requirement to be set for precautionary reasons.

Bids

The SEM-C Decision has already indicated that it expects each plant to provide separate bids, rather than bids being made on a portfolio basis across multiple units.

We propose to use *package bidding*, where each package bid specifies volumes for a number of system services that will be jointly supplied and a single overall price for the package. Bidders may submit a number of such package bids. A bidder could only win one of its package bids in its entirety or no package at all. A package bid will not be subdivided, so where a provider can make an investment to supply a number of system services there is no risk that it would supply some, but not all of these services.

Bid parameters

Formally, the package bids submitted by a bidder would be mutually exclusive. Each bid would specify the following parameters:

- for each service i, the quantity q_i for that service included in the package (e.g. MW of reserve of a specific type) setting the maximum amount of that service that the bidder would be willing to supply at any point in time;
- for each service i, the expected availability α_i for that service (e.g. as a percentage over the year, i.e. number of hours expected to be available divided by 8760);
- β – one overall bid amount for the entire package (an hourly amount, though it is also possible to require an annual amount), which is not a price per MW but one for all services included in positive quantities in the package; and
- contract length and lead time, if the bidder is eligible for a long-term contract.

The revenues that a bidder will ultimately receive depend both on the quantity and availability for the service, as well as on the clearing price for that service, which will be determined by the auction mechanism. Therefore, even with package bidding, a bidder still faces uncertainty over the total revenue it will receive depending on the clearing price of individual services. This is not resolved by allowing bidders to state individual bid amounts for each service in a package, as there may be many combinations of bid amounts that generate the same overall revenue for the package.

For this reason, it is desirable to allow bidders to express their expected availabilities such that these are taken into account by the winner and price determination process, insuring bidders against the risk described above. With the algorithms for winner and price determination we propose, winners are guaranteed that individual clearing prices are such that the availability-weighted quantities multiplied by the clearing prices give a total that is at least equal to the stated bid amounts (i.e. a bid will only be accepted if $\Sigma\alpha_i p_i q_i \geq \beta$, where p_i is the clearing price for service i). Therefore, bidders can guarantee that a package bid, if accepted, will earn total expected revenue at least equal to its bid amount provided that expected availabilities for the different services are achieved.

Bidding incentives

This mechanism provides good incentives for bidders to state their cost (through the bid amount) and expected availabilities truthfully. Deviating from this would expose bidders to the risk of winning a contract at clearing prices that are too low, with no significant benefit. To the extent that unanticipated changes lead to winners providing less than their stated availabilities in their winning bids, they will be paid less under the availability-based payment model. If they exceed their stated availabilities, this is primarily a budget control issue for the TSOs. If the TSOs wanted to lay off this risk, some claw-back mechanism could be used, though this would increase risks for providers and be reflected in higher bids and clearing prices.

Winner and price determination

We propose a two-step process to determine winners and prices. Determination of winning bids occurs first, with prices then being determined to support that winning outcome.

A winning combination of bids would be found by determining the outcome with the lowest possible sum of winning bid amounts that satisfies all volume requirements.

Uniform clearing prices for each service are then found which are as consistent as possible with the winning outcome being market clearing at these prices. This means setting prices such that each winning bid will receive expected revenue at least equal to its bid amount (making all winners 'happy') while minimising the extent to which clearing prices are high enough that losers are 'unhappy' (i.e. they would have wanted a losing bid accepted at the clearing prices).

Long-term auctions

The SEM-C Decision envisages distinct treatment of new and existing System Service providers. Long-term contracts will only be available to those supplying new capability, which potentially could be a new plant or an incremental investment to an existing plant. Long-term contracts are intended to provide a degree of revenue certainty and thereby to encourage new investment.

Treatment of short- and long-run requirements

One-year contracts for the first year, served by existing capability, and long-term contracts for future years, served by new investments subject to a lead time, contribute to meeting volume requirements over distinct timeframes.

A combined auction that evaluates existing and new capability bids together (e.g. by simply totalling volumes) appears conceptually flawed, given that their contract periods do not overlap and therefore the bids are not substitutable. New capability can only provide system services with some lag, so it cannot contribute to short-run volume requirements, whereas existing capability only meets short-run requirements, as it is prevented from bidding for long-term contracts.

Proposal for separate auction processes

We therefore propose to separate the auction processes for these two types of contracts. The auction mechanism described above works similarly for both annual and long-term contracts and the TSOs would need to determine how to divide the budget/volume between existing and new capability.

The auction for long-term contracts would establish a separate set of clearing prices based on which successful new investments are then paid for the duration of their contract. If practical and for simplicity, it may be preferable to clear the auction against a single future volume requirement (e.g. for five years ahead). In order to make bids comparable, it would be necessary to define how different contract lengths and lead times are assessed, as well as any discount factor that is applied to expenditure in future years. These parameters would need to be fixed prior to the auctions to allow bidders to make informed decisions.

New investments would receive substantial revenue certainty from having guaranteed clearing prices over the contracted period. Though the SEM-C Decision envisages offering new investments the opportunity to request a firm minimum revenue guarantee, this may be unnecessary and could even be detrimental for the following reasons:

- If providers were able to receive guaranteed revenues even when their actual availability is much lower than expected (in the extreme case, zero), there would be a clear risk that they are not incentivised to make themselves available.
- Additionally, it might create new strategic bidding incentives (e.g. bidders submitting very competitive bid amounts in combination with high minimum revenue requirements) and add unnecessary complexity to the bid evaluation process.

We assume that the TSOs do not necessarily need to procure the entire future volume requirement in any particular auction. The new investment bids received in one auction may be insufficient to fulfil a volume requirement for several years ahead, or they may be very uncompetitive. Since auctions are held annually, the procurement of future volumes may be postponed to a later auction, not least to provide fair opportunities to new capability becoming available at different times. It may therefore be desirable to introduce some flexibility in order to avoid having to accept expensive bids in the current auction, to the ultimate detriment of consumers. This flexibility could be as simple as a pre-determined maximum price the TSOs would accept for a particular service in the future. Alternatively, the future volume requirement could be scaled back at higher prices (relative to the price of annual contracts) and future volume requirements met through subsequent auctions. Any such measures would need to be transparent and implemented through rules announced prior to the start of the auctions.

Adjustments to SEM-C's approach

Some of the aspects of our proposed auction design do not fully correspond to the SEM-C's Decision and its emerging thinking, while other aspects are not specifically mentioned by the SEM-C. We set out these issues in Table 1 below. However, we note that the SEM-C acknowledges, "*that the design of the auction set out in [the Decision] is essentially a framework. Changes may be required to the auction design during the detailed design phase.*"[2]

[2] SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), §95

Table 1: Comparison of our proposal and the SEM-C's

Design feature	SEM-C Decision/Emerging thinking	Our proposal
Payments for losers	Losers receive clearing price for any volume of services provided while 'constrained on'	Losers are paid less than the clearing price
Contractual obligations	No mention of commitment for winning existing capability	Obligation for winners to make certain BM offers
Separate long-term auction	Suggestion that existing and new capability bids are evaluated together in a combined auction	Separated auctions
Bidding parameters	Price and capability for each service, also contract length for long-term	Volumes and availabilities for each service, one package price
Winner determination	'Least-cost outcome'/ Bid-stacking approach	Optimisation (separate from price determination)
Pricing	Pay-as-clear, uniform price per service	Uniform prices that are closest to supporting the efficient outcome
Minimum revenue requirement	Option available to new investments, winners are guaranteed the amount	Not needed given availability-based payments
Volume requirement	No mention of granularity	Capability to incorporate locational and technological granularity

1 Introduction

In order to set the context for the remainder of the report, this section introduces and briefly discusses the key auction design elements of the December 2014 SEM-C Decision Paper.

We also discuss the inclusion of the different types of system services in the auction.

DS3 System Services auction objectives

DS3 ('Delivering a Secure, Sustainable Electricity System') was launched by the TSOs in 2011 in order to ensure secure operation of the system in light of the significant increase in renewable energy generation, in particular wind, which is needed to achieve the 2020 renewable electricity targets in Ireland.

In its July 2014 consultation, the SEM Committee (SEM-C) defines the aim of the system services review as follows:

"The aim of the system services review is to put in place the correct structure, level and type of service in order to ensure that the system can operate securely with higher levels of intermittent wind penetration (up to 75% instantaneous penetration)."[3]

For this purpose, the December 2014 SEM-C Decision Paper[4] (hereafter, 'the SEM-C Decision') sets out a framework for an auction of these services. This annual DS3 System Services auction ('SS auction') is likely to play a pivotal role in promoting the objectives of the system services workstream. The SEM-C sets out its vision for the procurement design in its Decision:

- *"[to] encourage the development of competitive markets for all system services, ensuring best outcomes for consumers;*
- *[to] attract new investment, enhancing the performance of the system; and*
- *[to] facilitate the increase in the SNSP to 75%."*[5]

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[3] SEM Committee, July 2014, DS3 System Services Procurement Design, Consultation (14-059), page 6.

[4] SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108).

[5] SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), §53.

To achieve this, a regulated tariff will apply to all system services by October 2016. From October 2017, services that are deemed sufficiently competitive will be procured by means of an auction, with detailed auction rules to be proposed by the TSOs.

Key aspects of SEM-C Decision

The SEM-C Decision sets out a high-level framework for auctioning sufficiently competitive DS3 services based on the following principles:[6]

- "*Mandatory, sealed-bid, pay-as-cleared, instantaneous auction*
- *Multiple, mutually exclusive bids permitted*
- *Each bid includes price and capability for each service, provides a set of mutually exclusive outcomes for the auction*
- *Bids may include a minimum annual revenue requirement, if successful the TSO will guarantee to pay at least that revenue regardless of the provider's actual dispatch*
- *Required volume for each service fixed in advance*
- *Least-cost outcome is selected, results in individual uniform prices for each service*
- *Units decide contract length when bidding, existing capability of unit must be included as a bid with a fixed one-year contract*"

The SEM-C states that this auction design is *"intended to provide price discovery for each service and allow for the efficient allocation of long term contracts."*"[7]

The auctions will be held annually, starting from 2017. Existing units can bid for one-year contracts, whereas new investments or enhancements of existing capability can bid for contracts of up to 15 (and in exceptional circumstances 20) years. These long-term bids include a maximum lead time *"of the order of five years*[8]".

In addition, the SEM-C has published an expenditure cap limiting the total annual payments to be made under the DS3 system services auctions. There is a separate consultation on the

[6] Ibid, §94.

[7] Ibid, §97.

[8] 8 Ibid, §159.

methodology for estimating volume requirements[9]. The volume requirements for each service will be fixed prior to the start of the auction.

In order to evaluate bids, the SEM-C proposes to stack all offers in ascending order of price and thus set a clearing price for each service according to the published volume requirements (though such a simple stacking procedure is not easily applicable where bids include a bundle of system services, an issue we consider subsequently in Section 6.) Given these clearing prices, the SEM-C then proposes to find the least-cost outcome by removing bids in turn and checking whether the resulting clearing prices reduce the overall cost of procuring sufficient system services.

Contractual basis for supplying DS3 System Services

As well as these detailed elements of auction design listed above, the SEM-C has made two broad choices about the nature of the contractual arrangements for supplying system services:

- for all services, it has been decided that payments should be made on the basis of availability (i.e. whenever a system service is technically realisable from a provider, not whether that service is being actually supplied to the TSOs at that point in time); and
- the SEM-C has stated a preference for not requiring firm commitments from SS auction winners that would oblige them to supply contract services in all circumstances (including an obligation to position themselves in the market to be able to supply those system services).[10]

These two important choices will be the focus of our discussions in Sections 2 (payment basis) and 3 (contractual commitments). Paying on the basis of availability is intended to incentivise providers to make themselves available to supply system services, as otherwise they may not receive a payment. Therefore, it is implicit to this payment model that holders of a DS3 System Services contract ('SS contract') retain some discretion over their

[9] EirGrid and Soni, October 2015, Consultation on Volume Calculation Methodology and Portfolio Scenarios.

[10] Referring to the high-level decision (SEM-14-108), the Committee clarified that "*This approach is in contrast to other markets, such as BETTA, where system services are procured as firm contracts where the generator must position themselves to provide the services. … The approach adopted in BETTA is more suited to a self-dispatch as opposed to a more centralised market like I-SEM.*" SEM Committee, April 2015, Energy Trading Arrangements Detailed Design, Markets Consultation Paper (15-026), page 6.

choices about supplying system services. There is an interplay between the firmness of contractual obligations and incentives: the greater freedom a provider has to choose if, when and how to make itself available, the greater the role of incentives will be in determining its choices.

Availability payments and uncertainty

The approach set out in the SEM-C Decision has significant implications for the auction design. Actual availability is not known in advance but rather is determined jointly by actions of the TSOs and providers, after the system services contracts have been awarded. However, some expectations about availability – whether formed by the auctioneer or bidders and whether implicit or explicit – must be formed within the auction mechanism, otherwise it is not possible to assess whether an outcome meets the TSOs' requirements and what the likely expenditure implications may be.

The uncertainties of forecasting availability become more problematic the weaker the contractual obligations are on system services providers and the more discretion they have over their supply choices.

Firm commitment alternative

These problems can always be resolved by requiring firm commitments from providers to supply their contracted volumes of system services under all reasonable situations (such as under BETTA). Put simply, the TSOs would know what they were getting when they contracted with a provider, so could easily determine whether their requirements would be met or not, and what the cost implications would be. However, the firm commitment approach would not easily allow long-term contracting without creating significant risks for providers (in that they would need to forecast the consequences of their commitments far into the future) and potentially increasing costs to the TSOs and ultimately consumers. The SEM-C Decision has ruled out this firm commitment approach and instead opted for availability-based payments as being more likely to encourage investment.

Need for some commitment

Nevertheless, in order for a SS contract to be more than an empty shell, some kind of obligations on providers to make themselves available to supply system services seem to be necessary. Achieving an appropriate balance of rights and obligations within SS contracts is also important for establishing reasonably neutral competition in provision of system services between different technologies. As the obligations can fall well short of firm commitment, we call our proposed approach 'contingent commitment'. For example, a contingent-commitment approach might require that a provider offers availability to the TSOs on certain terms for the TSOs to draw on when needed, but not require the provider to be in merit at all times.

Services to be included in the auction

The auction mechanism has been designed to allow the inclusion of any system service for which a volume requirement can be specified and for which bids can be aggregated to meet that requirement.

We illustrate the incentives likely to be faced by providers and the mechanics of the SS auction for two types of services: reserve services and inertial response services. Other services (DRR, SSRP, FPFAPR) are similar to inertial response services in that they can only be delivered by providers who are exporting; given this similarity, these services are not discussed in great detail here[11].

Reserve services

The majority of services to be included in the auction can be classed as reserve services, including the relatively fast reserve services (POR, SOR, TOR1, TOR2, RRS, RRS) and the slower ramping services (RM1, RM3 and RM8). On the other hand, SIR and FFR, for the purposes of this report, are classed as inertial response services.

In general, conventional technologies using fossil fuels are only capable of providing the faster reserve services when exporting at part load, though they may be able to provide slower reserve services (e.g. RM8) even if not currently exporting where these allow sufficient time for the generator to start up. On the other hand, non-conventional technologies (e.g. battery storage, Demand Side Response (DSR) when consuming) do not face this trade-off for faster reserve services.

Inertial response services

FFR, despite being an inertial response service, has similar characteristics to POR (though with a yet faster response time), in that for most technologies it could only feasibly be provided from a part-loaded position.[12] Therefore, for the purposes of the auction it can generally be treated similarly to reserve services.

SIR differs from reserve services in that there is no relationship between the volume of energy being exported by a provider at a

[11] An auction is not necessarily the appropriate mechanism to ensure system security with respect to certain services. In particular, the *Consultation on Volume Calculation Methodology and Portfolio Scenarios* states that for DRR and FPFAPR the additional volume requirement is *"simply the capacity of any new non-synchronous generation connected"* (Section 2.6 of the consultation, available at http://www.eirgrid.com/site-files/library/EirGrid/DS3-System-Services-Consultation-on-Volume-Calculation-Methodology-and....pdf). In this case it seems more sensible to include a requirement for such new generation to provide DRR and FPFAPR.

[12] A notable exception may be wind generation, which could be able to provide some volume of FFR even when exporting at full-load. For the avoidance of doubt, some technologies such as batteries could also provide FFR from a no-load position.

particular time and the volume of inertia that it provides, as long as the provider is exporting. A provider's inertia capability (measured in terms of kinetic energy) does not vary with output. This simplifies its treatment in the auction; for the provision of SIR, it is irrelevant whether a provider is full- or part-loaded, only whether the provider is exporting.

Because of the trade-off faced by some providers between the volume of energy being exported and the volume of reserve that can be provided, reserve services can be more complex than SIR from an auction design perspective. Therefore, throughout this report we pay particular attention to the case where reserve services are provided by a conventional generator that must be exporting at part-load in order to be available.

Inclusion of services with market power

In combinatorial auctions with package bidding, bids are made for packages of services that are accepted or rejected in their entirety; a package cannot be split so that only some of the included services are procured from that bidder. This has the great advantage that bids can reflect the cost synergies of providing different services together (e.g. reserve services on different timescales).

Risks related to market power

However, with package bidding there is a risk that providers with some market power in the provision of a particular service might be able to win with a rather uncompetitive bid, leveraging their market power to provide other services. Specifically, if a provider knows that its offer is likely to be accepted in order to meet the volume requirement for one particular service, it can simply include this service in all of its packages. Even if the overall bid amounts are uncompetitive, a package is likely to be accepted because this is necessary to fulfill the volume requirement for the one service where the provider has market power. The bidder may then end up supplying other system services that it would not have been competitive enough to supply, had it not leveraged its market power.

Therefore, in a combinatorial auction the distortionary impact of a bidder having market power may not be limited purely to higher prices for the uncompetitive service, but also may affect who supplies other services as well.

Mitigation measures

There are several possible ways to mitigate this problem of leverage from uncompetitive services:

- services deemed uncompetitive might not be included in the auction;
- such services might be included in the auction but not as part of package bidding;

- there might be bidding restrictions imposed to ensure bidders also bid on packages that exclude particular services.

We would suggest excluding any services with significant market power from the auction and rely on a regulated tariff for these services. For example, these could be services where all or almost all providers of these services would be required as winners to satisfy the volume requirement. The benefits of including such services in an auction are most likely negligible, but the potential for distorting the outcome for other services could be substantial.

Services for which there is limited competition could be included in the auction, but bidders would not be allowed to include them in their package bids to prevent leverage of the type discussed above. Bidders would submit separate, standalone bids for these services instead.

Scope of this report

The auction design has been developed in the context of the Integrated Single Electricity (I-SEM), which is anticipated to be operational and replace the current SEM in Q4 of 2017[13].

Our remit is to make proposals for design of an auction for system services that implements the approach outlined in the SEM-C Decision. We cover the following issues:

- auction design framework and methodology;
- bid criteria and the bidding process including rules, specifications, guidelines and risks;
- market power and sealed bid interaction;
- evaluating bids and resolving the auction;
- guidelines on pass/fail criteria for the bids (definition of a failed auction);
- implementation issues including scalability and integration into an IT platform;
- contractual details for annual and long-term auctions; and
- interaction with other projects.

The SEM-C Decision and this report

In this report we discuss the above requirements, as far as possible *within the proposed framework set out in the SEM-C Decision.* This introduces a number of limitations for the choice of auction design

[13] SEM Committee, October 2015, I-SEM Project Plan Quarterly Update: October 2015, 1.2.

features that may mean that the proposed auction mechanism has certain inefficiencies.

In particular, we note that aspects of the SEM-C proposal, such as holding an annual auction for system services, paying on the basis of availability and favouring relatively weak contractual commitments, appear to rule out alternative procurement models that have been adopted elsewhere (e.g. BETTA, or the German model). Our report does not include a full assessment of the SEM-C's overall framework compared to alternative models that have been adopted in other markets.

Whilst we attempt to maintain consistency with the broad framework set out in the SEM-C Decision, there are some aspects of the SEM-C's proposed approach that we have adjusted in our proposals, where doing so seems to be in line with the SEM-C's overall objectives. Such adjustments are clearly signposted and justified.

Structure of following sections

In **Section 2**, we examine certain fundamental aspects of the DS3 system services market design related to the payment basis for system services. This includes the interactions between the system services market and other markets under the new I-SEM framework. Understanding these fundamental issues is a necessary prerequisite for consideration of the auction design.

Section 3 focuses on the nature of the system services contracts and the degree of commitment, if any, that they require from SS auction winners to provide system services under various contingencies. We set out three potential models of commitment, which we term 'no commitment', 'full commitment' and 'contingent commitment', in each case examining:

- the contractual obligations;
- their effects on other markets;
- the bidding incentives in the SS auction;
- the impact on the volume requirement; and
- the impact on TSO expenditure.

We show that the contingent-commitment model is the most conducive to an effective annual auction that supports the DS3 objectives.

Adopting the contingent commitment, we set out a general auction mechanism for an annual auction, initially focusing on existing capability. We analyse the key elements of the auction mechanism, which include:

- the volume requirements (**Section 4**);
- the bidding parameters (**Section 5**); and

- the determination of winners and prices (Section 6).

The general auction mechanism that we set out is also compatible with the allocation of long-term contracts to new investments, though long-term contracts involve some additional considerations that we discuss in Section 7. We consider how the volume requirements, bidding parameters and winner and price determination would apply to long-term contracts and make recommendations that should ensure that the auction mechanism deals adequately with new investments as well as existing capability.

Section 8 considers how interconnectors might be included in the auction and what obligations they might have.

Finally, Section 9 discusses practical issues related to auction implementation.

All sections begin with a box summarising the findings of the subsequent part, in order to allow readers to see the key points at a glance.

2 Payment basis

Key points

Defining the payment basis is necessary in order to design an effective auction.

Availability-based payments, as decided by the SEM-C, are inherently uncertain. Availability depends both on the actions of providers and of the TSOs. This payment basis creates uncertainty in the context of an annual auction, as availability cannot be precisely known in advance.

Our interpretation of availability is based on the maximum technically realisable volumes of system services from a provider, either at the market position or at the dispatch position. Therefore, availability can only increase or remain the same as a result of TSO non-energy actions (where providers are constrained up/down for reasons related to the supply of system services), but never decrease.

System services payments are expected to interact with other markets. Anticipated system service payments could affect the market position that providers choose to take up and might also be factored into Balancing Market (BM) bids. For new investments, system service revenues and Capacity Remuneration Mechanism (CRM) revenues may also be closely related.

The system services payment regime for SS auction losers is important. Our interpretation is that losers would only be paid when they are made available for system services by a TSO non-energy action. We recommend that, in such cases, losers be paid strictly less than winners (e.g. they receive a share of the auction clearing price). Otherwise, winners and losers would both factor in the same anticipated system service payments into their BM offers. This would risk undermining the bidding incentives for bidders in the SS auction and producing an arbitrary or inefficient auction outcome.

With availability-based payments there is uncertainty about total system services expenditure. This would be eliminated through an alternative approach (e.g. capability-based payments or availability-based payments with firm commitment). Within the SEM-C's framework, total expenditure might be managed through a regime that reduces payments to providers once they have exceeded their expected availability.

Scalars can be applied to the clearing prices set by the auction. Product and performance scalars should pose no problems in an auction context. Scarcity and volume scalars may decrease investment certainty by introducing uncertainty over winners' revenues. The exact effect of scalars depends on their detailed implementation and is therefore not discussed in great detail in this report.

In this section we explore how payments for system services on an availability basis may work in practice and set out our understanding of how payments might be made for different types of services. Defining the payment basis accurately is crucial for auction design as it is one of the key factors that determines bidding incentives in the SS auction, as well as in the energy market and the Balancing Mechanism (BM).

Availability payments and uncertainty

Adoption of an availability payment basis for the purposes of an annual auction necessarily introduces an element of uncertainty to the process, both for providers and for the TSOs. The auction will determine clearing prices annually in advance, but the actual volumes of availability to be remunerated are only determined in real time throughout the year.[14]

Providers' anticipated revenues depend on their future availability. Therefore, providers must price their bids in the SS auction on the basis of their *expected* availability over the term of the contract, which is uncertain and can only partly be controlled by the provider itself, making system service revenues uncertain. A further complexity with using availability payments is that, when prices for system services are determined by an auction, there is a degree of circularity between the clearing prices and expected availability.[15] A provider's incentive to make itself available through the market schedule depends on the clearing price, which is only determined after bids have been made. At the same time, the TSOs can only partly control availability themselves and therefore face uncertainty about the amount of system service payments that will be made to a particular SS auction winner, or to all winners in total.

These uncertainties are intrinsic to the availability-based payment model, which we explore in more detail below.

2.1 Defining availability

Fast reserve services and FFR

The SEM-C's Decision Paper states that "*the payment basis for all services will be on an availability basis*"[16]. This means that "*a provider with a system services contract will be paid for the volume of the service that has actually [sic] provided or made available in that trading period to the TSO regardless of the TSO's real-time requirement for that service.* ***The higher of a unit's market***

[14] That is, unless an extreme 'full-commitment' model is adopted, requiring all SS auction winners to be available at all times. See Section 3.

[15] Note that this complexity is absent under regulated tariffs.

[16] SEM Committee, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), December 2014 , §105.

position or physical dispatch will be used to determine the available volume*. Where a provider does not need to be physically exporting to provide a service it is considered available even when not exporting. In most cases this means that a provider must be in the market (or constrained on by the TSO) to receive system service revenues."*[17]

The definition appears to have been written primarily with reserve services in mind, where the volume of energy being exported by a provider can directly affect the volume of reserve available from that provider.

'Market position'

We note that there is some ambiguity in the term 'market position', which might for example refer to the schedule determined at the end of the Day Ahead Market (DAM) or at the end of the Intra-Day Market (IDM). Throughout this report, we will use the terms 'market position' or 'market schedule' to refer to a fully traded-out position at gate closure, after which no further trading is possible for the time period in question, but after which TSO actions in the BM are still possible.[18]

Interpreting the SEM-C definition

There are two possible interpretations for the notion of "*the higher of a unit's market position or physical dispatch*", which is critical for establishing the volume of reserve services that is considered 'available' at any particular time. Specifically, this notion could be interpreted as:

1. the higher of a unit's market or dispatch *MW* position in terms of exported energy, so that the provider is considered available for the *lower* of the reserve volume across its market and dispatch positions; or
2. the higher of a unit's market or dispatch *reserve* position, so that the provider is considered to be available for the *higher* of the reserve position across both positions.

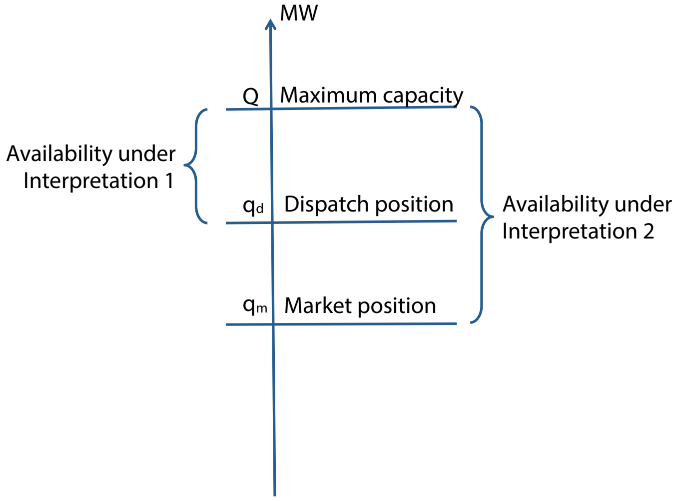
The following diagram provides an illustration of the two interpretations and their implications for the availability of system

[17] Ibid., §107 and §108; emphasis added.

[18] We understand that there are potential gaming opportunities intraday when the BM and the IDM are running in parallel as currently envisaged. For example, a provider that has to be constrained down to provide reserve in a certain location (such as Northern Ireland) can easily trade itself back up to full load in the IDM while this is still open. To prevent providers from exploiting their market power in the BM, we therefore assume that the TSOs will only constrain providers down once the IDM is closed. We acknowledge that constraining a provider on will have a longer lead time and necessary actions in the BM will therefore have to be taken before the IDM closes.

services in a scenario where the dispatch position is above the market position.[19]

Figure 1: Example of available reserve volumes



The second interpretation appears to fit the SEM-C's apparent intended meaning more closely and can be integrated coherently with an auction, as sorting of winners and losers works correctly when units need to be decremented. Under this interpretation, in the case that the TSOs need to constrain down a SS auction winner to increase reserve availability, the winner would receive payment for system services when constrained down. In a competitive BM, it will factor this anticipated payment in its BM bids (see Section 2.2 for further discussion). We therefore adopt the second interpretation of availability.

Implications of this definition

Using this interpretation means that a provider has a degree of control over its availability, because it is always considered available for at least the volume of reserve that is technically realisable based on its market position. The TSOs can increase but never reduce availability through non-energy actions that change the provider's position at actual dispatch: for example, if the TSOs require the provider to export less than its market position, the availability of reserve increases.

Availability for different technologies

A simplified summary of the payment basis using this interpretation of reserve volume is given in the table below. It is based on a conventional generator that can technically realise reserve when part-loaded but not when off or fully loaded. The conventional

[19] In this simple illustration we assume that the provider's maximum reserve capability is at least $Q-q_m$.

generator has a maximum exporting capacity Q, a market position q_m, a dispatch position q_d and a maximum reserve capability R_{max}.

Table 2: Illustrative example of a conventional generator's reserve availability

Market position (q_m)	Dispatch position (q_d)	Available volume of reserve
Full-load	Full-load	0
Full-load	Part-load	$Min(Q - q_d, R_{max})$
Full-load	Off	0
Part-load	Full-load	$Min(Q – q_m, R_{max})$
Part-load	Part-load	$Max [Min(Q - q_m, R_{max}), Min(Q - q_d, R_{max})]$
Part-load	Off	$Min(Q - q_m, R_{max})$
Off	Full-load	0
Off	Part-load	$Min(Q - q_d, R_{max})$
Off	Off	0

For a conventional generator, technically realisable volumes of FFR would be similar to those set out above for reserve. However, for some technologies, such as certain wind turbines, providers can be available for FFR even when at full load.

For technologies that are available for reserve even when not exporting (e.g. 'new' technologies such as battery storage), availability would be as follows.

Table 3: Illustrative example of a new technology's reserve availability

Market position (q_m)	Dispatch position (q_d)	Available volume of reserve
Full-load	Full-load	0
Full-load	Part-load	$Min(Q - q_d, R_{max})$
Full-load	Off	R_{max}
Part-load	Full-load	$Min(Q – q_m, R_{max})$
Part-load	Part-load	$Max [Min(Q - q_m, R_{max}), Min(Q - q_d, R_{max})]$
Part-load	Off	R_{max}
Off	Full-load	R_{max}
Off	Part-load	R_{max}
Off	Off	R_{max}

For these technologies, the table above also holds for FFR.

Ramping services

For the slower reserve services (RM1, RM3 and RM8), applying this notion of availability is relatively straightforward. For these services, any provider that is exporting energy and technically capable should generally be considered available. Gate closure for the relevant time period (X hours ahead) has not yet been determined and therefore the provider should have the opportunity to reduce its exporting output if required to do so.

For a provider that is currently off, availability depends on whether the start-up time is shorter than the time required by the respective ramping product. For example, if a generator is able to start up in less than eight hours, it would be considered available for RM8 even when off. Therefore, such a provider would be considered available for RM8 at all times (aside from periods of maintenance).

Non-reserve services

Applying the notion of availability to services other than reserve is typically more straightforward, as there is often no relationship between the volume of energy being exported by a provider and the volume of the system service available from that provider.

For example, for SIR it is irrelevant whether a provider is full- or part-loaded. A provider's inertia capability measured in terms of kinetic energy (and also a provider's minimum generation level, which is a term in the SEM-C's proposed formula for SIR) does not vary with output and can technically be realised whenever the provider is exporting. As availability is determined by the highest technically realisable volume of the service either at the market position or at actual dispatch, we consider the provider available for SIR unless it is off both in the market schedule and at actual dispatch.

Table 4: Availability for SIR

Market position (q_m)	Dispatch position (q_d)	Available for SIR?
On	On	Yes
On	Off	Yes
Off	On	Yes
Off	Off	No

Availabilities for SSRP and DRR can be defined in a similar manner as providers are usually technically capable of providing those services when 'on', regardless of load.

FRPAPR is somewhat different, in that a provider can only recover back to its pre-fault output level and therefore the service is related to the provider's load. If the 'volume' of FPFAPR were defined as the recoverable output level that can be achieved post-fault, then applying the notion of availability would mean that the available volume of FPFAPR is the highest of the market position or the dispatch position (i.e. Max(q_m, q_d)).

2.2 Availability payments and interaction with other markets

On the definition of availability set out above, the market for system services can be expected to interact with other markets, namely the energy market (DAM and IDM), the BM and the CRM. These interactions will be identified and addressed in order to achieve a SS auction design that promotes the objectives set out by the SEM-C and avoid any unintended consequences.

Interaction with the energy market and the BM

Energy payments made to providers in the market schedule are understood to be final at the point of gate closure and are unaffected by any subsequent TSO non-energy actions in the BM. We assume that the TSOs will use non-energy actions in the BM to ensure that there is sufficient availability of system services at actual dispatch.[20]

Non-energy actions in the BM

For reserve, this could mean:

- constraining down providers that are in the market schedule, so as to increase the volume of reserve available from these providers; and/or
- constraining up or on providers that are not in the market schedule to a part-loaded dispatch position, so that these providers are then available for reserve.

For SIR, the only option to increase availability would be to constrain on providers that are not in the market schedule.

[20] We refer to non-energy actions as those that the TSOs take to ensure sufficient availability of system services, rather than to balance demand and supply of energy. We note that there is a potential ambiguity in any definition of energy and non-energy actions, since some actions may arguably be deemed to be both energy and non-energy actions at the same time. However, the issue falls outside the scope of this report.

These non-energy actions will be based on bids made by providers in the BM and those non-energy actions will operate on a pay-as-bid basis:

- Constraining down a provider would mean that the TSOs accept a decrement (DEC) offer from that provider. Conventionally, we take that DEC offer as being negative, i.e. involving a payment from the provider to the TSOs. This is because the provider receives energy payments as determined in the market schedule, and will enjoy cost savings from exporting a lower quantity.
- Constraining up a provider or constraining on a provider that is not currently in the schedule means accepting an increment (INC) offer from that provider. The INC offer would be positive (in our convention of considering revenues to the provider), in the sense that the TSOs would make a payment to the provider, reflecting the start-up costs and any fuel costs incurred.

For the purposes of our report, we assume that the TSOs' BM decisions are of a binding nature and take place after gate closure, such that providers cannot subsequently trade back to a different position. An important factor in evaluating our proposed auction models is whether the BM is sufficiently competitive or whether there is substantial market power that may lead to BM bids not being based on costs and any anticipated system services payments. At the time of writing, the rules for operation of the BM within I-SEM have yet to be determined, including whether there will be a Bidding Code of Practice that might help to control any such market power. Nevertheless, some of the models set out in Section 3 might be particularly susceptible to market power concerns in the BM, which forms a factor in our evaluation.

Interaction with the energy market

If a provider anticipates being paid when available for system services (whether based on a SS auction clearing price or a regulated tariff), the bidding behaviour in the energy market is likely to be affected. Specifically, such a provider will consider not only the potential revenue from exported energy, but also the potential revenue from being available for system services. Taking the case of a generator that can provide reserve when part-loaded, the interaction between the energy price and the price of reserve may influence bidding in the DAM and IDM.

In a simple illustrative case where there is a constant cost c of exporting energy, a price p_e for energy and a price p_r for reserve, this interaction is as follows (for simplicity we ignore system service payments for non-reserve services):

- if the energy price is sufficiently low[21], the generator would not position itself in the market schedule at all;
- if the energy price is somewhat higher, it may be that energy payments are not sufficient to cover costs, but energy payments plus reserve payments are;[22] in this case the generator would position itself at part-load;
- if the energy price is higher than the cost of exporting, but profit margin from exporting energy is smaller than the price of reserve (i.e. $0 < p_e - c < p_r$), then, the generator would position itself at part-load; and
- if the energy price is sufficiently high, the profit margin from exporting energy exceeds the price of reserve (i.e. $p_e - c > p_r$); in this case, the generator would position itself at full-load.

Interaction with the BM

The anticipation of potential reserve payments can also be expected to affect bidding behaviour in the BM. Taking the case from the example above where the generator is positioned at full load in the market schedule, the generator can anticipate receiving a reserve payment if its DEC offer is accepted. If the BM is perfectly competitive, this expectation of additional revenue for system services would be fully reflected in the DEC offer. Put simply, a competitive DEC offer would be equal to the cost savings from the reduction in the exported quantity of energy, plus the anticipated reserve payment for the quantity of reserve that becomes available as a result of being constrained down.

However, if there is market power in the BM then the behaviour may be quite different. For example, if the generator expects that its DEC offer is likely to be accepted even if it is not very competitively priced (e.g. because there is likely to be a lack of alternative sources of reserve available to the TSOs at this time), then it may bid an amount significantly below the competitive DEC offer. It would thereby understate its cost savings (and anticipated DS3 system services payment) and not pass them on fully to the TSOs.

From the TSO perspective there is also a clear interaction between system service payments, based on the SS auction clearing prices, and expenditure through the BM in relation to non-energy actions:

- In an extreme case where all system service prices are zero, system services expenditure would be zero. However, since

[21] Such that $(p_e - c)\, q_m + p_r\, (\text{Min}(Q - q_m, R_{max})) < 0$, where Q is the maximum generation level, R_{max} is the maximum reserve capability and q_m is any feasible generation level, including the minimum generation level.

[22] i.e. $p_e < c$, but $(p_e - c)\, q_m + p_r\, (\text{Min}(Q - q_m, R_{max})) > 0$ for some positive q_m.

there is no incentive from system service payments for providers to take up market positions where system services are technically realisable, there may be a great reliance on TSO non-energy actions to secure sufficient availability of system services, potentially leading to high BM expenditure.

- In the opposite case, where system service prices are very high, there is a clear incentive for providers to take up market positions where system services are technically realisable, leading to potentially high system services expenditure. On the other hand, BM expenditure related to non-energy actions in this case can be expected to be lower, as there would be a reduced reliance on non-energy actions to achieve sufficient availability of system services.

Interaction with the CRM

The SEM-C has rightly pointed out in its Decision that revenue sources, as well as their split in the energy market, are most likely going to change in the future. Energy prices may on average come down with increased weather-variable generation on the system, but may become more volatile. To cover fixed costs, some generators may need to rely on fewer hours of operation in combination with more volatile prices.

Importance of CRM and system services revenues

CRM and system services revenues are expected to provide predictable revenue streams despite this likely increase in volume risk and price volatility. In the case of I-SEM, the Reliability Options (ROs) are expected to act as a hedge with providers giving up energy market revenue in exchange for an upfront payment. The importance and value of system services may also increase, forming an additional revenue stream for providers. Providers may increasingly have to rely on revenues from the provision of system services and the CRM. Both revenue streams can play an important role in incentivising new investment.

Revenue uncertainty

Under separate capacity and system services auctions, a new investment or upgrade of existing capability may be risky if it depends on revenues from both sources (though we understand that energy market revenues will usually make up a larger proportion of the investment case). Assuming that the SS auction is held first, at the time of bidding to provide system services a provider does not know whether it will be successful in the CRM. It will therefore most likely bid more conservatively, factoring a risk premium in its system services bids that will ultimately have to be paid for by the consumer if this new investment or upgrade is successful in the system services auction. Moreover, if this is a material concern for new investment, it may not actually bid in the first place. Equally, it is possible that new investment that is successful in the SS auction could bid quite competitively in the CRM and could thus push the price in the CRM down. However, investment that relies on both revenue streams and that did not win in the SS auction will not be present in the CRM, which could make the CRM much less competitive than it could have been, had both auctions been combined. Overall, the impact on the price in the CRM is thus ambiguous.

Possible mitigation measures

A solution to the risk that arises from having two separate auctions might be to allow new investment to specify whether it would have to be successful in both auctions in order to accept the SS contract, though this measure is problematic. If the provider was successful in the SS auction but then failed to win in the CRM, it could be replaced by an alternative provider (a losing bidder in the SS auction). However, this approach is inherently complex and carries significant implementation and litigation risk due to the need to revisit auction results and re-determine winners in some cases. Signing up a loser to provide system services instead would require that the TSOs could still hold a loser in the system services auctions to bids they made at an earlier time. It may also not be clear which losing bid should be taken instead, and there might be no losing bid that adequately replaces the new investment.

Whilst such an approach would give some certainty to new investment that requires both revenue sources, it would still not allow bidders to express their willingness to substitute CRM revenues for system service revenues. For example, if the price of capacity were to be fairly high and therefore CRM revenues were to account for a substantial portion of recoupment, bidders should be willing to provide system services fairly cheaply, but currently have no way of expressing this in separate auctions.

An alternative option that allows bidders to express the interdependencies between capacity and system services in a combined auction may be desirable, as it would address the risks described above. With a combinatorial auction bids could be made for packages including both capacity and system services. Such a package bid would express the expected revenue that would need to be earned in total across both capacity and system services. Therefore, an integrated approach would remove risks for new investment that could arise from running separate CRM and SS auctions.

From an auction design perspective, there should be no particular difficulty in integrating an auction of capacity with an auction of system services using a variation of the auction mechanism that we propose. We understand that this is currently not planned and therefore set out proposals for a standalone system services auction.

2.3 Payments for DS3 System Services

Winners in the SS auction would be paid whenever they are available to provide system services, regardless of whether the available volume is:

- the result of the provider's positioning in the market schedule, which is within the provider's control and likely dependent on the energy price at any given time; or
- the result of TSO non-energy actions in the BM that increase availability, which are not within the provider's control.

Some important questions that are crucial for determining bidding incentives in the auction are:

- what payments, if any, providers should receive when they provide system services as a result of TSO non-energy actions if they had not won in the SS auction;
- whether payments should be capped at the volume of system services for which a contract has been awarded through the SS auctions; and
- whether any measures should be used to cap the total system services expenditure, e.g. in the event that total availability is much higher than anticipated.

Payments to SS auction losers

On this point, the SEM-C has stated that "*the [losing] provider will not be paid on the same basis as those providers that were successful in the competitive process. These providers will receive the market price (i.e. the clearing price in the auction) for any volume of services provided while constrained on by the TSO, energy payments and any applicable dispatch costs will be paid separately paid. [sic] However, such providers will not receive a system services payment if they are not constrained on by the TSO.*"[23]

Interpreting the SEM-C Decision

This aspect of the SEM-C Decision will need to be clarified in the detailed design process. A literal interpretation would indicate that SS auction losers are paid when constrained *on* to provide system

[23] Ibid., §109

services but not when constrained *down* to provide system services (i.e. reserve).[24]

A broader interpretation would suggest that SS auction losers are paid only when the TSOs take a non-energy action (constraining them on or down) to make them available for system services. However, it would need to be established for what volume of availability the SS auction losers would be paid in particular cases.

For example, suppose a SS auction loser has maximum exporting capacity Q=100MW and maximum reserve capability of 20MW. It has market position q_m=90MW and it is constrained down to dispatch position q_d=80MW. This leaves open the question whether this provider should be paid for 20MW of available reserve or only for 10MW (the volume by which it was decremented in the BM).[25]

Interaction with the BM

We will illustrate below the importance of the payment regime for SS auction losers by considering how this influences behaviour in the BM.

Suppose that a SS auction loser is paid for system services on exactly the same basis as winners whenever the TSOs take a non-energy action to constrain the loser on or down. For example, provider A is a SS auction winner and provider B a loser; suppose that both providers employ the same technology and have identical costs, maximum capacity Q and maximum reserve capability R_{max}. If either of these providers is decremented from Q to Q-R_{max}, it will receive exactly the same reserve payment for reserve quantity Q-R_{max}.

If the BM is reasonably competitive, we would expect the providers to factor the anticipated reserve payment into their DEC offers (as explained in Section 2.2). Therefore, providers A and B will make equal DEC offers that are equally likely to be accepted.[26] More generally, if SS auction losers are paid for system services on the

[24] A separate point is that a literal interpretation of the Decision could mean that some auction losers are worse off than others. For example, a battery that has not won a SS contract and is never constrained on would not receive any SS payments even though it is available most of the time, whereas a conventional provider that has not won a contract would receive SS payments whenever it is constrained on by the TSO (to part-load).

[25] We note that the SEM-C statement "*the provider will not be paid on the same basis*" suggests that it would only be paid for 10MW of reserve, whereas the statement "*[t]hese providers will receive the market price … for any volume of services provided*" suggests that it would be paid for 20MW of reserve.

[26] As noted above, this example abstracts away from technological differences that can affect dispatch decisions. When providers A and B use different technologies they may not be equally likely to be picked – e.g. at a particular time a wind generator could be more likely to be picked due to priority dispatch obligations, or less likely to be picked due to SNSP constraints.

same basis as winners, in the event of a TSO non-energy action being applied to them, then winners and losers will price their BM offers on the same basis. This means that a provider that wins in the SS auction faces the same likelihood of TSO non-energy actions as it would if it had not been successful in the auction; in other words there is no 'sorting' in the BM between offers made by SS auction winners and offers made by losers.

Implications for the SS auction

The lack of sorting in the BM would cause problems for the SS auction design. In order to run a meaningful auction it needs to be the case that a provider can expect to receive significantly higher system service payments if it wins rather than loses, otherwise there is no incentive to win. Given that payments are on an availability basis, we therefore require that a provider's total expected availability contingent on winning in the auction (call this Π_W) is substantially greater than its expected availability from being constrained on or down contingent on losing in the auction (call this Π_L). However, if losers were paid on the same basis as winners, BM offers from winners and losers would compete on an equal footing, so Π_L may be relatively high, weakening the incentive to win in the SS auction.

In the extreme case, if we had winners and losers paid on a similar basis, with a provider expecting similar availability regardless of whether it won or lost (i.e. $\Pi_W = \Pi_L$), then becoming a winner in the SS auction would have no consequence, rendering the auction meaningless.

Payments to losers may also create gaming incentives in the auction. A provider that expects to be marginal in the auction may have a stronger incentive to raise its bids (rather than bid competitively to try to make sure it is in merit), because doing so could increase the overall clearing price that it would then receive even as a loser.[27] In contrast, if losers did not receive payments, such behavior would be discouraged by the increased probability of losing if bids are increased.

Need for lower payments to losers

To run a meaningful and competitive SS auction, losers should be paid a lower price than winners for the system services they provide when constrained down or on by the TSOs. The effect of this is that winners would then, all else equal, make more attractive BM offers than losers because they anticipate a higher system services payment. This would then make their BM offers more likely to be accepted than those made by a loser with similar technical characteristics, reducing the value of Π_L and creating stronger

[27] Assuming a second-price rule, as favoured by the SEM-C Decision.

conditions for a meaningful SS auction and weaker incentives for gaming.[28]

We acknowledge that paying SS auction losers a lower price than the SS auction clearing price paid to winners (whenever they are providing reserve services as a result of the TSO non-energy actions) may be a deviation from the SEM-C Decision. However, based on the argument above, this approach has clear benefits that appear to be aligned with the objectives of developing competitive markets for system services and protecting consumer interests.

In the remainder of this report we make the simplifying assumption that losers are paid nothing for system services. This assumption is not essential, provided that losers receive lower payments for providing system services than winners.

Payments and contracted volumes

Depending on the auction design options that are chosen, it may be that providers are able to specify quantities in their bids that are lower than their maximum capabilities. For example, a provider with maximum reserve capability 50MW may only bid for, and be awarded a contract for 40MW of reserve. Such a provider might be available for 50MW of reserve at a particular time, either as a result of its market position or of TSO action, which raises the question whether SS auction winners should receive system service payments only up to their contracted volumes, or potentially for higher volumes too.

One interpretation of the 'additional' volume (in the example, 10MW), which is not covered by a SS auction contract, would be to treat it as if an auction loser were providing it. Alternatively, paying a winner for more than its contracted quantity may have undesirable consequences on the bidding behaviour in the BM and in the SS auction as it might then be desirable to win a SS contract for very small volumes. The exact implications of paying providers only up to their contracted system service volumes, or of potentially paying for additional volumes at times, depend on various elements of the auction design, so this will be discussed in the following sections.

[28] Another more practical advantage is that the likelihood of calling on SS auction losers to provide system services is reduced, which may be preferable if winners are subjected to stricter controls ensuring that they have the required technical capability.

Availability and total expenditure

Expenditure uncertainty due to 'circularity'

The circularity between clearing prices and availability may have implications for system services expenditure. When a bidder makes a bid, it does not know what the clearing price will be for each service. A winner might find that clearing prices are higher than it anticipated and that it wants to make itself available more often to benefit from the availability-based payment. Indeed, this incentive for providers to make themselves available is one of the reasons given in the SEM-C Decision for favouring this payment model. However, we could then have a situation in which the winner is available substantially more than expected by the TSOs (and by the provider itself). This would lead to excess supply of availability for some services and increased expenditure for the TSOs under SS contracts to a higher level than anticipated.

The circularity issue is largely addressed by our proposed auction mechanism, which allows a bidder to make a number of bids to reflect different availabilities at different prices (see Section 5.3).

Expenditure uncertainty due to other factors

Aside from this circularity, a provider's availability remains uncertain ex-ante for various reasons and may turn out to be higher than expected – e.g. unexpected changes in cost factors over the contract period. Within the SEM-C's high-level framework, the choice of availability payments, annual auctions and no firm commitment necessarily introduce an element of volume uncertainty, which translates to expenditure uncertainty for the TSOs.

Scalars

The SEM-C Decision envisages various scalars that may be applied to system services payments. These are:

- a product scalar;
- a performance scalar;
- a scarcity scalar; and
- a volume scalar.

Our proposed auction design is robust to the addition of any scalars that would be applied to the clearing prices generated from the auction. In general, it is key that the use of any scalars is made clear to auction participants ahead of the auction, so that they are able to form accurate expectations about the payments they will actually receive and adjust their bids on this basis.

However, we recommend that the potential benefits of the proposed scalars in an auction context (as opposed to regulated tariffs) should be considered carefully in light of the chosen auction design. Alongside any benefits, there may be risks in terms of increased uncertainty for providers. The product and performance scalar should not pose any particular problems in an auction context, whereas the scarcity and volume scalars introduce additional issues, as we explain below.

Product scalar

The product scalar is based on a provider's technical characteristics and its ability to exceed the required performance standards for system service, which should be known to the provider. Providers will be able to accurately predict the impact of the product scalar on their revenues, so this scalar does not create significant bidder uncertainty. It is useful in that it effectively creates multiple prices for different 'sub-products' where technical characteristics vary, which may be preferable to an alternative of defining a much larger set of products to be offered in the auction. The auction would determine a price for a 'standard' version of the product, with product scalars then being applied to determine prices for other variant versions of the product relative to the standard version.

For example, in some cases it might be reasonable to interpret a superior version as providing 'more' of the relevant service than the standard version (e.g. version 'A' provides 10% more than version 'B'). Such cases are straightforward to incorporate within an auction, as the variants can be represented by appropriate interpretation of the quantity of the service being offered within a bid. Such adjustments may be somewhat ad hoc, but may be an acceptable approximation in certain cases.

When using product scalars care will be needed to ensure that the TSOs' volume requirement is still appropriately defined. In particular, product scalars should not introduce a risk of over- or under-procuring the requirement if the mix of variants is not as expected; this becomes more of a concern the more different the variants are.

Performance scalar

The performance scalar varies in accordance with a provider's behaviour and potentially has a large impact on the revenue received. However, a provider should be able to form accurate expectations about its own reliability standard and therefore about the revenue it would receive after the scalar is applied. Again, the scalar should not significantly increase bidder uncertainty and may be beneficial in incentivising high reliability. In terms of an auction, the only concern is to ensure that the rules for performance scalars are clear so that risks can be reflected in bids.

Scarcity scalar

The scarcity scalar is very different in that its value varies to reflect temporal and locational scarcity, in a way that cannot be influenced by the provider itself. This necessarily creates uncertainty for bidders in the SS auction, as it may be quite difficult to predict the net impact that this scalar will have on their SS revenue. There may be benefits in terms of giving providers stronger incentives to make themselves available in the market schedule when most needed, but this depends on other auction and contract design choices. Under a no-commitment model, incentivising certain market positions and thus aligning the market and dispatch schedule more closely may be possible through the use of a scarcity scalar. However, in our proposed 'contingent-commitment' approach (see Section 3) the TSOs can draw on providers to supply system services through the BM on favourable terms, so there is no particular need to incentivise providers to position themselves to be available in the market schedule.

We note that there is an alternative way in which temporal and locational scarcity can be taken into account in the auction. Rather than varying prices at different times through the scarcity scalar, separate volume requirements can be set for different time periods (e.g. peak/off-peak) and locations (e.g. Ireland / Northern Ireland), creating different clearing prices which then remain constant in real time. This allows prices to reflect, to an extent, temporal and locational constraints without creating revenue uncertainty for providers. Therefore, as an alternative to using scarcity scalars a more granular volume requirement could be used. We discuss this possibility and the impact it has on the auction in Section 4.

Volume scalar

The SEM-C proposes the use of a volume scalar to protect consumers from overpayment, though the exact details of this scalar have not been published yet.

One possibility is that the volume scalar serves to prevent that existing capability benefits from high clearing prices set by new investments. The use of such a scalar would only apply in a case where existing capability and new investment bids are evaluated together in a combined auction. However, we argue in Section 7 that there are good reasons against a combined auction, therefore we propose an auction that sets separate clearing prices for existing capability and for new investment. Therefore, there is no need for the volume scalar for these purposes.

The other possibility is that the volume scalar prevents overpayment by reducing the price at times when there is more availability on the system than needed (essentially, the opposite of a temporal scarcity scalar). It appears that the SEM-C envisages this use of the volume scalar only for regulated tariffs:

"*In the case of services that are priced through the tariff methodology, those services will have a scalar applied to them where, notwithstanding the lack of sufficient competition, there is a surplus volume of the service*"[29]

Indeed, applying such a scalar in an auction context may have some detrimental consequences. As with the scarcity scalar, the net

[29] SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), §170.

impact on a provider's total system services revenue may be quite difficult to forecast in advance. Moreover, reducing payments to all providers at times of surplus availability is a somewhat blunt mechanism. It may reduce payments to individual providers who already have a shortfall in revenue due to being available less often than expected and this revenue uncertainty could be particularly significant for new investments. Therefore, a preferable approach to preventing overpayment would most likely be to take into account a provider's expected availability and to reduce payments when a provider's availability exceeds this level, but not otherwise.

3 Commitments offered by winners

Key points

Before considering detailed aspects of auction design, it is essential to define the nature of contractual obligations that SS auction winners would take on. The SEM-C appears to favour no, or at least weak, contractual obligations. However, we consider that, combined with the other aspects of the high-level auction design framework, this could be detrimental to the auction's success in meeting the objectives.

Under a 'no-commitment' model, the SS contracts awarded to winners do not impose any new obligations with regard to providers' behaviour in the energy market and BM. SS auction winners can sometimes increase their payoffs by making themselves available through their market position, but have no obligation to do so and no costs from choosing not to do so. Therefore, the SS contract represents a valuable option with no associated downside, similarly to the regulated tariff case.

With no commitment, the SS auction seems likely to have little material impact on the supply of system services. The TSOs remain able to secure availability in real time through its central dispatch rights and the auction may have some benefit by selecting a set of winners that does not include all providers, contrary to the regulated tariff case. However, because contracts have no associated cost to be reflected in bids, there is a risk of setting arbitrary clearing prices. Moreover, with no commitment the auction could favour particular technologies and disadvantage the deployment of alternative technologies.

At the opposite extreme, a 'full-commitment' model would require SS auction winners to always take up a market position in which they are available (or make alternative arrangements through secondary trading). This model has some desirable properties and may be viable when contracts are awarded frequently and close to real time, but is not appropriate for an annual auction.

We propose a 'contingent-commitment' model. Under this model, SS auction winners remain free to take up any market position, but have an obligation to submit BM offers that allow the TSOs to make them available for the contracted volumes of system services. The terms of these BM offers are pre-determined, so the TSOs effectively procure a commitment from providers to offer flexibility in the BM on certain terms.

With this model, there is now both a benefit from winning the contract (potential higher payoffs from system service payments), but also a cost (loss of flexibility) that can be reflected in bids. The auction would reward those providers who can offer this flexibility at the lowest cost and should set meaningful clearing prices. Under contingent commitment, there should be a more level playing field between technologies. There should be greater certainty from the TSOs' perspective regarding the supply of system services over the contracted periods and the associated expenditure.

Importance of contractual obligations

The nature of the contracts that are to be awarded to successful bidders is fundamental for the auction design. While it is not necessary to have decided on all the details in these contracts in order to design the auction, the broad nature of the obligations included in the contracts awarded in the SS auction are important.

As a starting point, we assume that all SS auction winners are required to demonstrate that they have the technical capability to deliver the volumes stated in their winning bids and face sufficiently strict penalties if they fail to do so. This is relevant both to existing capability that bids for one-year contracts, but especially for new investments where a financial commitment to deliver sufficient technical capability may be crucial to avoid accepting bids to supply future system services that are subsequently not honoured.

Commitment options

Aside from an obligation to demonstrate technical capability – which we deem necessary under any of the options presented in this section – there is a question of what further commitments, if any, are required from SS auction winners to ensure their availability to provide system services:

- At one end of the spectrum, an auction winner might face no new obligations (on top of existing Grid Code obligations among others) and simply receives payments whenever it is available (as explained in Section 2). We refer to this as the **no-commitment** model.
- Alternatively, winners may be faced with certain new obligations in relation to their behaviour in the energy market and/or in the BM throughout the period of the contract. In this case, winners take on some **commitment**, though there are then many options about how strenuous those commitments are.

This section sets out three possible commitment models, specifying what winners are required to do in each case. We then draw out the implications for:

- other markets (energy market, BM) both from a provider and TSO perspective;
- the likely bidding incentives in the SS auction;
- how the model deals with different technologies; and
- what the TSOs actually will be able to procure through the SS auction and what the associated expenditure might be.

Overview

In summary, this section shows that:

- Under the no-commitment model, winning in the SS auction provides a valuable option for some technologies, as winners are able to enjoy revenues from system services whenever they choose to position themselves in the market as available, without any associated downside when they choose not to. However, this would mean that bids in the SS auction could lack any meaning, as they would not reflect any underlying cost of complying with the system services contract. The result is that the auction risks setting arbitrary prices and that it may favour certain types of technology over others. There may be little or no benefit from holding the auction, compared to the counterfactual where regulated tariffs are used.

- The full-commitment model, where the contracted volumes must be made available at all times, could work well if volumes were procured on a short-term basis, but would not appear to work well for an annual auction as planned by the SEM-C.
- A workable compromise should be to impose some degree of commitment on winning providers in certain situations (what we refer to as contingent commitment), but without requiring full commitment.

In order to illustrate the three models this section focuses primarily on reserve services. As discussed, this is the more complex category of system services because of the interaction with the energy market, where for some technologies there is a trade-off between the volume of energy being exported and the remaining volume that is technically realisable as reserve.

3.1 No commitment

No contractual obligations

The current SEM-C proposals appear to envisage issuing system services contracts without any commitment, over and above the requirement that winners must demonstrate sufficient technical capability to be able to provide the volumes of system services specified in the contracts. Winners would receive system services payments whenever they are available, but they do not take on any new obligations in relation to their conduct in the energy market and the BM.

As mentioned previously, we maintain the simplifying assumption that losers would receive no system service payments. With no obligations, contract holders' bidding incentives in the energy market and in the BM would follow the broad outline set out in Section 2.2. In particular:

- Conventional generators can be expected to bid their full exporting capacity into the energy market when the energy price is high enough that the profit margin from exporting energy exceeds the availability payment they would receive for reserve.
- When the energy price is low and it is not profitable for conventional generators to export energy, they can be expected to be out of the market schedule.

- There may be an incentive to take up a part-loaded market position where the profit margin from exporting energy is smaller than the payment for reserve availability.

This incentive structure is broadly similar to how the market currently operates. The TSOs would essentially take the same actions in the BM to ensure sufficient availability of system services, regardless of the outcome of the SS auction.

As set out in Section 2.2, assuming a competitive BM, because of their anticipated reserve payment, providers should be expected to submit more attractive BM offers (all else being equal) as a result of having won in the SS auction, where the INC or DEC would increase their availability. As a consequence, SS auction winners would generally be more likely to be constrained down or on to be available for reserve than losers.

Interaction with other markets

Because there are no new obligations attached to the contract, all winners would make their DAM and IDM decisions based on the difference between the energy margin at that point in time and the price of reserve. Losers would make their decision purely based on the energy margin. This would lead to the following scenarios for the anticipated profitability of a conventional provider at any particular time, depending on whether it won or lost in the SS auction:

Table 5: Payoff differences between winning and losing in SS auction (for a conventional generator) in different energy price scenarios

Energy price vs price of reserve	Market position if won	Market position if lost	Difference in profit between winning and losing
Sufficiently high energy price and thus high energy margin	Full load	Full load	None
Energy margin lower than reserve price, but still profitable to export	Full load minus contracted reserve quantity	Output at full capacity	**Always better off to win**
Energy margin negative, but reserve price large enough for winners to still make a profit from operating	Minimum generation level	Off	**Always better off to win**
Sufficiently low energy price	Off	Off	None

This example highlights that with a no-commitment model SS auction winners can *never* be worse off than losers, and are better off in some cases. Note that this point holds regardless of any actions taken by the TSOs at dispatch, on the assumption that BM offers are rationally priced in such a way that the provider is indifferent between having them accepted or not, i.e. the payoffs are unchanged. The system services contract effectively gives the provider an *option* to make itself available at gate closure and receive a reserve payment in cases where doing so increases its overall profit, but the contract imposes no obligations or costs in any other scenarios. In other words, there is a benefit to winning in the SS auction, but there is no downside. The TSOs could always arrange sufficient availability of reserve through non-energy actions in the BM, including by relying on Grid Code obligations, but they would have no control over the costs associated with this.

Bidding in the SS auction

The fact that winning a SS contract provides a valuable option, with no corresponding cost, has severe implications for the auction. *If it is always better to be a winner than a loser for any clearing price greater than zero, then existing providers will have an incentive to submit very low bids in the auction – theoretically, they should bid zero.*[30] Even new investments might submit very low bids if they do not rely on system services revenue in order to secure the investment.

Regardless of the type of bidder (existing or new capability), under this approach it can be assumed that bidders would choose to bid for quantities equal to their maximum technical capabilities in the SS auction. Since there is no downside to winning and a potential upside in terms of system service payments that are applied to the quantities specified in the winning bid, it is optimal to try to win a contract for the largest possible volumes. Nevertheless, if it is anticipated that bidding full capabilities entails a risk of not 'fitting' in the volume requirement, providers may also wish to include bids for less than their maximum capabilities.[31]

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[30] Even if there are operating costs associated with providing system services – e.g. activation costs in response to an event – this would not appear to change the optimal strategy of bidding zero. If the services relate to inherent plant capability and cannot be 'switched off', then the optimal strategy is to bid zero. This does not change when services can be 'switched off'. This is because a SS auction winner can always choose to be 'unreliable' and in the worst case it will receive zero system service payments due to the performance scalar, which still leaves the provider no worse off than if it had been a SS auction loser.

We note that, though the no-commitment model is not suited to an auction, it seems a more viable model with regulated tariffs, which the TSOs can use as a price instrument to incentivise providers to position themselves as available. The level of technically realisable reserve in the market schedule would still vary with the energy price, but for a given energy price a higher price of reserve would increase the volume of available reserve in the market schedule.

[31] This might not be allowed, however, as the SEM-C Decision foresees that "*[a]ll providers must submit a bid for at least their existing capability*" (SEM Committee, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), December 2014 , §140).

Other technologies

The implications may be very different for alternative technologies, such as battery storage and DSR. The notion of a SS contract as an option to trade off energy margins for system services payments may be desirable from the point of view of conventional generators that routinely export energy. On the other hand, technologies that do not typically export energy may receive little benefit from such an option and therefore are not favoured by the no-commitment model.

Therefore, the no-commitment model is not technologically neutral from an auction perspective. For example, a battery would be providing a system service which could be relied on to be available often, whereas a conventional plant could not be relied on in the same way, as it might withdraw supply of system services if the energy price is high and the TSOs would then have to pay in the BM to make it available, at an uncertain cost. We cannot create a situation in which different technologies can compete fairly to provide system services as, from the perspective of the TSOs, they are not providing like-for-like offers.

Furthermore, for some providers, whether existing or not, system services may be a key revenue stream, such that they require a price that is sufficient to cover a large fraction of their fixed (or even variable) costs. For such providers, a clearing price significantly above zero is required for the investment to go ahead. Bids that reflect this would be less competitive in the SS auction. This means that in the no-commitment case, any provider might have desirable technical characteristics for the provision of system services (e.g. batteries that are almost always available for reserve), but that rely relatively strongly on system services payments rather than energy margins, are at a disadvantage. A SS auction with no commitment would favour providers with significant alternative revenue sources (other than system services revenues), which may lead to inefficient outcomes.

Volume requirement and expenditure

In the no-commitment case, the TSOs effectively procure a certain volume of *capability* that is deemed highly likely to result in sufficient volumes of *availability* to cover worst-case scenarios. However, the TSOs have no contractual guarantee in relation to the volumes of system services that will be available at any particular time and the cost that may be incurred in the BM when it is necessary to increase availability.

As discussed, clearing prices may be low (or even zero) in a SS auction with no commitment, which would mean a low level of system services expenditure; in this scenario system services (especially reserve) would still need to be procured (and paid for) in the main through non-energy actions in the BM. Subject to procuring sufficient capability, the TSOs always retain the ability to procure the required availability in the BM in real time, but under the no-commitment model there is no certainty about how much this may cost in the BM, which may be especially significant if there are any concerns about market power in the BM.[32,33]

Summary: no commitment

In summary, for existing capability the only genuine impacts of having an auction under the no-commitment model would most likely be:

- to restrict the set of providers that may receive full system service payments to those who win in the SS auction, as opposed to the regulated tariff approach where all providers stand to receive the payments whenever they are available; and
- to set a price for system services, though this price may not be meaningful and may be very low (or even zero) due to the bidding incentives described above, so that the outcome risks being less efficient than if regulated tariffs had been used.[34]

For new investments, by offering revenue certainty through long-term contracts, the auction could at least succeed in incentivising the deployment of new capability that will be required in the future. However, the no-commitment model appears to favour conventional technologies strongly and might reduce the likelihood of incentivising the development of alternative technologies that have desirable characteristics, from the perspective of system services provision.

[32] In the event of clearing prices significantly above zero – the likelihood of which would depend on how clearing prices are set – there is also no certainty about the total expenditure on system service payments from the DS3 pot. Total expenditure through system service payments would depend not only on the TSOs' requirement for availability throughout the year but also on how often providers choose to take up the 'option' to make themselves available for reserve at gate closure, even when not needed.

[33] Market power in the BM may be constrained by various measures, such as a bidding Code of Conduct, but these features of I-SEM have yet to be determined.

[34] Regulated tariffs can be used as a price instrument to incentivise providers to position themselves as available. The level of the regulated tariff could be set to produce an appropriate incentive for some providers to take up a part-loaded position and could also provide good incentives for reliable service provision through the performance scalar.

3.2 Full commitment

The previous section showed that the no-commitment model may deliver very limited benefits and appears to favour certain technologies. The polar opposite approach would be to require winners in the SS auction to be always available to provide a service regardless of their market position. The SEM-C has specifically decided against a full-commitment model, and indeed the model is not suited to an annual auction, though it might work well as part of a market design where short-term contracts are allocated more frequently (which would also remove some of the risks of EU Network Code compliance). The full-commitment model is briefly presented here because, together with the no-commitment model, it provides the context supporting our proposal for contingent commitment.

Contractual obligations

Under a full-commitment model, SS auction winners would be required to ensure that they are always available throughout the year to provide system services at the level of their successful bids (subject to some permitted periods of downtime for maintenance or unplanned outage). In practice, this would mean that winners are obliged always to position themselves at gate closure such that the contracted volume of system services is technically realisable from that position, and would face penalties when they fail to do so.

Interaction with other markets

Such an obligation has clear implications for winners' behaviour in the energy market. In particular, conventional generators that won a SS contract would need to bid in the DAM and IDM in a manner that ensures that they are (i) in the schedule at gate closure, and (ii) taking up a position that leaves sufficient headroom for the volume of reserve for which they are contracted.

Bidding in the SS auction

This would make full commitment onerous for such generators, whereas for some other technologies (e.g. battery storage, DSR) that are available for reserve even when off and that would rarely or never export energy at full-load, it would be less onerous. Hence, technologies that are inherently more suited to being continuously available – which is a desirable property from the TSOs' perspective – would have a relative advantage in the SS auction.

For conventional generators, full commitment significantly reduces flexibility and increases exposure to risk. Even if the energy price were high, they would not be able to position themselves at full-load in the energy market (penalties would have to be sufficiently high for providers never, or very rarely, to renege on their obligation and accept a penalty). Even if the energy price were low, they would have to ensure they are in the schedule, or pay a penalty. These risks would need to be reflected in their bids in the SS auction. Providers would have to form expectations of the cost of compliance in terms of lower profits from the energy market. To form this expectation providers would need to take a view about energy price developments over the year.

Thus, even if some providers for which full commitment is not onerous make low bids, clearing prices in the SS auction could potentially be high,[35] reflecting the loss of flexibility suffered by conventional generators, who are in all likelihood required by the TSOs in order to obtain the desired volume of system services.

Secondary trading

In case a SS auction winner cannot ensure its availability in a certain period, it would be desirable to allow it to pass on the obligation to another provider whenever this is cheaper than incurring a penalty. This could be done by allowing portfolio bids, so that the risks described above could be shared across plants in a provider's portfolio, or through some form of secondary trading, where one provider could effectively sub-contract another provider for system services when needed.

With secondary trading, providers should be in a better position to manage the risk associated with full-commitment contracts, which should be reflected in lower clearing prices in the SS auction. However, there would be costs and practical challenges in implementing an efficient secondary trading regime. The fact that providers' technical capabilities can differ substantially may make it more difficult for subcontracting to take place. In particular, when there are only a very small number of alternative providers with similar capabilities and that therefore represent viable options for subcontracting, there may be market power concerns in the secondary market.

Volume requirement and expenditure

Under a full-commitment model, the TSOs are procuring an exact volume of *availability* throughout the year on which they can rely.[36] TSO actions in the BM to increase reserve availability should therefore be needed only in cases where providers have failed to meet their obligations.

The TSOs would also benefit from certainty about exactly how much they will have to spend for system services procured through the SS auction, as they will need to pay all winners at all times.

Whilst the full-commitment model has a number of desirable properties in principle, it does not work particularly well with an *annual* auction. As noted above, it creates risks for conventional generators who have to forecast energy prices and the cost that they would have to incur in order always to position themselves in

[35] Assuming the same clearing prices apply to all technologies, though this may not be the case if granular volume requirements are used. See Section 4.

[36] Note that a granular volume requirement could be specified, such that the volume requirement in fact varies for different time periods. See Section 4.

the market as required by the contract. These risks may be manageable where contracts are offered for short time periods and close to the delivery period, so that there is relatively little uncertainty. However, they will become large – and thus rather expensive to compensate providers for – where availability has to be guaranteed for an entire year (and potentially more than one year in the case of longer term contracts).

The requirement for availability of system services can vary substantially, even from one hour to the next. With full commitment, the TSOs would have to estimate its availability requirement for the entire year in advance and would likely have to procure sufficient availability to cater for the worst-case scenario over the course of the year. Most of the time there would be a substantial oversupply of availability from SS auction winners who are obliged to position themselves as available, even when not required. Whilst a finer level of granularity in specifying the volume requirement over time reduces this problem somewhat (as discussed in Section 4), it does not eliminate it.

3.3 Contingent commitment

Contractual obligations

Neither the full-commitment nor the no-commitment setting is truly suited to an annual auction of system services. Each model favours certain types of provider relative to others. Therefore, it is desirable to impose *some* contractual obligations on SS auction winners so that the contract is not merely an 'option' to be exercised when it suits the provider, but also the obligations fall below the level of requiring winners to guarantee availability of the contracted volumes at all times.

The idea behind the contingent-commitment model described in this section is that SS auction winners face certain commitments to make system services available when required by the TSOs on certain terms, but not universally and at all times. In this sense, there is a commitment, but it is 'contingent' in that it only applies to limited circumstances.

There are various ways in which such obligations could be imposed in practice. We propose a version that tries to strike a reasonable compromise, by allowing for a meaningful SS auction without imposing excessive obligations on providers. However, the precise commitments that are imposed on winning bidders remain to some extent a matter of choice and there may be alternative options that could also be viable. Therefore, we consider that the details are up for debate, though the broad principles we discuss in this section should remain widely applicable under an availability-based payment model.

Under our proposed model, SS auction winners are free to take up any market position, but if their market position is such that the volumes of services that are technically realisable from that position fall short of the contracted volumes, this will create certain obligations in relation to their BM offers.

We have deliberately defined 'contingent commitment' in a sufficiently general manner that it can be applied to any combination of system service and technology. Applying this notion of commitment requires an objective and transparent assessment, for each technology, of the amounts of different system services that are realisable from each possible operating state. These assessments may have to be updated as technologies evolve.

Specifically, under the contingent-commitment model SS auction winners must:

- either take up a market position such that the contracted volumes of system services are technically realisable from that position (in the reserve case, we call this 'the contracted reserve position'[37]); or
- in the event that the volumes of system services that are technically realisable from the market position fall short of the contracted volumes, submit BM offers that allow the TSOs to increase the volume of system services available from that provider, including up to, but not exceeding, the contracted volumes. The price at which these BM offers are made is subject to conditions stipulated in the system services contract.

Under this approach, conventional providers with SS contracts would be required to make DEC and INC offers in the BM on certain terms, giving the TSOs certainty about the cost involved in dispatching providers to ensure sufficient availability in real time. This would not require any modification of the BM mechanism itself and could be implemented through a contractual obligation on SS contract holders to make certain BM bids.

As we discuss below, contingent commitment allows conventional plant to compete on reasonably neutral terms with other technologies. Different technologies would be making broadly similar offers to the TSOs.

[37] In practice there may not be a single 'contracted reserve position', e.g. a CCGT that is positioned at any quantity greater than zero and not exceeding Q-R (where Q is the quantity corresponding to full load and R is the amount of reserve) is available for its contracted volume of reserve.

Contractually required DEC offers

We first discuss the case of reserve provided by a conventional generator and what obligations on BM bids might be appropriate if a plant has a SS contract to provide reserve.

Commitment for DEC offers

For DEC offers, we propose that winners may be required to make (or alternatively are deemed to have made) certain DEC offers at the level of the 'energy price'.[38] This would apply only for reserve services that are only technically realisable by a provider that is exporting at part load and it would mean that, when there is insufficient reserve available on the system, the TSOs could increase the volume of reserve made available by this provider at no additional cost, over and above the system services payment.

Specifically, if the provider's market position q_m does not leave sufficient headroom for the contracted volume of reserve to be available, then it has to make DEC offers to be moved to dispatch positions between q_m and its contracted reserve position Q-R (inclusive) to make the contracted volume of reserve available. When there is insufficient reserve in the schedule, the TSOs can accept these DEC offers to make the full contracted reserve volume from this provider available.[39] Requiring the DEC offers to be made at the energy price results in the provider being indifferent between the case where the offer is accepted and the hypothetical case where it had taken up the position q_d at gate closure in the first place.

Note that the DEC commitment would apply only for those services where exporting at or close to full capacity affects the available volumes of the services from a provider (i.e. reserve services). On the other hand, for services such as SIR, there would never be a DEC commitment, because the services are technically realisable regardless of whether a provider is exporting at part load or full load.

The notion of contingent commitment for DEC offers is illustrated in more detail with the example below, which considers a

[38] In practice, the reference price that is used for the purpose of setting bids 'at the energy price' could be the DAM price, or a price that is closer to real time (e.g. an IDM price). Ideally, the price should be as close to real time as possible in order to accurately reflect any changes in scarcity (e.g. due to higher/lower wind than expected) which significantly affect the value of energy at that time. However, it may be that at any given time the IDM is not very liquid and therefore does not provide a robust proxy. Therefore, the choice of energy price may involve a trade-off.

[39] In practice, this might be implemented as a requirement to make a certain number of DEC offers for different quantities, or a continuum of offers.

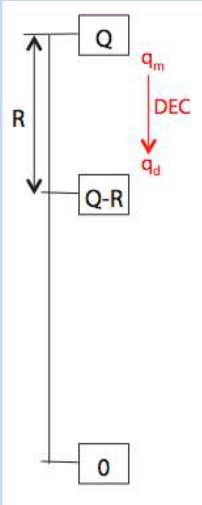
conventional generator providing fast reserve services. Box 1 demonstrates the impact of contingent commitment on SS auction winners who would prefer to earn additional energy margins rather than reserve payments at sufficiently high energy prices and thus take up a market position from which the contracted volume of reserve is not technically realisable. If there is sufficient reserve on the system, providers will not need to be constrained down and will be able to earn the energy margin on their full exporting capacity. However, if a winner does need to be constrained down, this can be done at no additional cost for the TSOs aside from the reserve payment, as the winner is required to make a DEC offer that is set so that payoffs are exactly as if it had chosen this lower market position in the first place.[40]

[40] Notice that the saving for the TSOs compared to the no-commitment case is in the BM rather than from DS3 system services expenditure.

Box 1: Required DEC offers from winners

Suppose a conventional generator with maximum capacity Q won a contract for reserve quantity R. Suppose the energy price is p_e, the unit has constant cost c per unit of energy (for simplicity these examples assume no fixed costs) and the clearing price for reserve is p_r. Assume further that the provider's market position is q_m. If q_m is higher than Q-R and there is insufficient reserve on the system then the TSOs might have to constrain down the provider to a dispatch position $q_d < q_m$. To enable the TSOs to do this, the provider has to make DEC offers at p_e.

Payoffs are as follows:



- If the provider is not constrained down from its market position, it gets the energy margin for q_m plus a reserve payment for $Q - q_m$.
- If the provider is constrained down from its market position, it gets a reserve payment for $Q - q_d$ plus the energy margin for q_d, as acceptance of the DEC offer means that it will be paid the energy price for its dispatch position rather than its market position.
- Therefore, the payoff is the same in the case where the provider is constrained down as in an alternative case where the winner had chosen a market position at which it could have provided the required reserve (i.e. a market position q_m equal to q_d).
- A loser is not restricted in its DEC offers so in this position it would always receive the full energy margin for q_m regardless of any TSO action.

Contractually required INC offers

Commitment options for INC offers

If we apply the similar logic as above to INC offers, then for any service that is only technically realisable by a provider when it is exporting, a conventional producer winning in the SS auction would take on a commitment to make certain INC offers. Specifically, if the provider were not in the market schedule, then it would be required to make an INC offer to export at its minimum generation level. If accepted, the INC offer would then make its contracted volume of reserve technically realisable.

However, such a commitment to make INC bids at the energy price when out of market is potentially very onerous, particularly for conventional generators who might not be in the market schedule in periods when wind generation brought the energy price low. Whereas a commitment to make DEC offers at the energy price entails a risk of reduced – but still positive – payoffs if those offers are accepted, a commitment to make INC offers at the energy price entails a risk of *negative* payoffs if those offers are accepted. These risks would have to be compensated for in the price that the bidder received for system services.

A less onerous alternative would be to mandate that these INC bids are made at a level that reflects the costs of that provider (i.e. marginal generation plus start-up costs) minus the system service payments received as a result of being constrained on. This requirement would mean that the provider is indifferent between remaining out of the dispatch schedule or being constrained on, as it receives a zero payoff in either case. The viability of this option relies on suitable proxies for costs being available.[41] However, it is not essential that costs are precisely measured, rather that any mandated INC is at a level that leads to rough indifference between being out of the market and being constrained on.

Below we illustrate these two alternative options, which again consider a conventional generator providing fast reserve services.[42] In this example, a SS auction winner chooses not to export energy because the energy price is too low (rather than because of planned maintenance or a fault). It cannot technically realise the contracted volume of reserve from its market position, so it will have to make an INC offer to allow the TSOs to constrain it on, if necessary, to be available for reserve.

Box 2 considers the strict case where the offer must be made at the energy price, whereas Box 3 considers the more lenient case where the offer must be cost-reflective, minus the reserve payment.

[41] More specifically, a provider would only be indifferent if the INC offer were reflective of fixed start-up costs as well as variable energy costs.

[42] For the avoidance of doubt, this case would not apply to certain technologies, such as battery storage, for which reserve is technically realisable even when off. Such technologies would never be required to submit any particular INC offer.

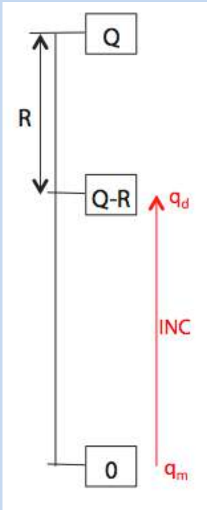
Box 2: Required INC offers at the energy price

Assume that a conventional generator has market position q_m=0 (i.e. it is out of market). If there is insufficient reserve on the system then the TSOs might have to constrain on the provider to its minimum generation level – we make the simplifying assumption that the provider is contracted for a reserve volume equal to its full reserve capability, which is equal to the difference between its maximum exporting capacity and its minimum generation level.

The INC it is required to submit is at the energy price p_e.

Payoffs are as follows:

- If the provider is not constrained on, it gets a payoff of zero.
- If the provider is constrained on, it gets the energy margin for q_d plus a reserve payment for Q - q_d. Notice that this implies a loss for the provider (the energy margin is negative, otherwise it would have preferred to be in the market schedule).
- This is the same payoff as if the provider had chosen a market position at which it could have provided the required reserve (i.e. a market position equal to q_d).
- A loser is not restricted in its INC offers so in this position it will not make a loss even if constrained on, because it can reflect costs in its INC.



As long as there is sufficient reserve on the system, winners can stay out of the market and receive a payoff of zero. However, if the TSOs need to constrain on a winner to provide reserve, they can do so at no additional cost over and above the reserve payment. The provider makes a loss, as the energy price is not high enough to make a profit even when taking into account additional reserve payments. Note that we require INC bids up to the minimum generation level, rather any higher level that would still leave sufficient headroom for the contracted reserve volume, because this avoids exposing providers to unnecessary additional losses on higher volumes of exported energy.

Box 3 considers the more lenient case where the offer must be cost-reflective, minus the reserve payment.

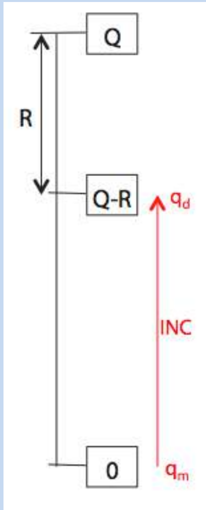
Box 3: Required INC offers at cost, minus reserve payment

As before, assume that a conventional generator has market position q_m=0 and it may be constrained on to its minimum generation level. Again, the provider is contracted for its full reserve capability, which is equal to the difference between its maximum exporting capacity and its minimum generation level.

This time, the INC offer it is required to submit must reflect costs, minus the anticipated reserve payment, i.e. it is priced at c(Q-R) - p_rR.

Payoffs are as follows:

- If the provider is not constrained on, it gets a payoff of zero.
- If the provider is constrained on, it gets a payment of c(Q-R) - p_rR from its accepted INC offer and a reserve payment of p_rR, so that its net revenue is c(Q-R).
- As revenue equals cost, the net payoff is zero, meaning that the provider is indifferent between being constrained on or remaining off.
- A loser is not restricted in its INC offers. In this position, with a perfectly competitive BM it would bid at price c(Q-R), or otherwise it might bid somewhat above this price in order to receive a positive payoff once constrained on.



With cost-reflective INC offers, there is no longer a negative payoff from being constrained on, which makes the requirement much less onerous. In fact, assuming a perfectly competitive BM, this INC requirement would make no difference because SS auction winners would be submitting cost-reflective BM offers in any case. However, if there is a degree of market power in the BM then this INC requirement entails a commitment to forego any energy margins that could otherwise have been earned from having above-cost INC offers accepted.

Compliance with the EU Network Code

We note that the imposition of restrictions on BM offers would potentially contravene the EU Network Code on Electricity Balancing, which has yet to be finalised at the time of writing. However, the high-level auction design framework set out by the SEM-C includes provisions for the award of long-term contracts and it favours annual auctions over more frequent procurement intervals that would be closer to real time.[43] Our recommended approach seeks to promote the intended objectives while minimising adjustments to the SEM-C's framework, rather than proposing a completely new and different auction design framework that could comply more closely with the Network Code.

In practice, it may be that the pro-competitive rationale that lies behind the contingent-commitment approach – in terms of providing for neutral competition between different technologies - can be used as a justification for adopting this model. It may also be that the implementation of the contingent commitment could avoid formally restricting the BM offers that can be made. For example, contracts could be specified in such a way that SS auction winners are notionally able to price their BM offers in the same way that losers do, but with some pre-specified arrangements requiring financial transactions to take place between TSOs and providers outside the BM depending on outcomes in the BM; this could make the net payoffs the same as if the providers had made the BM offers required under the contingent-commitment model.

DS3 System Services payments compensate for loss of flexibility

Regardless of which INC commitment option is adopted, winning in the SS auction does not necessarily provide a free option for providers, which was the key deficiency of the no-commitment case:

- Because a winner may be committed to make certain DEC offers, it loses the flexibility to earn the energy margin on its full exporting capacity with certainty when the energy price is high.
- Because a winner may be committed to make certain INC offers, it loses the flexibility to stay out of the market schedule with certainty when exporting would imply a loss (the magnitude of the cost associated with this depends on the INC commitment option).

The system services payments now provide compensation to providers who agree to forego such flexibility and provide a commitment to the TSOs that reserve will be available on contractually defined terms.

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[43] These aspects may contravene Article 34(6) of the Final Draft of August 2014. See http://networkcodes.entsoe.eu/wp-content/uploads/2013/08/140806_NCEB_Resubmission_to_ACER_v.03.pdf

We can compare the payoff from winning and losing in the SS auction – as we did in the no-commitment case – to show that there are now contingencies where a provider might be worse off as a winner of a SS contract, due to the commitment that this entails.

Table 6: Payoff differences between winning and losing in SS auction (for a conventional generator providing reserve) in different energy price scenarios

Energy price vs. price of reserve	Market position if won	Market position if lost	Difference in profit between winning and losing
Sufficiently high energy price and high energy margin	Full load	Full load	Winners are worse off if constrained down, otherwise no difference
Energy margin lower than reserve price, but still profitable to export ($p_r > p_e - c > 0$)	Full load minus contracted reserve quantity	Exporting full capacity	Winners always better off
Energy margin negative, but reserve price large enough for winners to still make a profit from operating ($p_e - c < 0$ and $p_e Qmin + p_r R > 0$)	Minimum generation level	Off	Winners always better off
Sufficiently low energy price	Off	Off	Winners are potentially worse off if constrained on, otherwise no difference[44]

Inertial response services

While the above analysis focused on reserve services, when we consider other services (such as SIR) the quantity of energy being exported has no impact on availability, subject to the provider being in the market schedule. Therefore, there is never a requirement related to DEC bids in this case.

[44] In the case of INC offers at the energy price, winners make a loss. In the case of cost-reflective INC offers, winners receive the same payoff as losers (zero) if the BM is perfectly competitive, but otherwise winners may forego some positive margins and therefore would be worse off.

For these services, a provider could be required to submit an INC offer (either at the energy price or based on cost, depending on the option adopted) for its minimum generation level if it is not in the market schedule. Again, requiring INC bids at the energy price could be a very onerous requirement – even more so if the price of a service such as SIR is substantially lower than the price of reserve services. Therefore, an alternative approach such as the cost-reflective requirement seems preferable.

Nevertheless, regardless of how these commitments might be structured, the broad principle still applies to inertia response services that a SS contract holder is subject to some degree of obligation to provide those services. There will be a cost to providers of taking on these obligations, which will be reflected in their bids within the SS auction.

Interaction with other markets and DS3 System Services auction bids

Interaction with the BM

If BM offers from SS auction losers are assumed to be cost-reflective or close to cost-reflective, the SS auction winners' BM offers would be more attractive – all else equal (cost structures and technical characteristics) – whenever the TSOs must take non-energy actions to increase the availability of system services. Winning in the auction therefore increases a provider's likelihood of being selected in the BM when there is insufficient availability of system services. When the TSOs must choose between identically priced BM offers from multiple winners in identical situations, it is desirable to choose at random to avoid polluting bidding SS auction incentives (a technical issue discussed in Annex 1).

Interaction with other markets

With the BM offers that would be required from winners in the contingent-commitment case, a provider has exactly the same incentives for bidding in the DAM or IDM as in the no-commitment case.

We can illustrate this by considering a scenario where the energy price is high. If it is profitable to export at full capacity, then a SS auction winner will deviate from its contracted reserve position. Its payoff then depends on whether the TSOs need to constrain it down to increase available reserve. If there is no TSO action, the provider obtains the energy margin. However, if the TSOs constrain it down, it will lose the energy margin and be paid for reserve instead. Its payoff in this case is the same as if it had positioned itself at the dispatch quantity in the market already. The provider therefore, has the same incentive to position itself at full load in the market as in the no-commitment model.[45]

The fact that winning in the SS auction implies a contingent commitment to provide reserve availability at a pre-agreed price when required does not change the winners' bidding behaviour in the energy market, relative to the case where no such commitment exists. However, the fact that this commitment may, on occasion, cause them to receive a lower payoff than they would obtain in the same circumstances without a SS contract (i.e. because they could earn higher energy margins or avoid losses from being constrained on at a loss) does affect bidding in the SS auction.

Bidding in the SS auction

Clearly, there is now a cost associated with being a winner, and positive payments for reserve services would be required to induce a conventional generator to give up the option to earn guaranteed high energy margins whenever the energy price is sufficiently high and to be protected against possible reduced payoffs when the energy price is low. In order to evaluate the cost of winning a reserve contract, bidders need to estimate the foregone margins they are likely to face (and the risk of suffering losses from being constrained on, under the stricter INC commitment option). This means that providers need to form expectations about how likely it is that they would want to deviate from their contracted reserve position and would then be constrained down/on by the TSOs.

With this setup, we can anticipate different bidding incentives for different types of conventional generators[46]:

- Generators with very low energy costs would be most exposed to the risk of being 'forced' to forego high energy margins when constrained down, so they are likely to not bid very competitively in the SS auction.
- Similarly, generators with very high energy costs that often do not find it profitable to be positioned in the schedule would be most exposed to the risk of being 'forced' to turn on at a loss, or at a payoff of zero only. These providers would also not bid very competitively in the SS auction.
- Generators with moderate energy costs that are often marginal would benefit the most from a reserve contract, because a reserve payment allows providers to increase their payoff when the price of reserve is greater than the

[45] In order to induce different behaviour in the energy market, the required BM offers would have to include a penalty (e.g. DEC offers would have to be priced slightly above the energy price) so that deviating from the contracted position is risky.

[46] At this point, we assume no particular sorting mechanism amongst 'tied' BM offers from SS auction winners. This issue is explored in more detail in Annex 1.

energy margin. These providers face lower risks in terms of large foregone energy margins. They should be relatively competitive amongst conventional generators in the SS auction.

Therefore, the contingent-commitment model has desirable incentive properties that should make marginal providers – who are most likely to be in a position to provide availability when needed – relatively competitive in the SS auction, all else equal.[47]

These bidding incentives are summarised in the table below.

Table 7: Bidding incentives in the SS auction (without sorting amongst winners in the BM)

Provider type	Increased payoff when price of reserve > energy margin[48]	Incentive to deviate from contracted reserve position	Potential loss when there is TSO action	Bids in the SS auction
Very low energy costs	Sometimes	Often (to earn large energy margin)	High (lose large energy margins)	**High** (less competitive)
Moderate efficiency (often marginal)	Often	Sometimes	Low	**Low** (more competitive)
Very high energy costs	Sometimes	Often (to avoid exporting at a large loss)	High / moderate (depends on INC commitment option)	**High** (less competitive)

Other technologies

Under the contingent-commitment model, providers whose technological characteristics make it 'easier' to be available face smaller costs in fulfilling the contractual commitments. For example, battery storage technology that is available for reserve even when off does not face any requirements in relation to INC offers. Additionally, any technologies that rarely export energy at full load would only face requirements in relation to DEC offers in a limited number of cases. Such technologies will be more

[47] There may be a number of suppliers close to this margin who provide reserve. In practice, given the small scale of the all-island market, these may be a significant proportion of the available suppliers.

[48] And it is profitable to export, i.e. $p_e(Qmin) + p_r(R) > 0$

competitive in the SS auction. Therefore, the contingent-commitment model does not discourage technologies that are better able to provide availability regardless of operating status, but rather provides reasonably level ground for different technologies to compete.

Volume requirement and expenditure

SS auction winners effectively commit to providing availability as and when needed by the TSOs, to a large extent at no additional cost to the TSOs. As with the full-commitment model, the TSOs therefore only have to know its worst-case availability volume requirement. However, unlike in the full-commitment model, the TSOs do not require winners to take up any particular market positions and therefore does not mandate the provision of availability at all times, even when not needed. This means that the volumes of availability of system services in real-time should match requirements more closely and the volume requirement does not need to include a large 'buffer'.

Overall system services expenditure should be more certain under this model than under the no-commitment model. There may be some residual uncertainty – SS auction winners may still on occasion take up market positions such that the total volume of availability of system services is greater than the real-time requirement.[49] Note that expenditure in the BM will be lower because of the required INC and DEC offers allowing the required volumes of availability to be procured in real time at no additional cost.

3.4 Summary of commitment models

Table 8 summarises the main features of the three commitment level models. The full-commitment model shifts most risks from the TSOs to providers, who have to model their expected costs of always achieving the required market position (or of subcontracting this obligation, if permitted). In contrast, with no commitment, providers do not have to estimate any such opportunity costs before the annual auction, as they face no restrictions on their DAM/IDM/BM decisions. This means that the TSOs need to carry out

[49] We note that proposals for a volume scalar might mean that prices would be scaled back in such cases of oversupply of system services, limiting the TSOs' exposure to the risk of high expenditure. However, doing so could introduce significant price variability, which would increase uncertainty for providers (particularly those relying on revenue to cover the costs of new investments). In general, any scalar that causes prices to vary significantly and unpredictably over time would seem at odds with the objective of setting fixed clearing prices for one year in advance (or for several years in the case of long-term contracts).

some modelling in order to estimate what volume requirement is likely to ensure sufficient availability[50]. In order for the TSOs to estimate the expenditure associated with system service payments, they would have to model providers' availability (i.e. their market positions and dispatch positions) over the contract period. Procuring the required availability at different times throughout the year would be done entirely through the BM; again there would be uncertainty over the costs of this (which could be high if there is market power in the BM).

The main disadvantage of the full-commitment model is that it imposes obligations on providers at all times, which usually will be stricter than what the TSOs actually require. This would not be a concern if system services were procured for shorter time periods and closer to real time, but is problematic in connection with an annual auction. It would provide little flexibility for the supply of system services to change over time as fuel costs and other cost drivers change, potentially affecting who is most efficient to provide those system services.

The contingent-commitment approach addresses this disadvantage, whilst imposing some degree of commitment on winning bidders, such that the contracts are not mere 'options' to supply system services and therefore the SS auction should produce meaningful clearing prices. The bidding decisions for providers are likely to be rather complicated and involve some modelling of the (opportunity) costs that the contractual commitments create, but the risks are not as severe as in the full-commitment case.

With contingent commitment, the TSOs essentially buy flexibility upfront from providers and can be certain that they will be able to draw on the volume of availability up to the total volume procured in the SS auction throughout the year on contractually defined terms that imply no additional cost.[51]

Contingent commitment has other desirable properties in that it should allow providers who are often 'marginal' in the energy market to be relatively competitive in the SS auction. Moreover, compared to the no-commitment model, contingent commitment provides a relatively neutral playing field for different technologies and does not disadvantage alternative technologies.

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[50] Whilst the TSOs' volume requirement already calculates capacity requirements rather than actual requirements, under the no-commitment model there is no certainty about the cost associated with guaranteeing sufficient system services in practice.

[51] For the DEC case, though for the INC case this would depend on the INC commitment option chosen, as discussed previously.

Table 8: Summary of the different commitment models

	No commitment	Full commitment	Contingent commitment
System Service contract	Winners have no obligations	Winners have obligations in terms of DAM/IDM bidding	Winners have some obligations in terms of BM offers
BM interaction	'Sorting' works, assuming competitive BM	BM not needed to guarantee reserve availability (unless insufficient volumes procured in SS auction)	Sorting works because winners make more competitive BM offers
DAM/IDM interaction	Winners not restricted; market position depends on energy vs. SS price	Winners required to take certain actions regardless of market vs. SS price	Winners not restricted; market position depends on energy vs. SS price but energy margins may be clawed back in BM
SS auction	Not meaningful because winners are always better off	Meaningful as winners face a cost in terms DAM/IDM limitation	Meaningful as winners face the cost of having to make certain BM offers
Bidding incentives	Simple for provider	Complicated for provider (in an annual auction)	Complicated for provider
Clearing prices	Low	High in an annual auction, medium in monthly auction	Medium
Volume requirement	Model needed from TSOs to estimate availability	No model needed from TSO	No model needed from TSO
DS3 system services expenditure	Low	High in an annual auction, medium in monthly auction	Medium
BM expenditure	High (especially if BM not competitive)	Low	Low
New technologies	Less competitive	More competitive	More competitive
Investment	Incentive if clearing prices positive	Some incentives for new technologies and marginal plants	Incentives for new technologies and marginal plants

4 Specifying volume requirements

Key points

In order for an auction approach to be viable, volume requirements should be additive, in the sense that quantities from winning bidders can simply be added together in order to produce a total value that satisfies the volume requirement.

In some cases, volume requirements may inherently be more complex, when they need to cover different contingencies. Then, it may be possible to cover different contingencies while keeping volume requirements additive, by specifying more granular volume requirements. For example, separate volume requirements could be set for different time periods (e.g. seasons or time of day), for different technology groups (e.g. static/dynamic response), and/or for different locations (e.g. Ireland / Northern Ireland).

Granularity has the advantage that it may allow the TSOs to express volume requirements that match real-time requirements more closely. It may also allow a more efficient outcome, in particular when separate clearing prices are set for different groups (e.g. Ireland and Northern Ireland). On the other hand, any benefits from granularity would need to be balanced against the downside of additional auction complexity and the risk of setting out an overly prescriptive approach.

We propose that the volume requirement should be flexible, e.g. in the form of a minimum requirement (without a maximum volume). This would allow volumes beyond the minimum requirement to be procured, if it were cheaper to do so. Alternatively, a price-dependent volume requirement has some desirable features, but adds substantial complexity to the process.

In this section, we consider different options for setting volume requirements and integrating them into the auction.

4.1 Are volumes additive?

Consider a simple auction to procure, say, 10 units of a service. The auction would consider different bids for different number of units and try to select the cheapest option. For example, an offer of 4 units from one bidder and 6 units from another might be cheaper than taking 5 units each from another two bidders. Once 10 units had been obtained at least cost, other bids would be rejected. Implicit to this approach is that the total quantity required can be defined and that this could be met in different ways provided the individual quantities supplied add up to that total.

Ideally, the procurement of system services would conform to this simple model. We could define a total quantity of reserve required and then procure this from various sources, totalling up the reserve supplied by each provider. However, in practice, this approach may oversimplify some of the issues involved in procuring an appropriate mix of system services; it might not be sufficient to procure some *total* volume, but the *composition* of the providers may also matter.

There are three main reasons for this:

- System services are required to provide sufficient redundancy. For example, the volume of reserve services ultimately derives from a need for n-1 redundancy, so if the largest single in-feeds were to fail, there is sufficient reserve to take over. This may lead to a requirement that the supply of system services is sufficiently diverse to cover such cases.
- As system services are being procured in advance (as proposed, through one-year or longer contracts) rather than in real time, the TSOs need to be assured that sufficient system services will be available in different contingencies (for example, depending on the strength of demand, the weather conditions and so on). In particular, at different energy prices different plants will be closer to the margin and most able to contribute to providing reserve. Therefore, the TSOs may want to procure contracts for reserve from plants with different generation costs to ensure that reserve is available under different scenarios for the market price. For example, this might again be achieved by procuring system services from a diverse set of providers using a mix of technologies.
- Transmission constraints may mean that demand for and supply of system services cannot be balanced simply on a market-wide basis. For instance, there could be a requirement to have sufficient reserve in a specific geographic area.

In this report we have largely adopted the simplifying assumption that it will be feasible for the TSOs to define a total quantity of system services that they seek to procure – the volume requirement – and that this can be split between different providers in an additive manner. To the extent to which this simple approach may fail to capture all of the TSOs' requirements for procurement of system services, it may be possible to address this by defining more granular requirements, as we discuss in the following section.

4.2 Granularity in the volume requirement

While the TSOs can choose to define a single volume requirement for each service required for a whole year (or, in the case of longer term contracts, multiple years), actual requirements are likely to vary in a systematic way and there could be benefits from using a more granular specification.[52] For example, the TSOs might set:

- different volume requirements for different time periods (e.g. off-peak/peak);
- different volume requirements for different locations (e.g. Ireland/Northern Ireland); or
- different volume requirements for different technology classes (e.g. static/dynamic).

Below we explain how this may be done, under what conditions it may be beneficial, and what the associated downside may be in terms of complexity. In general, a sensible approach should be to consider allowing some granularity where there are substantial benefits from doing so, but without excessively increasing complexity.

At this point, we do not consider the issue of defining volume requirements for different years, which is discussed later in Section 7.

Granularity of time periods

A single annual volume requirement specified for each service (e.g. 700MW of POR) would have to reflect the highest possible availability requirement (i.e. the worst-case scenario, taking into account outages, different plant combinations dependent on system conditions, etc.) anticipated by the TSOs throughout the year. A successful SS auction ensures that at any point in time the TSOs will either have the required availability already 'offered' by providers at gate closure or will be able to achieve this level of availability in the BM at no additional cost. As the volumes procured in the auction are sufficient to cover the worst-case scenario, they are likely to be substantially higher than what is needed in the majority of real-time scenarios. Depending on providers' behaviour in energy markets, this may also have

[52] We note that the auction mechanism proposed could, if needed, be modified to include constraints on the acceptable combination of winning bids. Section 6 discusses how winning bids can be selected to minimise subject to the constraint that the winning bids in total meet the volume requirement. Additional constraints on the mix of winning bids – for example, a diversity requirement represented by no winner providing too great a share of the overall volume requirement – could be added to this process. However, it is not at present clear that such additional complexity would be required to represent the TSOs' requirements and so we have not developed this alternative.

expenditure implications, as discussed in Section 3.3.[53] As a result, the TSOs might pay for more availability than is needed at any given time, even though this issue is less severe with contingent commitment than in the full-commitment case, where the TSOs would pay for availability of the entire volumes procured at all times.

Possible benefits of granularity

Even with an annual auction, it may be possible to align the volume requirement for the SS auction more closely to real-time requirements by specifying more granular volume requirements for each service differentiating by time periods, such as seasons, times of day, or combinations of season and time of day. Table 9 shows an example of what a granular volume requirement may look like. In this case, each volume requirement needs to reflect the worst-case scenario within the corresponding time period. If volume requirements vary substantially between different time windows, this could reduce the TSOs' exposure to oversupply of system services. By contrast, if the requirement for system service is driven primarily by extraneous factors that do not vary strongly across time periods then there may be little benefit from specifying volume requirements for different time periods.

Table 9: Illustrative example of volume requirement granularity

Period covered	POR volume requirement (worst-case scenario)
Annual	700MW
Winter	700MW
Spring	600MW
Summer	500MW
Autumn	600MW
Winter-morning	700MW
Winter-afternoon	600MW
Winter-evening	700MW
Winter-night	400MW
…	…

[53] As mentioned in Section 3.3, this is assuming that there will not be a volume scalar to reduce prices in cases of oversupply of system services.

In order to avoid aggregation risks for bidders (i.e. the risk of winning contracts for the supply of DS3 system services for some time windows, but not others, which would then leave the provider with insufficient revenues to cover costs), bidders would need to be able to specify the periods covered by their respective bids. This would imply an increase in the number of products offered in the SS auction. For example, instead of a single POR product, there might be several available (POR_winter_night, POR_winter_morning etc.), as shown in Table 9. This introduces additional complexity in terms of bidding decisions and increases the likely number of bids that each bidder would wish to make.

Enabling bidders to express the difference in their cost of providing the respective services is also in the interest of the TSOs, because they might be able to procure their requirements at a lower cost. For example, consider SIR with INC bids required at the energy price from winners. For existing capability, the expected cost of being contracted for SIR reflects the potential losses incurred when the provider is not in the market schedule but is constrained on by the TSOs in order to increase SIR availability. For each provider, this expected cost may differ across time periods, and depends on:

- how often the provider expects to be out of the market schedule;
- how often the provider expects to be constrained on by the TSOs in order to increase SIR availability; and
- the average size of the loss it expects to make each time it is constrained on.

Suppose there are three providers with the following expected costs of complying with an SIR contract in each time period (Table 10). For simplicity, assume the providers have the same technical capabilities.

Table 10: Illustrative example of expected costs across time periods

Provider	Expected cost of complying with SIR contract				
	Morning	Afternoon	Evening	Night	Total (all periods)
A	10	25	10	30	75
B	20	20	15	20	75
C	12	21	12	25	70

With a single annual volume requirement and an auction format that encourages bidders to bid according to their true cost, the TSOs could only identify which bidder has the lowest cost across the four time windows (in this example, provider C). More granular bids would allow the TSOs to select combinations of bidders that can meet the requirement at lower cost (in this example, provider A for the morning and evening periods, and provider B for the afternoon and night periods).

Against any potential benefit from temporal granularity in the volume requirement and in the bids submitted, one has to consider the downside of increased bidding complexity and the substantial increase in computational complexity of the winner determination process (described in Section 6 below). For example, one option might be to include only two time periods – peak and off-peak – the precise definitions of which would be published in advance of the auction.

We note that the current consultation on volume requirement calculations does not envisage different volumes for different times, though no decisions have yet been taken on the matter of volume requirement granularity.[54]

Locational granularity

The TSOs face some locational constraints in relation to system services that need to be available. For example, it may be that a certain proportion of POR must come from Northern Ireland at all times. This problem may be eliminated once the second North-South interconnector is fully operational. Thus, the rationale for locational granularity may then no longer exist.

We understand that, for at least some services, the technical capability in Northern Ireland is somewhat scarce relative to the volumes that may be required for Northern Ireland in real time and it is owned by a small number of entities. Providers in Northern Ireland may be able to anticipate that they will be required to provide certain volumes of system services, meaning that they may be more likely to exert market power in the system services market than providers in Ireland, where there may be stronger potential for competition as not all providers would necessarily be needed in order to fulfil the volume requirements.

Ignoring locational constraints in the SS auction could have undesirable consequences because it would be likely to select mostly providers located in the more competitive region (likely to be Ireland). This could result in over-procurement of system services from this region, relative to what is likely to be required in real time, whereas the availability of system services in Northern Ireland falls short of requirements. Losing providers in Northern

[54] EirGrid and Soni, October 2015, Consultation on Volume Calculation Methodology and Portfolio Scenarios

Ireland would face no obligations to make BM offers at certain price levels and may anticipate that the TSOs will still need to call upon them in the BM to provide system services in order to meet the system's locational constraints. This could leave those providers with substantial market power in the BM.

Possible benefits of granularity

An alternative approach would be to incorporate locational constraints in the SS auction by setting separate volume requirements for each service in Northern Ireland and in Ireland. This approach would shift market power concerns from the BM to the SS auction, but this may be preferable in order to obtain upfront commitments from providers, which would then prevent the exercise of market power in real time as the TSOs act to satisfy their locational constraints in the BM. With locational volume requirements, the SS auction would procure volumes that match real-time requirements more closely, avoiding inefficient outcomes where system services are over-procured from the more competitive region and under-procured from the less competitive region.

If separate volume requirements are set for each region, the auction would be more efficient if it set separate clearing prices for each region. Otherwise, with a single clearing price, market power in one region could raise the clearing prices for the entire market.[55] This could also mean that there is a possibility of 'unhappy losers' – these are providers in the more competitive region (e.g. Ireland) who would be happy to have won system services at the overall clearing prices set by the less competitive region (e.g. Northern Ireland), but who have been unsuccessful due to the volume requirement for the more competitive region having been satisfied by cheaper bids from other providers.

Technological granularity

For certain services the TSOs may have an objective of ensuring that it can draw on sufficient availability from a mix of technologies. For example, if the SS auction were to award contracts for one service mostly to one type of provider (e.g. wind generation) this would be problematic if that service were required when that particular type of provider is unlikely to be in the market (e.g. at times of low wind). More generally, when technologies are similar in terms of providers' likely availability at any given time (i.e. their availabilities are

[55] When determining whether a system service is competitive enough to be included in an auction, it might be best to carry out this analysis separately for different regions.

strongly correlated), then allocating contracts only to these technologies may be undesirable and inefficient.

Possible benefits of granularity

If this were a significant issue, it would be possible to specify multiple volume requirements for the same service for different technology classes. The rationale would be to avoid over-procuring from one technology class and under-procuring from another, analogously to the rationale for locational volume requirements.

Technology classes should be defined as broadly as possible, while distinguishing fundamental technical characteristics that need to be taken into account in order to ensure that the volumes procured in the SS auction cater for real time requirement. This is because a relatively narrow definition of technology classes creates the risk of setting an overly prescriptive technology mix and of setting volume requirements that are too rigid and cannot be met, or can only be met inefficiently (e.g. if there are no, or few bids received from providers using a particular technology).

Depending on the technical considerations underlying the procurement of each service, possible candidate definitions of technology classes could include synchronous/non-synchronous, or static/dynamic. From the consultation on volume requirement calculations we understand that the TSOs currently do not envisage significant technological granularity for most services.[56]

With regard to clearing prices, the same arguments discussed in relation to locational granularity apply here. If volume requirements are set for different technology classes but a single clearing price is determined, the price will be set by the least competitive class. Setting separate clearing prices should lead to a more efficient (lower cost) outcome.

4.3 Flexibility in the volume requirement

Rather than specifying each volume requirement as a single, fixed amount, it would be preferable to allow some flexibility in the volumes that are procured. If a fixed volume requirement is used, there is no guarantee that there will be a feasible combination of bids that produces exactly the volume required. Moreover, even if there are feasible outcomes that produce exactly the volume required, it may be more economical to procure slightly more or slightly less.

[56] EirGrid and Soni, October 2015, Consultation on Volume Calculation Methodology and Portfolio Scenarios

Minimum volume requirement

Flexibility can be introduced in more than one way. In the simplest case, the TSOs may specify volume requirements as a minimum and procure more if this is cheaper than procuring any other quantity that satisfies this minimum requirement. This is incorporated in the proposed version of the winner determination (see Section 6.2). We note that the SEM-C has suggested setting both a minimum and a maximum volume requirement, but there is in fact no possible benefit from specifying a maximum.[57]

Price-dependent volume requirement

A more sophisticated option could be to allow flexibility by using price-dependent volume requirements. A price-dependent volume requirement has the additional benefit of potentially limiting the impact of any market power on prices. It could avoid situations in which procuring a small additional volume of a system service has a large effect on the clearing price; in such a circumstance, the TSOs would compromise with a slightly reduced quantity and a much lower price. Although this approach adds some complexity for the TSOs in terms of having to specify volume requirements at different notional prices, in practice the flexibility would reflect the uncertainty that does exist when attempting to precisely set volume requirements and the fact that the TSOs can always procure additional volumes of system services from SS auction losers in exceptional circumstances. Therefore, we recommend that the TSOs consider the feasibility of this type of flexible volume requirement.

There are further issues to be considered when procuring contracts of different lengths. We discuss how to deal with long-term contracts in more detail in Section 7.

[57] In its clarifications paper SEM-C 14-075, the SEM Committee sets out examples that include both a minimum and a maximum volume requirement. However, with a minimum requirement and any approach that selects the 'least cost' solution, there is no need for a maximum requirement. The volume procured in the winning outcome will only exceed the minimum requirement if doing so if less costly than accepting any outcome with a lower volume that still satisfies the minimum requirement. Setting any maximum requirement potentially prevents a less costly outcome from being selected.

5 Bidding parameters

Key points

Any bid must include quantity and price. Quantity should be specified for each individual service, in the relevant units. On the other hand, price should be specified as a single bid amount for the overall package, which differs from the SEM-C Decision but better supports the benefits of combinatorial bidding. Bidder preferences will depend on their total remuneration for the package, rather than the individual prices for each service within the package.

A bidder's expected probabilities of availability may differ between services. As a result, bidders would face a risk if they were not allowed to express expected availabilities in their bids. The risk is that clearing prices are set relatively low for those services with relatively high expected availability, so that the bidder is unable to recover its costs. The uncertainty could compromise the efficiency of the outcome.

To address this, we propose allowing bidders to express expected availabilities for each service. With this approach, the bid amount guarantees that, if the winning bid is accepted, the provider's expected system services revenue is sufficient to cover the costs of complying with the contract.

We consider any incentives for gaming, where the stated availabilities and quantities are manipulated to try to achieve a more profitable outcome. Although there are no incentives to overstate availability, a potential issue is that a bidder might want to make itself available more that it stated, especially if the clearing price for that system service is higher than it expected. This problem arises primarily because the amount by which a provider wants to make itself available may depend on the clearing price and is an unavoidable feature of the availability-based payment model. The problem that availability depends to some extent on clearing prices in the auction is addressed by allowing bidders to make multiple bids at different availability levels. To the extent that there is a need to cap future expenditure on availability payments, there may be some need for a risk-sharing regime in which winners who significantly exceed stated availability face some claw-back.

Bidding restrictions would need to be in place to ensure that only valid price/quantity combinations could be accepted from bidders.

This section sets out the various parameters bidders would submit in their bid. In addition to the parameters mentioned in this section, new investments would also submit the contract length for each package. New investments are discussed in Section 7.

5.1 Quantities

Bidders need to specify quantities for different system services in their bid, but the notion of quantity may differ for each service.

- Reserve services are defined as the increased MW output that can be delivered within a certain timeframe. Quantity is therefore expressed in MW.
- The quantity for SIR is more complicated. The key quantity expressed in a bid would simply be the stored kinetic energy. This can be added up across a combination of bids and checked against a total kinetic energy volume requirement. The SEM-C has determined that a provider of SIR will be remunerated based on the kinetic energy it provides multiplied by a SIR factor, expressing the ratio of kinetic energy to the lowest sustainable MW output at which the unit can operate while providing reactive power control. Therefore, it is desirable for this minimum output level to also be expressed in the bid. With the multiplier in place, providers with a lower minimum generation level would obtain a higher payment per unit of kinetic energy provided than providers with a higher minimum generation level. Thus, everything else being equal, providers with lower minimum generation levels would submit lower bids in the SS auction in anticipation of a higher payment if successful.
- FPFAPR can be seen as binary, in the sense that a provider is either capable of it or not. Thus, no further 'quantities' would have to be expressed in a bid. The volume requirement may be expressed as the total number of units that satisfy the FPFAPR requirement, or alternatively as the total exporting capacity of units that are capable of FPFAPR.[58]

Table 11 shows the notion of quantity for the different system services. We note that, depending on any assessment of competition and market power, some of the services may be unlikely to be included in an auction.

[58] The current volume requirement consultation sets out that the volume requirement for this is *"simply the capacity of any new non-synchronous generation connected"* (Section 2.6 from http://www.eirgrid.com/site-files/library/EirGrid/DS3-System-Services-Consultation-on-Volume-Calculation-Methodology-and....pdf).

Table 11: Quantity for the difference system services

Service	Quantity
All reserve services (including replacement reserve)	MW
Ramping	MW
SIR	Stored kinetic energy (but payments based on formula which takes into account minimum output level)
Fast frequency response	MW
Fast post-fault active power recovery	Binary (capable or not capable)
Steady- state reactive power	Mvar range × (the capacity at which it can provide it/Registered Capacity)
Dynamic reactive response	Binary (capable or not capable)

Notice that some quantities of different services are very likely to be highly correlated across bids; for example a provider that is available for 20MW of POR would usually also be available for at least 20MW of SOR and TOR. However, as these linkages might differ across technologies, it may be more flexible to retain these as separate services rather than combining them in fixed proportions.

5.2 Bid amounts

When bidding is combinatorial, it is not necessary for bidders to state a price for each service within a package, as has been envisaged by the SEM-C. Bidders may depend on the total remuneration received, rather than the split of this total amount between different services. Indeed, requiring bidders to specify, and taking into account individual prices eliminates most benefits of combinatorial bidding, as explained in Section 6.

Single bid amount for a package of services

Therefore, we propose that each bid has a single price for the package of services included in its bid ('the bid amount'). The bid amount is not a price per unit (e.g. per MW) but rather a total price for the quantities of services included in the package, reflecting the revenue that the bidder requires in order to cover the cost of complying with the contingent-commitment contract. If bidders expected any performance or product scalars to be applied to their payments, they would adjust bid amounts correspondingly. Bid amounts may either be specified as an hourly amount or an annual amount. In the remainder of this section, we assume that an hourly bid amount is used.

With this approach, a bidder is guaranteed that the sum of the products of the clearing prices and quantities for the services included in the bid will be at least the bid amount. However, with the proposed payment for availability, this does not necessarily provide a revenue guarantee and makes bidding decisions complex.

In the case of a bid that includes only one service, the determination of the bid amount from a bidder perspective is relatively straightforward. Bidders can simply adjust their bids to reflect the proportion of time they expect to be available. A bidder expecting to be available only half of the time would need to double its bid amount in order to be guaranteed the same revenue as if it were available all of the time.[59]

Expected availabilities and bidding uncertainty

This approach also works when the bids include multiple services but expected availability is very similar across them. However, if the bid includes multiple services with rather different expected availabilities, the bidder is exposed to a risk that clearing prices are relatively low for those services that it expects to be available for relatively often. The uncertainty makes bidding decisions complex, as shown in the following example.

[59] One complication comes from the fact that expectations of availability may in part depend on the clearing prices, because a provider's incentive to position itself as available increases with the prices paid for system services. However, this is an inherent problem with holding an annual auction in advance and then paying on an availability basis that can only be determined ex ante.

Box 4: Example with multiple services that have different expected availabilities

Consider a provider who bids for service X and service Y together. The expected availability for X is 60% (i.e. 5256 hours in a year) and for Y it is 40% (i.e. 3504 hours in a year). The expected cost of complying with the contract is €1m. The quantities bid for are 10 units for X and 10 units for Y.

In this case, the bidder faces uncertainty about what the eventual clearing price for each service will be. The greatest risk is that the clearing price for X is relatively low, which would make it less likely that the bidder can recover its costs.

For example:

- If it assumes that the clearing price for X will be zero, it requires a price for Y of around 285€/h.[60] On this basis, its bid amount should be 285€/h.
- If it assumes a higher clearing price for X, say of 100€/h, it requires a price for Y of around 135€/h.[61] On this basis, its bid amount should be 235€/h.
- If it assumes that the clearing price for Y will be zero, it requires a price for X of around 190€/h.[62] On this basis, its bid amount should be 190€/h.

Depending on its expectations and risk aversion, the provider would bid between 190€/h and 285€/h. A bid amount below 285€/h would make the offer less competitive, but would entail a risk of not recovering costs. Thus, the bidding decision is complex and involves uncertainty.

Expressing expected availabilities in bids

One option for addressing this problem would be to allow bidders to express their expected availabilities. A bid would then contain quantities and expected availabilities for each service, as well as a single bid amount. Clearing prices (p_i) could then be determined to ensure that the constraint $\Sigma\alpha_i p_i q_i \geq \beta$ is satisfied, where a β is the bid amount, α_i the probability of being available for service i, and q_i the quantity for service i.

Note that, regardless of whether the auction allows expected availability to be included in the bids, providers would need to estimate their expected availabilities in any case in order to price

[60] €1m divided by 3504 hours.

[61] Expected revenue from X is €525,600. This leaves €474,400, which is then divided by 3504 hours.

[62] €1m divided by 5256 hours.

their bids, as it is expected availabilities together with the clearing prices that determines the expected revenue that they receive.[63]

Allowing bidders to include expected availabilities could also simplify the notion of the volume requirement. Under this approach, the volume requirement does not need to be based on availability assumptions as these could just be taken from bids and it may be that providers are in the best position to judge their expected availabilities. The winner determination process then needs to ensure that the sum of the expected quantities (expected availability times quantity) satisfies the volume requirement.[64]

5.3 Bidding incentives

Under the proposed approach set out above, bids contain quantities (q_i) and availabilities (α_i) individually, whereas the winner determination process only considers the expected quantity of system services supplied, which is product of these two parameters, which we denote '$\alpha_i q_i$'. It is this product, together with the bid amount, that determines the competitiveness of a bid (i.e. its likelihood of being accepted).

For each set of possible quantities, bidders would have a corresponding set of expected availabilities and bid amounts. Note that a provider's actual availability may depend on the eventual clearing prices, as high prices for system services create stronger incentives for providers to make themselves available through the market schedule. Providers may reflect this in their bids by placing multiple bids for the same quantities; those bids with higher expected availability would have higher bid amounts.

Possible bidding strategies

We should consider whether this set-up might lead to undesirable bidding incentives in terms of deliberately misstating the quantity and availability parameters (whilst holding the bid amount constant). We show below that there should be reasonable incentives for truthful bidding in most cases, but there may be some issues with auction winners exceeding stated availability in certain cases.

There are various cases of possible non-truthful bidding behaviour to consider:

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[63] In practice, one option might be for the TSOs to make their 'best guess' about a provider's availabilities, while still allowing bidders to submit different values.

[64] Although there may still need to be constraints to enforce a certain technology mix as actual availabilities are likely to be highly correlated amongst similar technologies.

- A bidder might understate quantities and overstate availabilities, such that the product $\alpha_i q_i$ is unchanged. The competitiveness of the bid is unaffected, so there is no benefit from the strategy in terms of increased likelihood of winning or affect on auction clearing prices. However, there is a downside in that the bidder may receive lower payments if it wins, due to having stated lower quantities in its bid. Therefore, there should be no incentive for such a strategy.
- A bidder might overstate quantities[65] and understate availabilities, such that the product $\alpha_i q_i$ is unchanged. The competitiveness of the bid is unaffected, so there is no benefit from the strategy in terms of increased likelihood of winning. However, by committing to a higher quantity, the bidder is giving up greater flexibility, which entails a greater cost. By doing so without having adjusted the bid amount, it is therefore exposed to a risk that it will win with clearing prices that are too low to cover its costs. Therefore, this discourages such a strategy.
- A bidder might understate its quantities and/or its availabilities, such that the product $\alpha_i q_i$ is reduced. This reduces the competitiveness of the bid, such that the likelihood of winning and therefore the expected payoff is lower. Moreover, there would be a further downside in that the bidder may receive lower payments if it does win, due to having stated lower quantities in its bid. Therefore, there should be no incentive for such a strategy.
- A bidder might overstate its quantities and/or its availabilities, such that the product $\alpha_i q_i$ is increased. This increases the competitiveness of the bid, so there is a higher likelihood of the bid becoming a winning bid. However, this simultaneously exposes the bidder to a risk that it will win with clearing prices that are insufficient to generate expected revenue that covers its costs.

Incentives for truthful bidding

The last case increases the likelihood of a bid winning, so it merits further explanation. The examples below show that, by overstating quantities or availabilities without adjusting the bid amount, the bidder is increasing its likelihood of winning only because it becomes possible to win with clearing prices that do not generate enough expected revenue to cover costs. Therefore, there should be no incentive to follow this strategy. The optimal strategy should be to bid truthfully, so that the probability of winning is maximised

[65] These examples of overstating quantities assume that the increased quantities do not exceed the provider's technical capability, as this would make the bid invalid.

subject to ensuring that the clearing prices are high enough for winning to be desirable.

First, we provide an example where a bidder overstates availabilities. Suppose a bidder bids for the provision of two services (1 and 2) and its true values are as follows, where the bid amount β reflects the minimum hourly revenue that the bidder would require in order to comply with the contract:

q_1	α_1	q_2	α_2	β
10MW	60%	10MW	40%	100

By bidding truthfully, the bidder is guaranteed that it will only win the contract if the clearing prices satisfy $\alpha_1 p_1 q_1 + \alpha_2 p_2 q_2 \geq \beta$, i.e. $6p_1 + 4p_2 \geq 100$. For example, if the price for each service is 10€/MWh, the bidder receives just enough expected revenue to cover its cost (100€/h).

Now suppose the bidder overstates availabilities by bidding as follows:

q_1	α_1	q_2	α_2	β
10MW	80%	10MW	60%	100

The bid now guarantees that $8p_1 + 6p_2 \geq 100$. The non-truthful bid is more likely to win, but that is purely because the bidder is now exposed to the risk of winning with clearing prices that will not generate sufficient revenue to cover its cost, based on its expectation. For example, the bidder could now win at a clearing price of 8€/MWh for each product, which satisfies the bidder's constraint based on overstated availability values, yet generates only 80€/h revenue based on its true expectation. Therefore, there should be no incentive to pursue such a strategy.

Now suppose that the bidder opts to overstate its quantities, rather than its availabilities. It bids as follows:

q_1	α_1	q_2	α_2	β
15MW	60%	15MW	40%	100

The bid now guarantees that $9p_1 + 6p_2 \geq 100$. The non-truthful bid is more likely to win – for example, it could win with clearing prices of 7€/MWh, giving expected revenue of 105€/h.[66] However, the potential cost of complying with this contract would in all likelihood be greater, because by stating larger quantities the bidder is giving up a greater degree of flexibility in complying with the contingent-

[66] Assuming the truthful expected availability for 15MW is the same as for 10MW, which may not necessarily be the case.

commitment contract. For example, the bidder's cost of complying with a contract for 15MW in each service (rather than 10MW) could be 130€/h (rather than 100€/h). By bidding non-truthfully, therefore, the bidder has again exposed itself to the risk of winning at clearing prices that do not generate sufficient revenue and should be better off by simply expressing its true values.

Therefore, we do not expect there to be significant incentives to deviate from straightforwardly bidding capacity and expected availability in the auction, as straightforward bidding assists the bidder to ensure that bids win if and only if clearing prices are such that the bidder would want to win.

Impact of availability caps/penalties

Note that, if the TSOs wish to impose strict budgetary controls on total expenditure under SS contracts, there is the possibility of imposing caps on the payments winners receive, or penalties that claw-back some expenditure once winners actually exceed their stated availability (see Section 2.3). If such measures were in place bidding incentives would be affected, as bidders would be exposed to greater risks. Specifically, they would still face a downside risk that actual availability will be somewhat lower than expected, which would be fully reflected in their revenues, but they would not face an equivalent upside risk (as excess availability is not remunerated on the same basis). Therefore, bid amounts would most likely be higher to reflect the greater uncertainty.

5.4 Bidding restrictions

Bid parameters would be subject to certain restrictions:

- any bids that are priced above the reservation price[67] would not be valid;
- any bids that include quantities larger than the provider's technical capability would not be valid. Technical capability for this purpose will have to be declared in the qualification process.

Bidders should also only be allowed to submit one bid for a specific package of services and quantities. They should not be allowed to bid different availabilities for the same package.[68]

[67] Which may be set in line with the prices determined by the regulated tariff methodology.

Other restrictions may be necessary if awarding contracts for very large volumes to a single provider is undesirable. In such cases, the auction should include a cap on the maximum quantity that any bidder may specify for the service in question, regardless of its technical capability.

[68] It may be reasonable to allow different expected availabilities to be stated for different quantities of a service. E.g. a bid for 20MW of reserve might state an expected availability of 0.5 and a bid for 10MW of reserve might state an expected availability of 0.6. However, it may be desirable to place some restrictions on this to prevent inconsistent bidding, e.g. the bidder could not state a higher expected availability for 10MW than for 20MW, because at any time that the provider can technically realise 20MW of reserve it can also realise 10MW of reserve,

6 Winner and price determination

Key points

The winner and price determination process proposed by the SEM-C is ambiguous in some aspects. Where it suggests a 'bid stacking' approach that looks at each service individually, this appears to be incompatible with the combinatorial auction format, where package bids mean that the supply of one service is inevitably linked to the supply of other services.

Therefore, we propose an approach that employs a linear programme to select the optimal outcome and prices. It is robust to different contingencies and to the possibility of having a very large number of feasible outcomes.

The determination of winners would select the set of bids with the lowest sum of bid amounts, subject to satisfying the volume requirements and to selecting at most one bid from each bidder. If necessary, additional constraints could be added to this optimisation without difficulty. This approach considers all bids holistically and therefore avoids the potentially inefficient selection of outcome from a 'bid stacking' approach that looks at services individually.

The determination of prices would take place after winning bids have been selected. The process is based on the idea that, from the bids received, we can infer each bidder's preferences. Then, given any set of hypothetical clearing prices, it is possible to infer each bidder's preferred package. The objective of price determination is to identify the clearing prices under which each bidder's preferred package is their winning package.

There may not be a set of clearing prices that satisfies the above condition. In other words, there may not be a set of prices under which each bidder is 'happy' with its winning package, as some could have obtained a higher payoff from an alternative package. This 'unhappiness' can be measured. In this case, we select the optimal set of prices by minimising the extent of 'unhappiness' amongst bidders.

We consider that this approach to winner and price determination should be computationally tractable without unduly restricting the number of bids that bidders may place.

This section explains the SEM-C's current thinking on winner and price determination and sets out our concerns with the approach. It then explains our proposed alternative, covering the determination of winners and prices separately. Winner and price determination for long-term contracts are discussed later in Section 7.

6.1 Issues with SEM-C's winner and price determination proposal

The approach for determining winners and prices needs to take into account the combinatorial element of bids. The SEM-C requirements state that bids should be mutually exclusive and will either be accepted or rejected in their entirety. Such combinatorial bidding addresses aggregation risks that bidders might otherwise face, e.g. because they need to win contracts for a number of reserve services in order to cover their costs.

'Bid stacking' methodology

When evaluating bids, the SEM-C envisages selecting the 'least cost' outcome. The meaning of this is somewhat ambiguous. The SEM-C Decision envisages a 'bid stacking' approach, sorting all bids to establish a supply curve for each service, so that for each service units are in merit or out of merit. Providers that are out of merit for all services will be eliminated. All other providers (i.e. those that are in merit for all services included in their bid and those that are only in merit for some services in their bid) are then removed individually to check whether their exclusion increases or decreases overall costs.

A fundamental difficulty with the SEM-C's proposed approach is that it is unclear how different bids from one bidder could objectively be used to establish a supply curve for a single service[69], as only one of these bids can be accepted in the winning outcome and each bid has implications for the other services included in the bid. In order to establish which of the bids would be included in the supply curve for a particular service, one would need to identify which of the bids is highest up in the merit order for this service, whilst ensuring that the bid is also in merit for all the other services. Selecting the correct bid would therefore require knowledge of what other prices would eventually emerge. This can only be achieved if winning bids and prices for all services are determined simultaneously.

The clarifications paper (SEM-C 14-075) suggests a slightly different approach, where a precise assessment of each possible outcome is carried out in order to select the 'least cost' outcome. However, with many units and many bids, listing all possible outcomes (i.e. full enumeration of all possible winning outcomes) will quickly become infeasible. In fact, the SEM-C does acknowledge that, in practice, the bid stacking approach "*may require the TSO or the auction algorithm to carry out some optimisation between the*

[69] As per SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), §145.

services in order to select the final optimum outcome".[70] Indeed, we propose an optimisation technique that avoids the need to assess each individual outcome explicitly, by evaluating all bids holistically.

Uniform pricing requirement

A separate issue is that the uniform pricing requirement as envisaged in the SEM-C Decision may be incompatible with selecting providers that together have the lowest expected cost for providing the required services. Consider a situation in which a single service is provided. Suppose bidders bid according to cost and have the same expected availabilities. The required volume can either be achieved by:

- a bid for 8 MW with cost of 10€/MWh and a smaller bid for 2 MW with cost of 15€/MWh; or
- two bids for 5 MW each with costs of 14€/MWh.

The first outcome requires a clearing price of at least 15€/MWh, otherwise the smaller quantity bidder will be unwilling to supply. The second outcome requires a clearing price of at least 14€/MWh, otherwise neither bidder will be willing to supply. If bids are considered in merit order with uniform prices being set, then the least-cost outcome is the second outcome, with a clearing price of 14€/MWh and total cost of 10*14=140€. However, if it were possible to set different prices for different winners, the price for the high-capacity bidder in the first outcome could be set at a lower level (e.g. 10€) and the allocation could be feasible at a total deployment cost of 8*10+2*15=€110. With a uniform pricing requirement, cost savings from economies of scale enjoyed by some providers may not be passed on adequately as price savings for the TSOs.

However, we note that whilst a uniform pricing requirement would be incompatible with guaranteeing that benefits from scale economies are fully reflected in the payments that will need to be made for balancing services, with multiple services and combinatorial bids, it may be possible to support the efficient outcome through a set of uniform prices as we will discuss below.

Proposed solution

In order to address these problems, we propose to separate the determination of winning bids from the determination of prices. The bidding parameters are discussed in detail in Section 5.

[70] SEM Committee, Clarifications to SEM-14-059 Information Paper, Decision Paper (14-075), August 2014 , page 11.

Winner determination

Each bid will only contain one bid amount and not prices for specific services, as bidders rationally would not care about the individual price for each service as long as the bundle of services in the package achieves sufficient revenues. We propose that the optimal combination of bids should ensure that the required volumes can be met, whilst minimising the total expenditure across all services based on the bid amounts. This optimisation technique would have the benefit of being transparent and based on objective criteria. It is also much simpler to understand than the iterative process described by the SEM-C and may reduce the scope for legal challenges of the award.

Price determination

To provide bidders with good incentives to bid according to their actual costs, we need a pricing mechanism that implements a second price framework (winner is paid according to the lowest losing bid). Establishing a linear price for each service is then done in a second step. Specifically, we propose to identify a set of clearing prices that ensures that:

- overall, each winning bidder achieves nonnegative surplus at the resulting prices; and
- the extent to which bidders, at these prices, might have preferred to win with some other bid is minimized across bidders.

We will discuss the winner and price determination in detail in Sections 6.2 and 6.3, respectively.

6.2 Winner determination

We adopt the following notation. There are I bidders labeled $i = 1, \dots, I$. Bidder i makes bids $(b_{ij}, x_{ij}, \alpha_{ij})$ where b_{ij} is the bid amount of the jth bid, x_{ij} is the package bid for (the quantities associated with each service) and α_{ij} represents the probabilities of being available. Each bid would be associated with a dummy variable d_{ij}, which is equal to 1 if this is a winning bid and 0 otherwise. Conventionally, each bidder's set of bids always includes a zero bid (i.e. a bid of amount zero for a package of zero quantities for all services), which represents the possibility of that bidder losing in the auction. The volume requirements for all services are specified in a vector X.

To identify the winning bids we would minimise the following mixed-integer linear programme:

$$\min_{d_{ij}} \sum_{ij} d_{ij} b_{ij}$$
$$s.t.$$
$$\sum_{j} d_{ij} = 1 \forall i$$
$$\sum_{ij} d_{ij} (\alpha_{ij} \circ x_{ij}) \geq X$$

In summary, we would minimise the sum of bid amounts of winning bids, subject to satisfying all volume requirements and accepting a maximum of one bid from each bidder.

Discussion of proposed approach

The winner determination accepts or rejects bids in their entirety. Each bidder can also win at most one bid. It therefore satisfies the requirement of the SEM-C for package bidding and for bids to be mutually exclusive.

The winner determination also solves the issues with the approach described in the SEM-C Decision (stacking bids for each service) without having to resort to evaluating every possible outcome explicitly[71]. For instance, consider the earlier example set out in Section 6.1, where the algorithm has to choose between either accepting:

- a bid for 8 MW with cost of 10€/MWh and a smaller bid for 2 MW with cost of 15€/MWh; or
- two bids for 5 MW each with costs of 14€/MWh.

Our proposed approach accepts the more efficient first combination, as this entails a sum of bid amounts of 25€/MWh, as opposed to 28€/MWh in the second case. In contrast, the stacking approach would accept the second combination, as the bid at 15€/MWh is considered last in the bid stack.[72]

The winner determination takes into account expected availability of bidders when evaluating bids. Including these probabilities essentially makes bids with higher expected availability more competitive, everything else equal. To see this, consider two bids with identical bid amounts and quantities. The bid with higher

[71] Evaluating every possible outcome becomes infeasible with too many potential solutions. For example, with 20 bidders, each submitting 100 bids, the number of possible outcomes is approximately 100^20.

[72] Our proposed approach chooses the right winners but the problem with a uniform price remains: in this case the two losers would be 'unhappy' at a clearing price of 14€/MWh.

probabilities will be more competitive because it contributes more towards the volume requirement at the same price.

The complexity of the winner determination process depends on the number of volume requirements, the number of bidders and the number of bids submitted by each bidder. With increasing complexity it may be necessary to approximate the solution. Computational tractability is discussed further in Annex 2.

6.3 Price determination

The process of price determination would take place once the set of winning bids has already been determined. By considering the set of bids received – both winning and losing bids – we can infer the supply preferences of each bidder at different price levels. The basic idea behind the price determination method is that, if we suppose a hypothetical set of clearing prices across all services, we can use the inferred preferences of each bidder to determine which package they would prefer at these hypothetical clearing prices. The objective of price determination is to identify the set of clearing prices for all services that would make each bidder choose as its preferred package the package that has in fact been selected as their winning bid.[73]

Measuring 'excursion'

In practice, we may not always find a set of clearing prices at which all bidders would choose their winning packages. Nevertheless, for each bidder, we can effectively measure its 'unhappiness' (which we call its 'excursion') about receiving its winning package at a certain set of hypothetical market clearing prices. The excursion is the highest increase in payoff it could achieve by choosing a package it did not win, relative to the payoff it receives from being awarded its winning package. Note that the excursion is either zero or positive. When a bidder's payoff is higher from its winning package than from any alternative package (i.e. it is a 'happy winner'), we denote its excursion as zero.[74]

For example, suppose that a bidder submits two bids:

- Provide 10MW of POR at an expected availability of 50% with a bid amount of 40€/h; and
- Provide 20MW of POR at an expected availability of 40% with a bid amount of 60€/h

[73] Note that a loser's 'winning package' would be the zero bid that is notionally included for each bidder.

[74] Rather than a negative number to represent the reduction in payoff it would have received from an alternative package.

Assume the bidder wins the first package. At a hypothetical clearing price of 15€/MWh, the hourly payoff from each of these packages is:

- 10*0.5*15-40=35€/h
- 20*0.4*15-60=60€/h

The bidder's unhappiness about winning (excursion) is therefore 25€/h at these prices. At different prices, its unhappiness could be different and at some prices it would be happy to receive its winning package (at zero excursion).

At a given set of clearing prices, there is at least one losing bid for each bidder with maximum excursion (note that the losing bid could be the notional zero bid). The total maximum excursions across all bidders are minimised through the choice of clearing prices. Therefore, even though the resulting clearing prices might not support the auction outcome fully because at those prices some bidders might actually prefer to win one of their losing bids, they are nevertheless the clearing prices that *best* support the outcome.

The price determination would be a three-step process:

- First step: Minimise the sum of maximum excursions subject to all winners receiving their bid amount at the resulting prices.
- Second step: Identify the sets of clearing prices that minimise the sum of excursions and also maximise revenues (the sum of prices of all quantities supplied).
- Third step: If there is more than one set of clearing prices which maximises revenues, use the alignment of clearing prices to the regulated tariffs to break ties.

We will discuss these three steps in turn.

First step

Minimise the sum of maximum excursions

Using the notation from the winner determination, there are I bidders labeled $i = 1, \ldots, I$. Bidder i makes bids (b_{ij}, x_{ij}) where b_{ij} is the bid amount of the j^th^ bid, x_{ij} is the package bid for the j^th^ bid, and α_{ij} is the expected probability of being available. Conventionally, each bidder's set of bids includes a zero bid (i.e. a bid of amount zero for an empty package) representing the possibility of that bidder losing. Let $(b_i^\star, x_i^\star, \alpha_i^\star)$ be the winning bid by bidder i, where $x_i^\star = 0$ for a losing bidder.

Let γ_k denote the candidate clearing price for service k and γ the vector of these clearing prices.[75] Let ρ_k be the regulated tariff for service k and ρ the vector of regulated tariffs.

The first step in the price determination is to find clearing prices that minimise the following linear programme:

$$\min_{\gamma} E = \sum\nolimits_i \varepsilon_i$$
$$s.t.$$
$$\varepsilon_i \geq \left(\gamma \cdot (\alpha_{ij} \circ x_{ij}) - b_{ij}\right) - (\gamma \cdot (\alpha_i \circ x_i^\star) - b_i^\star) \forall i, j$$
$$\gamma \leq \rho$$
$$\gamma \cdot (\alpha_i^* \circ x_i^\star - b_i^\star) \geq 0 \forall i$$

where E is the minimum sum of excursions.

This linear programme identifies a set of clearing prices that minimises the sum across bidders of the maximum excursion for each bidder ensuring that all bidders make nonnegative surplus on their winning package. The clearing prices are also required to be no higher than the regulated tariffs.

Second step

If the first step produces multiple possible solutions, identify the sets of linear prices that maximise revenues

There may be more than one set of clearing prices that minimises the sum of maximum excursions. An objective way to select clearing prices is to maximise expected revenues for providers (based on their stated quantities and expected availabilities), which is conceptually equivalent to setting prices on the basis of the lowest losing bid. While this is not essential, this second-price approach may be more conducive to truthful bidding.[76]

We therefore identify the set of clearing prices, among the candidates selected in the first step, that maximises revenue R in the following linear programme.

[75] Note that categories in which no lots were awarded in the winner determination are ignored in this analysis. Notionally, the prices for categories in which no lots were awarded are held at zero.

[76] Alternatively, we could minimise revenues. Conceptually this equates to setting prices based on the highest winning bid. This might lead to gaming incentives when there is market power in the auction and a marginal bidder is able to influence prices.

$$\max_{\gamma} R = \sum_{i} \gamma \cdot (\alpha_i^* \circ x_i^\star)$$
$$s.t.$$
$$\varepsilon_i \geq \big(\gamma \cdot (\alpha_{ij} \circ x_{ij}) - b_{ij}\big) - \big(\gamma \cdot (\alpha_{ij} \circ x_i^\star) - b_i^\star\big) \forall i,j$$
$$\gamma \leq \rho$$
$$\gamma \cdot (\alpha_i^* \circ x_i^\star) - b_i^\star \geq 0 \forall i$$
$$E = \sum_{i} \varepsilon_i$$

Third step

If the second step produces multiple solutions, use the alignment of linear prices to the regulated tariffs to break ties

If there is more than one set of clearing prices that minimises the sum of maximum excursions and maximises overall revenues, the set of clearing prices is chosen which minimises the sum of squared differences relative to the regulated tariffs:

$$\min_{\gamma} \sum_{k} s_k \rho_k \left(\frac{\gamma_k}{\rho_k} - \lambda\right)^2$$
$$s.t.$$
$$\varepsilon_i \geq \big(\gamma \cdot (\alpha_{ij} \circ x_{ij}) - b_{ij}\big) - (\gamma \cdot (\alpha_i^* \circ x_i^\star) - b_i^\star) \forall i,j$$
$$\sum_{i=1}^{I} \varepsilon_i = E$$
$$\sum_{i=1}^{I} \gamma \cdot x_i^\star = R$$
$$\gamma \leq \rho$$

where $s_k = \sum_{i=1}^{I} \alpha_{ik}^* x_{ik}^\star$ is the sum of supplied quantities of service k weighted by its expected availability.

In order to minimise the objective above, the parameter λ is determined by its derivative condition as $\lambda = R/(\sum_{i=1}^{I}(\alpha_i^* \circ x_i^\star) \cdot \rho)$.

This step in the linear price determination resolves any uncertainty in the calculation of clearing prices by aligning clearing prices to be as close as possible to a multiple of the regulated tariffs.

The third step may be necessary when there are some services that tend to be supplied together in the same quantities.

For example, suppose all bidders offer to supply the same quantities of POR and SOR in their bids. The TSOs require 15MW of POR and SOR and there are two bidders; bidder A is willing to supply 15MW of POR and SOR at a price of 20€/h whereas bidder B is willing to supply 20MW of POR and SOR at a price of 10€/h. For simplicity, assume both bidders state expected availabilities of 100% for both services. Bidder B would win.

In the first step of price determination, any set of clearing prices for POR and SOR whose sum is between 1.33€/MWh and 1€/MWh is identified as a candidate set of clearing prices (all such prices would make bidder B a 'happy winner' while minimising the excursion for bidder A, i.e. making bidder A happy to not have won).

In the second step, maximum revenues are achieved by any set of clearing prices for POR and SOR that sum to 1.33€/MWh. This narrows the set of possible clearing prices, but there are still many possible solutions.

Then, in the third step we would apply a further criterion that uses the regulated tariffs to identify a unique set of clearing prices for POR and SOR. If the regulated tariff for POR and SOR was set in the ratio 3:1, the clearing prices would be 1€/MWh for POR and 0.33€/MWh for SOR.

Discussion of the pricing approach

The pricing approach uses information from the losing bids as well as the winning bids, as losing bids constrain the clearing prices that support the outcome. However, in order to affect prices, losing bidders need to be close enough to being winning, in the sense that had they been somewhat lower then they might have won. Losing bids that are not competitive will not affect the clearing prices, as these will be far from the margin of winning at any reasonable prices and not contribute to the excursions.

If there are no synergies from supplying services together, this method identifies a set of clearing prices at which all bidders would be happy to win their respective winning packages (including the notional zero package for losing bidders). With synergies in the production of one or more services, there may not be a unique price that separates winning and losing bids cleanly. When such a solution is not feasible, the method proceeds to select the optimal feasible solution on an objective and transparent basis, by minimising the extent to which bidders would have preferred to win alternative packages across bidders with the clearing prices.

The price determination is robust in the sense that small perturbations of most losing bids amounts do not affect the resulting linear prices. This is because, for each bidder, there are two possibilities:

- The winning package would be chosen by the bidder on the basis of the clearing prices, in which case that bidder's winning and losing bids have no effect on the clearing prices (for small bid perturbations);
- The bidder would choose a package different to its winning package based on the clearing prices, in which case the clearing prices are affected only by the difference between the winning bid amount and the bid amount for the most preferred package, but not any other bids.

This approach thus solves the issues related to uniform pricing that the SEM-C's method suffers from.

6.4 Infeasible outcomes and a 'failed auction'

Assuming that there is at least one possible outcome that satisfies the volume requirements (and any additional constraints imposed by the TSOs), the proposed winner determination process guarantees that an optimal outcome can be selected.

The three-step price determination process guarantees that a single, feasible set of clearing prices is selected based on the winning outcome. Depending on the circumstances, this set of prices may be chosen at the first, second or third step of the process.

Failed auction

The only case where the auction is unable to select an outcome and therefore 'fails' would be when there is no possible outcome that satisfies the winner determination problem. This would arise when the bids received are insufficient to meet all volume requirements.

In case of a failed auction for existing capability, there is a natural fallback option in moving to a regulated tariff approach. We note that this scenario should be extremely unlikely, given that an auction process would have been initiated only after an assessment that market conditions would support a competitive process.

The case of a failed auction for new investments may be somewhat more likely, though this depends greatly on how the future volume requirement has been specified (see Section 7). Where the new investment bids in the current auction fall short of the volume requirement, the TSOs may still wish to accept these bids and attempt to incentivise further new investment projects in the subsequent auction. They may wish to reserve discretion for such cases, so that bids can still be accepted.

7 Awarding contracts to new investments

Key points

The SEM-C proposes allocating long-term contracts to new investments, in order to provide the revenue certainty that can facilitate such projects.

The SEM-C proposals suggest that bids from existing capability (for one-year contracts) and bids from new investments (for long-term contracts) might be evaluated together. However, because of the lead time on new investments, it seems fair to assume that the contract periods for existing capability and new investment would not overlap. Therefore, bids from existing and new capability would not compete for the same volume requirements and would not be substitutable.

A combined auction, allowing existing and new capability to compete over future volume requirements, might be feasible if the contract periods *did* overlap (i.e. if existing capability could compete for long-term contracts or for one-year contracts further into the future). However, this would be a sharp deviation from the SEM-C framework for existing and new capability. There appears to be little material benefit and substantial efficiency risks from holding a combined auction.

Therefore, we propose that bids from existing capability and new investment are treated separately. The bidding parameters would be essentially the same, though new investments would also specify contract length and lead time. The SEM-C proposes allowing new investments to specify a minimum revenue guarantee, but we do not consider that this is necessary within our proposed approach and it would add additional complexity.

We suggest that volume requirements for future years would ideally be specified for one 'target year' only, or a small number of years, otherwise there is a risk of an overly prescriptive approach and potential inefficient outcomes.

When comparing bids with different contract length and lead times, the TSOs may face certain trade-offs. There is also a trade-off between procuring all necessary future volumes in the current auction and deferring some procurement to later auctions. The TSOs may be required to set out their preferences in this regard in order to define how the winning bids are selected. If this is not feasible in practice, the process may have to be substantially altered and simplified to prevent these trade-offs from arising (e.g. by only offering one contract length to new investments), which may be detrimental to the effectiveness of the process.

Background

The SEM-C has decided to award contracts for system services of up to 15 years duration for enhancements and new investments.[77] The lead time on such projects could reasonably be up to five years.

The SEM-C acknowledges that there is a need to define what constitutes a 'new investment' that is eligible to bid for long-term contracts, stating that this will be considered as part of the detailed design phase. This might be based on the scale of the investment and the lead time required, which are likely to be correlated. In the following discussion we make the plausible assumption that new investments are projects with a lead time of at least one year, such that their contracted time period would never overlap with the one-year contracts awarded to existing capability.[78] When we refer to 'new investments', we use this term to potentially include substantial enhancements of existing capability, as well as entirely new projects.

The SEM-C Decision notes that take-or-pay contracts (i.e. with some kind of minimum revenue condition) are important as they increase investment certainty. However, the Decision also states that "*there must be a limit on the total volume of services covered by long-term contracts.*"[79] Without such a limit, it is argued that competition in future auctions is likely to be reduced as a large proportion of the volume requirement will have already been procured.

We note that the auction design should be robust to the possibility that, for a particular service at a particular time, there might only be an auction for one-year contracts (e.g. where the volume requirement is not forecast to increase over time, so new investment is not needed), or there might only be an auction for long-term contracts (e.g. because the existing market is not deemed

[77] Potentially up to 20 years for projects that can demonstrate significant public interest.

[78] We note that the SEM Committee "*has decided that any investment made after the publication of this Decision Paper* [December 2014] *will be eligible for consideration against these criteria*". The logic behind this is not clear. Any investment in new capability that has already been delivered by the time of the auction would then constitute existing capability. Any investment decision that had already been made long before the auction but not yet fully delivered at the time of the auction would not appear to be relying on winning a system services contract (and the revenue certainty that it provides), so it is not obvious that it should be allowed to participate.

[79] SEM Committee, July 2014, DS3 System Services Procurement Design, Consultation (14-059), §156.

to be sufficiently competitive, but the volume requirement is forecast to increase over time, so new investment is needed).

For any service where both one-year and long-term contracts are being awarded as part of a competitive process, one-year and multi-year contracts might either be procured in a combined auction process, or as part of separate processes (which could still be still held simultaneously and notionally form part of the 'same' auction).

We discuss these alternative options below at a high level, before discussing in more detail the proposed approach for a separated auction.

Combined auction

In a combined auction, all bids are evaluated together to set a single price for all contracts (short- and long-term). This appears to be the approach envisaged by the SEM-C.

A combined auction when contract periods do not overlap

There is a basic conceptual problem with adopting this approach. Evaluating a set of bids together is logical and efficient when the bids are substitutable, but that is not the case when one-year contracts for existing capability do not overlap with contracts awarded to new investments with a lead time. Because the contract periods are distinct, the bids from existing capability and from new investment do not contribute towards the same volume requirement. Existing capability competes for contracts under the first year's volume requirement and new investment competes for contracts under some future volume requirement, but there is no competition and no substitutability between bids from existing capability and bids from new investment.

A consequence of holding a combined auction is that clearing prices, which are paid to all winners, would most likely be set by new investments, resulting in higher rents for existing capability that win in the auction. There may be 'unhappy losers' – unsuccessful bidders for one-year contracts who made bids that were substantially below the clearing prices (set by new investment) but that could not be accepted because the volume requirement for the first year was satisfied by accepting bids that were yet lower.[80]

The treatment of bids in a combined auction can create gaming incentives. In the extreme, if there is a strong expectation that clearing prices will be set by new investments and will be high, all

[80] Note that this is analogous to the possibility of unhappy losers that arises when granular volume requirements are set, but a single clearing price is established, as discussed in Section 4.

existing capability would submit bid amounts equal to zero in order to maximise their probabilities of winning. In this scenario all, the bids submitted by these providers do not reveal any information about cost and therefore do not allow the auction to select an efficient allocation of one-year contracts.

Additionally, this approach would have an effect on DS3 system services expenditure. A single clearing price set by the most expensive winner then applies to all winners, so overall expenditure is likely to be higher than in the case where a separate, lower price is set for one-year contracts awarded to existing capability.

We note that these problems might be addressed by a volume scalar that prevents existing capability from benefiting from higher clearing prices set by new investments; this seems to be a somewhat convoluted solution that approximates the same outcome as simply setting separate clearing prices for existing capability and new investment in the first place.

A combined auction when contract periods overlap

An alternative approach to designing a combined auction could be to deliberately *allow* existing capability and new investment to compete over the same volume requirement. For example, rather than limiting existing capability to bidding for contracts that only cover the first year, existing capability could also be allowed to bid for contracts covering future years, so that they would then compete with new investment. In practice, this could be done (i) by allowing existing capability to win long term-contracts, or (ii) by continuing to restrict them to winning one-year contracts but allowing them to compete for multiple one-year contracts, including ones that cover future years.

We note that, in either case, allowing existing and new capability to compete would be a sharp deviation from the SEM-C Decision and any benefit from doing so would be questionable:

i. It would be contrary with the underlying objectives to also award long-term contracts to existing capability. The decision to award long-term contracts is justified purely on the basis of providing revenue certainty as a means to facilitate new investments.
ii. It would be unnecessary and potentially inefficient to award one-year contracts for future years to existing capability. We have already argued that holding an annual auction for system services creates substantial uncertainty and complexity – both from a bidder perspective and a TSO perspective – compared to a more frequent procurement strategy. If existing capability were allowed to bid for contracts several years ahead, the added uncertainty could be factored into their bid amounts. There may also be greater uncertainty about volume requirements further in the future and no clear benefit from seeking to satisfy the entire volume requirement for some future year several years in

advance. Therefore, this approach would risk awarding an inefficient set of contracts both in terms of the clearing prices (which may be inflated by additional uncertainty) and the volumes procured (which may be less likely to match actual needs).

Furthermore, if existing and new capability were allowed to compete in this way, the problem of gaming incentives remains. Future volume requirements would need to be set high enough so that they could not be met by existing capability alone, otherwise the combined auction may fail to incentivise any new investment. For example, if existing capability can deliver 400MW of service A, the volume requirement for some future year must be set above 400MW to ensure that contracts are awarded to new investment. However, if existing capability anticipates that bids from new investment will be relatively high, there is again a strong incentive for existing capability to submit bid amounts equal to zero, in the knowledge that the volume requirement is large enough to accommodate all existing capability and that the clearing price will be set by the marginal bid from new investment.

Need for separate processes

Because of these severe problems with any combined auction, it is desirable to separate the processes for awarding contracts to existing capability and to new investments. The separation of the processes reflects the distinct objectives of awarding one-year contracts and long-term contracts:

- the allocation of one-year contracts seeks to efficiently procure system services from existing capability in order to meet requirements for the coming year; and
- the allocation of long-term contracts seeks to efficiently incentivise relevant new investments in order to be able to meet requirements for some future year(s).

Separated auction

When we treat bids from existing capability and new investments separately, all bids could still be entered simultaneously in the same auction, but prices for one-year contracts would be established separately from those for long-term contracts.

Auction mechanics

In the auction, all bidders would submit package bids as described in Section 5.2, with the bid amounts expressing a lower bound on the clearing prices that each bidder would be willing to accept.[81] As is the case for existing capability, new investments would have to

[81] As mentioned in Section 5.2, the TSOs can require bidders to express bid amounts as hourly or annual, depending on their preference.

declare quantities as well as expected availabilities for all services included in a package. To avoid increasing the auction complexity, we propose that bidders would state a single set of expected availabilities, rather than stating the expected availability in each year covered by the contract. New investments would also need to specify the lead time (or equivalently the delivery date) and the contract length for each bid, subject to the minimum and maximum length permitted by the auction rules.[82]

The winner and price determination mechanism would establish winners and clearing prices for one-year contracts based on bids from existing capability only, resulting in clearing prices potentially much lower than those that would be established in a combined auction. Similarly, winners and prices would be determined separately for long-term contracts, considering only the bids received from eligible new investments. This would most likely reduce the overall DS3 system services expenditure, as existing capability does not benefit from the possible higher clearing prices of long-term contracts.

Investor certainty

For new investments, the auction would establish clearing prices that apply throughout the term of each contract, as per the SEM-C Decision. An inevitable implication of this is that, at a given point in the future after multiple annual auctions have been held, there may be different providers holding long-term contracts of different vintages, each receiving different prices for system services.

The long-term contracts would provide price certainty, ensuring that winners can receive a given level of system services revenues by making themselves available as stated in their bids. For example, suppose a new investment wins a contract for services A and B, with quantities q_A and q_B, prices p_A and p_B, and expected availabilities α_A and α_B. Then, it receives a guaranteed revenue $R=\alpha_A p_A q_A+\alpha_B p_B q_B$ throughout the term of the contract as long as it achieves the expected availabilities. Note that it still has an incentive to try to earn revenue greater than R by exceeding the expected availabilities.

Note that winners would remain exposed to a degree of volume uncertainty. The energy price and input costs over time remain uncertain and these affect winners' competitiveness in the energy market, thus determining the proportion of time that it is profitable for them to be available. However, new investments should have an expectation of the lower bound of availability that they might

[82] Note that we propose that each bid includes a single contract length that applies to the package of services and quantities included in the bid. The SEM Committee has published (in SEM-C 14-075) examples in which providers bid different contract lengths (and prices) for different services included in a package. However, this would add substantial complexity with no obvious benefit.

achieve in practice – i.e. the minimum feasible values of α_A and α_B – effectively allowing providers to form an expectation of the minimum system services revenue they will achieve. In our view this should provide sufficient investor certainty.

Minimum revenue requirement

Given the above, it appears unnecessary and undesirable to introduce a firm minimum revenue guarantee with take-or-pay contracts, as envisaged by the SEM-C Decision. Then, if providers were able to receive guaranteed revenues even when their actual availability is much lower than expected (in the extreme case, zero), there would be a clear risk that they are not incentivised to make themselves available. Moreover, a minimum revenue requirement could add unnecessary complexity to the bidding and bid evaluation processes.[83]

For the separated auction that we propose, the following sections consider:

- the notion of commitment applicable to long-term contracts;
- the trade-offs the TSOs may face when evaluating new investment bids;
- the specification of volume requirements for long-term contracts; and
- the determination of winners and prices.

Commitment and long-term contracts

As mentioned in Section 3, all winning providers will be expected to demonstrate that they have the technical capability to provide the contracted quantities of system services. This is particularly important to ensure that investments are carried through to deliver the entire planned capability, within the specified lead time. Indeed the SEM-C Decision states that "*formal commitments of deliver [sic] will be required of new entrants, these arrangements will be developed in the detailed design but may entail financial obligations and bonding arrangements*".[84]

[83] For example, the SEM-C's proposal for bids to include prices and a minimum revenue requirement creates complexity. It might have undesirable effects on bidding incentives as bidders for long-term contracts could submit very competitive prices in order to try to win a contract and then still be guaranteed their (potentially quite high) minimum revenue requirement. The TSOs would have to make a judgement about whether a minimum revenue requirement is deemed excessive and it could be difficult to do this transparently and objectively.

[84] SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), §160.

Need for contingent commitment

In addition to this general obligation, based on the analysis of contractual obligations in Section 3, we propose that all contracts – short- and long-term – would be subject to the same obligations under the contingent-commitment model.

The need for a contingent-commitment approach can be seen by revisiting the no-commitment model, with a focus on new investments. With no commitment, bids from new investment might reflect, to some extent, the underlying investment cost. However, some investments may not depend heavily on system services revenue and could still see a contract simply as a valuable option with no associated downside. Any such new investment could bid at zero and be guaranteed to be no worse off (perhaps expecting higher clearing prices for long-term contracts than they could otherwise obtain by participating in annual auctions for existing capability). On the other hand, those new investments that rely heavily on system services revenues would have to bid substantially above zero and would therefore be disadvantaged.[85]

Therefore, under our proposals the bids submitted by bidders would reflect two types of cost to be recovered through system services revenue:

- the cost of complying with the contractual obligations (loss of flexibility in the BM); and
- some part of the overall investment cost (depending on the extent to which the business plan relies on revenue from system services).

We acknowledge that this proposal means it is theoretically possible for a winner of a long-term contract to be bound to making certain BM offers at a particular time, while simultaneously other providers are subject to the regulated tariff and face no such commitment. Such a scenario would only occur if new investment had been insufficient, as a competitive constraint, to move the service from a regulated tariff to a competitive process. The TSOs should consider the likelihood of this scenario as part of the procurement process. If it is considered relatively likely then it may not be appropriate to follow the contingent-commitment model for long-term contracts.

[85] Note that, if a future volume requirement were set specifically for a technology class that *does* generally rely on system services revenues, then this would prevent the relevant new investments from being disadvantaged, though this approach might be seen as discriminatory.

Trade-offs when evaluating new investment bids

When evaluating bids from new investments there are certain trade-offs that may have to be made, which arise when there is a choice between:

- accepting bids in the current auction to satisfy a future volume requirement, or deferring to a subsequent auction;
- accepting bids with longer or shorter contract lengths; and
- accepting bids with longer or shorter lead times.

Procuring in the current auction / in future auctions

Consider a scenario where the TSOs wish to procure substantial additional capability for year five. Assuming that possible lead times may be substantially shorter than five years, it is not necessary for the TSOs to procure the full volume of additional capability for year five in the current auction. If the outcome of the current auction only satisfies part (or even none) of the additional capability, there is still a possible fallback option of accepting bids in subsequent auctions that contribute towards the year five volume requirement.

Therefore, there is always trade-off involved when evaluating bids from new investments because of this fallback option. Accepting a bid in the current auction has the benefit of contributing towards the future volume requirements and reducing the risk that requirements will not be met. On the other hand, accepting a bid in the current auction also exposes the TSOs to a risk that, in a subsequent auction, a bid could have been accepted to deliver similar capability, with a similar start date, at a lower cost. To assess this trade-off it would be necessary to have an expectation of new investment bids received in future auctions.

There are other types of trade-off when considering bids with different contract lengths and lead times.

Shorter / longer contract lengths

To illustrate the trade-off in relation to contract length, suppose a bidder places two bids for the same quantities of system services, with the same lead time:

- one bid is for a three-year contract, covering years two to four, with bid amount €X; and
- the other bid is for a five-year contract, covering years two to six, with bid amount €Y, which is less than X.

Accepting longer-term contracts means that the TSOs are locked into agreements for longer time and may face a higher risk of overpaying (for example, if the prices of system services fall substantially in years five and six). On the other hand, accepting shorter-term contract with higher bid amounts could commit the TSOs to paying higher prices over the contracted periods, which also carries a risk of overpaying (for example, if prices of system services are particularly low in years two to four). To assess this trade-off it would be necessary to have an expectation of future clearing prices.

Shorter / longer lead times

To illustrate the trade-off in relation to lead time, suppose there is a bidder who places two bids for the same quantities of system services, with the same contract length:

- one bid has a one-year lead time and bid amount €X; and
- the other bid has a three-year lead time and bid amount €Y, which is greater than X.

Suppose the TSOs wish to procure for target year five, so either bid makes the same contribution toward the volume requirements. Accepting bids with longer lead times may have the benefit of deferring expenditure, but if these bids have higher bid amounts it may also raise the clearing prices. To assess this trade-off it would be necessary to take into account a discount rate for future expenditure.

Factors needed to evaluate bids

In summary, resolving these trade-offs would require taking into account:

- expectations of new investment bids received in future auctions;
- expectations of future clearing prices;
- a discount rate; and
- the TSOs' particular aversion to any of the risks described in this section.

Possible alternatives

The above factors could be considered as part of the TSOs' procurement strategy and, if appropriate, could be published in advance of the auction. We acknowledge that there may be some subjectivity in determining these factors and some associated risks (e.g. possible legal challenges) that make it difficult to do so in practice, so we consider possible alternative approaches:

- With regard to the trade-off between accepting bids in this auction or in a subsequent one, the TSOs could simply decide that it will always accept bids in the current auction as necessary to meet the specified volume requirement, without ever rejecting bids or accepting additional bids based on an expectation of what may happen in future auctions. This provides transparency and certainty, though it exposes the TSOs to the risks outlined above.
- With regard to the trade-off related to different contract lengths, the only alternative would appear to be to fundamentally alter the auction design framework set out by the SEM-C. For example, standardising contract length so that bidders may only bid for, say, five-year contracts, would eliminate the trade-off related to comparing bids for contracts of different length. Clearly this also substantially reduces flexibility for bidders.

- With regard to the trade-off related to different lead times, this could again be resolved by standardising the lead time across all contracts, but this would be problematic for bidders whose projects necessarily involve shorter or longer lead times than the standardised lead time. Thus, it may be preferable to specify a reasonable discount rate (which may be zero in the case that the TSOs wish to treat expenditure in different years equally).

In the following sections we will consider further implications in terms of how the volume requirements should be specified and how the auction should select winners and prices.

Volume requirements for long-term contracts

There are various options for specifying volume requirements for long-term contracts. Below we discuss these options and recommend an approach that:

- specifies future volume requirements for a single future year only (or alternatively for a small number of future years); and
- considers allowing some flexibility in the current auction, if it is practical to do so, to award contracts that either satisfy the entire future volume requirement or that only satisfy part of it, depending on the bids received.

Interpreting the SEM-C Decision

The SEM-C Decision states that "*there must be a limit on the total volume of services covered by long-term contracts*".[86] The simplest interpretation would be to set a requirement for the volume procured from long-term contracts for each service, regardless of the lead time and contract length of the bids accepted. Indeed, the SEM-C stated that *"contract duration should not be a determining factor in the evaluation of bids".*[87] The term 'limit' is suggestive of a maximum requirement, but a volume requirement should always be set as a minimum rather than a maximum so as to not preclude the selection of any cheaper, higher-volume outcomes (as explained in Section 4).

This simplistic approach does not guarantee that the SS auction will meet its objectives. For example, the TSOs' analysis may indicate that they require substantial new investment to have been delivered in three years' time to cover a higher expected requirement for a particular service. However, setting a volume

[86] SEM Committee, July 2014, DS3 System Services Procurement Design, Consultation (14-059), §156.

[87] Ibid., §156.

requirement for *all* long-term contracts means that the TSOs risk procuring only contracts with a lead time of over three years, so that in practice they do not procure any additional volumes that they could draw upon in three years' time.

Granularity of future volume requirements

At the opposite extreme, the most granular approach would involve setting an individual volume requirement for individual future years, reflecting the TSOs' estimate of the additional capability that needs to be in place by each year (and the proportion that it would wish to procure in the current auction).

We note that the core rationale for including long-term contracts in the auction is to incentivise the deployment of additional capability, that is assumed to be operating from the contract start date thereafter, regardless of the contract length. After the contract expires, the provider would then be expected to participate in the annual SS auctions. The length of lead times is key and the SEM-C's view is that "*the maximum limit on the permissible lead-time should be of the order of five years*"[88], so that any contracts awarded in an auction would start five years after the auction at the latest. In this case, the TSOs would only need to specify volume requirements for each of the first five years at most;[89] any capability that is operational by year five should continue to be operational in subsequent years.

Possible simplification with a 'target' year

Even amongst these years it is not mandatory to specify a volume requirement for each year. In fact, it is preferable to set a single volume requirement for future years that is based on the estimated required volume at only one specific point in time. Doing so simplifies the auction process, compared with a more granular approach where individual volume requirements for each future year are specified. Moreover, setting individual volume requirements for many future years could be too rigid and prescriptive, especially if few bids from new investment are received, with the risk of producing undesirable outcomes.

The volume requirements could be set only for a 'target year' (e.g. 2020) for which robust analysis and estimates have been produced.[90] For example, if the TSOs estimated that, for a particular

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[88] Ibid., §160.

[89] Potentially a volume requirement for N+6 might also be specified, if those new investments with the longest lead time (close to 5 years) only become operational towards the end of year N+5 and are not counted as part of the year N+5 volume. This relates to a separate issue about how contracts are dealt with when the start date occurs during a year, or indeed whether contracts are required to specify a start date that is equal to the predefined start date of a future 'year'.

[90] This approach is viable as long as the TSOs expect that it is feasible for relevant new investments to have sufficiently short lead times that they are able to deliver in time for the target year.

service, no substantial additional capability is required for year one and two, additional capability of 50MW is required by year three, and for subsequent years the requirements are very uncertain, then they could set a minimum requirement of (up to) 50MW for year three only. This still allows full flexibility to accept any bids with a start date earlier than year three if they represent good value, but it does not impose any requirement to do so.

Flexibility

It should not necessarily be compulsory to procure the entire anticipated volume requirement for a future year in the current auction. As discussed, it may be possible to award further contracts that cover that year in subsequent auctions, subject to receiving bids with a sufficiently short lead time. Future volume requirements could therefore be price-elastic and take into account the TSOs' views on the likely bids from new investment in the following years. For example, this can be in terms of a cap on the maximum price the TSOs would accept for a particular service in the future. In the event that satisfying the volume requirement would require clearing prices that breach this cap, the future volume requirement to be procured in today's auction would then be scaled down.

Winner determination

In broad terms, the auction should seek to procure the desired volumes for future years whilst minimising the cost to the TSOs. There are, however, alternative ways in which this might be done in practice, because of the trade-offs involved when assessing bids with different contract lengths and lead times.

Consider an auction for a single service, where there is a volume requirement of 50MW for year five and of zero for other years.

Suppose the following bids are received[91]:

[91] For simplicity we ignore availability (suppose all bids state 100% expected availability).

Bidder	Quantity	Duration	Operational start date	Bid amount
A	50MW	5 years	Year 4	€1000
B	30MW	2 years	Year 2	€600
C	20MW	3 years	Year 3	€350
D	20MW	5 years	Year 4	€300

We can identify the following outcomes that would procure exactly 50MW in total for year five:

	Outcome 1	Outcome 2	Outcome 3
Winning bidders	A	B and C	B and D
Bid amounts	€1000	€600 and €350 (total €950)	€600 and €300 (total €900)
Contracted years	4 to 8	B: 2 to 3 C: 3 to 5	B: 2 to 3 C: 4 to 8
Sum of bid amounts	€1000	€950	€900
Sum of bid amounts (discounted at 10%)	€729	€824	€759
Sum of bid amounts (adjusted for contract length)	€1000	€450	€540

Winner determination with no adjustments

The winning outcome could be selected purely by treating all bids as perfectly comparable. Then, minimising the sum of bid amounts (as explained in Section 6.2) would select outcome 3, which has the lowest sum of €900. This would be the more straightforward approach, but it may be efficient to use a more sophisticated approach. As discussed previously, the winner determination could reflect the TSOs' preferences with regard to contract lengths, lead times and deferring expenditure, though this would require the TSOs making a decision with regard to these preferences, which might be infeasible or undesirable.

With the more sophisticated approach, formulae can be used to standardise contracts with different lead times and lengths in order to make them comparable, prior to running the winner determination algorithm. If this approach were followed, the sophistication of such formulae should strike a balance between being easily understood by bidders and accurately reflecting the TSOs' preferences. Here we use simple calculations to illustrate the underlying principles.

Winner determination with a discount rate

If the TSOs had a preference for deferring expenditure under long-term contracts, then some discounting of future years could be applied. Subject to still meeting future volume requirements, this would favour contracts with longer lead times and render them more competitive. To illustrate this, a simple implementation could be to apply a discount rate to the bid amounts based on the lead time. In the example, using a discount rate of 10% (taking year 1 as the base year) means that outcome 1 – where bidder A's contract does not start until year 4 – is selected as the winning outcome.

Winner determination with adjustments for contract length

The TSOs might have a preference for accepting bids with shorter contract durations. Again, bid amounts may be adjusted accordingly in order to favour bids with shorter contract lengths. To illustrate this, a simple implementation could be to multiply each bid amount by a parameter equal to the bid's contract length divided by the maximum possible contract length. In the example, if we suppose that the maximum permitted contract length was five years, then after adjusting the bid amounts outcome 2 – which involves bids with short contract lengths of two and three years – would be selected as the winning outcome.

Winner determination with adjustments for future auctions

The evaluation of bids could also take into account the TSOs' expectations about bids that may be made in future auctions, with rules that allow greater or smaller volumes to be procured in the current auction depending on the bids received. One way of doing this is to specify a future volume requirement that is price sensitive, so that the selection of winning bids takes into account whether or not the bids are seen to represent good value for money. To illustrate this with the above example, suppose that the TSOs select the winning outcome based on the sum of bid amounts (without adjustment) and they have specified a minimum volume requirement as follows:

- procure 50MW if this is possible without the sum of bid amounts exceeding €800;
- if it is not possible to procure 50MW; procure 40MW subject to the sum of bid amounts not exceeding €700;
- etc.

None of the outcomes would allow the TSOs to procure 50MW without exceeding a sum of €800, so the volume requirement would effectively be scaled back to 40MW. Then, bids from bidders C and D can be accepted to procure 40MW, with the sum of bid amounts being €650.

Any formulae used to make bid amounts comparable, or any price-sensitivity in the volume requirement, should be established as part of the TSOs' procurement process and clarified to bidders ahead of the first auction.

Price determination

Once the winning outcome has been selected, clearing prices must be determined. The process for doing this would be exactly the same as that described in Section 6.3 and the clearing price for each service would be common across bidders, regardless of contract length and lead-time.

8 Treatment of interconnectors

SEM-C Decision

The SEM-C Decision states that *"[t]he East West interconnector [EWIC] will be a price-taker in the auction, and will not participate by bidding directly in the auction."*[92] The volume requirements would be reduced by the volume the interconnector is capable of providing. However, it also notes that this part of the decision *"may be reconsidered if any inconsistencies relating to the implementation of future decisions on the I-SEM trading arrangements arise as a result of this decision."*[93] The SEM-C Decision does not consider the potential role of other interconnectors (aside from EWIC).

This section sets out various issues that arise when applying the proposed auction design to interconnectors given their particular characteristics.

Different nature of interconnectors

Interconnectors differ fundamentally from other system service providers in that they consist of transmission infrastructure and the technical realisability of system services is a function of the electricity flows across the interconnector at a given time. It appears unlikely that an interconnector would easily be able to influence its market position and therefore its availability for system services. Therefore, it is not clear that interconnectors should be paid on the same basis as other providers, that they should be able to participate in the SS auction, or that they could be subject to similar contractual obligations.

SS auction and contractual obligations

The notion of contingent commitment discussed in Section 3.3 does not appear to apply naturally to an interconnector, as the operator of the interconnector has little control over the availability of system services being provided (at least in the short-run). If it were infeasible for an interconnector to be subject to the same contractual obligations as other providers then it would not be sensible to allow interconnectors to participate in the SS auction, as they would be bidding for a contract under different terms to other providers.

Payment basis

With regard to the payment basis, interconnectors might be paid on an availability basis, as with other technologies. A technically capable interconnector is available for FFR, reserve and ramping services as long as it is not importing at full capacity. It is available for FPRAPR as long as it is importing (regardless of the level) and for

[92] SEM Committee, December 2014, DS3 System Services Procurement Design and Emerging Thinking, Decision Paper (14-108), §69.

[93] Ibid.

reactive power as long as it is on. An interconnector cannot provide SIR and RRS. Interconnectors may have very large capabilities relative to other providers.[94].

Interconnectors as price-takers

As discussed in Section 5.4 it is anticipated that there would be a cap on the maximum quantity of system services that can be contracted from a single provider, at least for some services. For the EWIC, this restriction would almost certainly be binding. According to the SEM-C's view, the volume requirement would therefore be reduced by the maximum quantity a single bidder can bid for and the EWIC would always be awarded a contract for this amount. It would be a price-taker and would automatically be paid at the clearing prices established without its participation. The EWIC would receive payments whenever it is available.

The same logic could be applied to other interconnectors. They would act as price-takers for the highest of (a) their technical capabilities for system services and (b) the maximum quantity that can be contracted from a single provided.

[94] We understand that the capability of various services an interconnector may provide depends on the interconnection technology (Voltage Source Conversion or Line Commutated Conversion).

9 Implementation issues

To implement the auction, several practical aspects would need to be considered:

- Legal aspects and contractual arrangements. The TSOs will have to develop contracts for the provision of system services that are in line with all applicable Irish, Northern Irish and EU law.
- Development of detailed auction rules. This report sets out a high-level design for an auction to procure system services. Detailed rules will need to be developed that cover all aspects and eventualities. For example, there needs to be provisions for breaking ties when different combinations of bids satisfy the volume requirement at the same lowest cost. The TSOs will also need to decide on any applicable maximum quantity of each service are that a single unit can provide.
- Implementation of winner and price determination tool.
- Decision on how to collect bids from bidders.
- Bidder seminars and mock auctions.
- Physical and human resources needed for evaluation of bids.

The last four points are covered in more detail below.

Implementation of winner and price determination tool

A first step in the implementation of this auction would be to develop an alpha version of the proposed winner and price determination with a simple interface for testing the accuracy of the algorithms. The interface could either be a simple spreadsheet linking to a standalone executable file for running the winner and price determination algorithm, or a bespoke frontend of the winner determination implementation.

This version of the software would be used to test different details of the auction mechanisms and should be built in conjunction with the detailed auction rules.

Once the detailed auction rules are finalised, it would be advisable to engage a third party to test the implementation of the winner and price determination.

Ideally, bidders should be able to use the winner and price determination tool to allow them to become familiar with the auction mechanics and to verify correct implementation of the rules. This could be either done by providing bidders with a standalone tool or by providing access to the winner and price determination tool through an online portal. The former is more desirable as it provides greater flexibility and avoids the need for bidders to upload data that may contain business secrets, to a platform that is ultimately controlled by the TSOs.

Bid collection

For a sealed bid process, bidders could submit bids 'manually' in a pre-formatted spreadsheet via encrypted email or on an appropriate medium via courier or in person. There would need to be a process specified for aggregating bid data and feeding it to the winner and price determination tool. This process needs to ensure that sufficient checks are in place to guarantee the integrity of bids, to minimise the scope for human error and to flag any potential issues for further investigation. There would also need to be clear rules for how the auctioneer should deal with bids that are partially invalid, and what opportunities should be given to bidders to correct such bids.

Alternatively, bidders might be able to enter their bids using a secure electronic auction platform available over the Internet. This would limit the need for intervention by the auctioneer in the processing of bid data, but would still require thorough checking of the underlying implementation. This approach has also the advantage that bids can be checked for compliance with the rules prior to submission, and bidders can be informed about potential issues that they would need to address to make their bids valid.

Bidder seminars and mock auctions

Bidder seminars are particularly helpful when the auction design is as complex as the one proposed by the SEM-C and developed here. Given the number of bidders in this auction and the potential need for not revealing bidder identities, this might best be held as a webinar.

Bidder seminars should be held sufficiently in advance so that bidders have time to incorporate any points in their bid strategy and bidding tools.

Closer to the auction date, mock auctions on the actual auction platform would help bidders familiarise themselves with the bidding process and – if an auction platform were to be used – the bidding software.

Physical and human resources needed for bid evaluation

The physical and human resources needed for bid evaluation greatly depend on the chosen method of bid collection. For an online platform more IT equipment would be needed, whereas with manual bid collection more human resources would be needed.

An online platform would be open for at least one day for bidders to submit their bids. Redundancy should be built in (in terms of connectivity as well as physical servers), ensuring that the platform is available during that time. Bidders would only be allowed to submit bids that are consistent with the auction rules and bidding restrictions. The effort on the TSOs' part of checking bids is thus fairly limited.

During the auction, it would be useful to provide technical support over the telephone. Bidders would be given a number to call in case they encounter any issues when using the auction platform. From experience, this functionality is usually most helpful during mock auctions and the number of calls probably comes down fairly rapidly. It should suffice to have between one or two qualified staff available to answer these calls. Detailed logs and recordings of any conversations on this hotline should be logged in case of any disputes.

The auction platform should allow the auctioneer to monitor what bidders are doing and should inform him once a bidder has checked or submitted a set of bids.

To run the auction would most likely require two members of staff that have been given the authority to:

- schedule the auction (set a start and end date);
- approve bids;
- cancel bids (special circumstances);
- run the winner and price determination (from within the auction platform);
- check the correctness of the results;
- approve the results; and
- publish results to bidders.

Any action from the auctioneer on the system should be undertaken by at least two people jointly to reduce the potential for human error.

Usually a third party checks the correctness of the final results with a second implementation of the winner and price determination algorithm. This should only take a few hours.

Regarding the total number of team members needed to run the auction, the TSOs would most likely need the following:

- two people for technical support;

- two people to monitor bidder activity on the auction platform; and
- two people authorized to take on the role as auctioneer (this could be the same people that monitor the auction platform during the auction).

The TSOs would also need to ensure that sufficient backup of personnel is available on the day. This might mean the TSOs would need four people to run the auction and the same number of people as backup.

If the TSOs decide to collect bids manually, then more staff will be needed to check and collate bids. A sufficiently detailed audit trail would also need to be created to help with any legal disputes after the auction. The TSOs would still need to have available sufficient IT resources to check and collate bids and to run the winner and price determination.

10 Conclusions

Why does the 'no-commitment' model risk compromising the effectiveness of the auction?

Without SS auction winners taking on new obligations, contracts may just provide a valuable option with no associated downside. The auction may then have little material impact of the supply of system services and may have undesirable effects.

For existing capability the only genuine impacts of having an auction under the no-commitment model would most likely be:

- to restrict the set of providers that may receive system service payments to a subset of all providers, as opposed to the regulated tariff approach where all providers receive payments whenever they are available; and
- to set a price for system services, though this price may not be meaningful and may be very low, due to a lack of cost-reflective bids.

For new investments, the auction could at least succeed in incentivising the deployment of new capability that will be required in the future. However, the no-commitment model appears to favour conventional technologies and might reduce the likelihood of incentivising the development of alternative technologies that have desirable characteristics, from the perspective of system services provision.

The 'contingent-commitment' model addresses these shortcomings by creating obligations that have an associated cost that can then be reflected in bids. Then, the auction would select those providers who can offer flexibility to be available most efficiently. There are desirable properties in that technologies are treated in a relatively neutral way those providers that are most often 'marginal' in the energy market are relatively competitive, and there is greater certainty for the TSOs about the costs of securing system services in real time.

How could the contingent-commitment model be implemented in practice?

The requirements for contingent commitment would be specified in contracts and have been designed deliberately so as not to require any modifications to the functioning of the BM itself. There would be a need for monitoring of BM offers in order to ensure compliance, but this process should not require substantial resources and most likely could be automated (essentially, all that is required is to check that the offers are priced at the level that is specified in the contract, e.g. in line with the chosen energy price measure).

We note that the imposition of restrictions on BM offers would potentially contravene the EU Network Code on Electricity Balancing, which has yet to be finalised at the time of writing. However, the high-level auction design framework set out by the SEM-C includes provisions for the award of long-term contracts and it favours annual auctions over more frequent procurement intervals that would be closer to real time.[95] Our recommended approach seeks to promote the intended objectives while minimising adjustments to the SEM-C's framework, rather than proposing a completely new and different auction design framework that could comply more closely with the Network Code.

In practice, it may be that the pro-competitive rationale that lies behind the contingent-commitment approach – in terms of providing for neutral competition between different technologies - can be used as a justification for adopting this model. It may also be that the implementation of the contingent commitment could avoid formally restricting the BM offers that can be made. For example, contracts could be specified in such a way that SS auction winners are notionally able to price their BM offers in the same way that losers do, but with some pre-specified arrangements requiring financial transactions to take place between TSOs and providers outside the BM depending on outcomes in the BM; this could make the net payoffs the same as if the providers had made the BM offers required under the contingent-commitment model.

Why separate existing capability and new investment? Is this treating all market participants fairly and equitably?

The SEM-C proposes different contractual arrangements for new investments. Long-term contracts can provide the revenue certainty to facilitate such projects.

The SEM-C proposals suggest that bids from existing capability (for one-year contracts) and bids from new investments (for long-term contracts) might be evaluated together. However, this approach appears problematic – because of the lead time on new

[95] These aspects may contravene Article 34(6) of the Final Draft of August 2014. See http://networkcodes.entsoe.eu/wp-content/uploads/2013/08/140806_NCEB_Resubmission_to_ACER_v.03.pdf

investments, it is fair to assume that the contract periods for existing capability and new investment would not overlap. Therefore, bids from existing and new capability would not compete for the same volume requirements and would not be substitutable. It therefore appears to be desirable to evaluate them in separate processes.

A combined auction, to allow existing and new capability to compete over future volume requirements, might be feasible if the contract periods *did* overlap (i.e. if existing capability could compete for long-term contracts, or for one-year contracts further into the future). However, this would be a sharp deviation from the SEM-C framework. Long-term contracts could be awarded to existing capability as well, but this undermines the rationale for long-term contracts and may disadvantage new investments. Allowing existing capability to bid for one-year contracts several years in the future introduces unnecessary uncertainty and may create gaming incentives.

Therefore, there appears to be little material benefit from allowing existing and new capability to directly compete within the SEM-C's high-level framework, while there are substantial efficiency risks from doing so.

How should volume requirements for new investments be specified?

When a volume requirement is set for several years ahead, it should reflect the additional capability that the TSOs deem necessary, over and above existing capability. However, there is always a possible fallback option of accepting bids in subsequent auctions that contribute towards the future volume requirement. Thus, the future volume requirement must not necessarily reflect the *entire* additional required volumes.

There is always trade-off involved when evaluating bids from new investments. Accepting a bid in the current auction has the benefit of contributing towards the future volume requirements and reducing the risk that requirements will not be met. On the other hand, accepting a bid in the current auction also exposes the TSOs to a risk that, in a subsequent auction, a bid could have been accepted to deliver similar capability, with a similar start date, at a lower cost.

It should not necessarily be compulsory to procure the entire anticipated volume requirement for a future year in the current auction. For example, flexibility can be introduced by specifying a price-sensitive volume requirement, though this may require the TSOs to make judgements on likely bids received in future auctions, which may be infeasible.

Does the auction design deal with infeasible outcomes?

Assuming that there is at least one possible outcome that satisfies the volume requirements (and any additional constraints imposed by the TSOs), the proposed winner determination process guarantees that an optimal outcome can be selected. The three-step price determination process guarantees that a single, feasible set of clearing prices is selected based on the winning outcome.

The only case where the auction is unable to select an outcome and therefore 'fails' would be when there is no possible outcome that satisfies the winner determination problem. This would arise when the bids received are insufficient to meet all volume requirements.

In case of a failed auction for existing capability, there is a natural fallback option in moving to a regulated tariff approach. We note that this scenario should be extremely unlikely, given that an auction process would have been initiated only after an assessment that market conditions would support a competitive process.

The case of a failed auction for new investments may be somewhat more likely, though this depends greatly on how the future volume requirement has been specified (see Section 7). Where the new investment bids in the current auction fall short of the volume requirement, the TSOs may still wish to accept these bids and attempt to incentivise further new investment projects in the subsequent auction. They may wish to reserve discretion for such cases, so that bids can still be accepted.

How should winning bids from new investment be determined?

In order to select a winning outcome from new investment bids it is necessary to assess bids with different lead times and contract lengths. It is possible to simply compare bids while ignoring these differences, but this may lead to undesirable outcomes, as shown in Section 7.

To make bids comparable it would be necessary to specify parameters by which they are adjusted to become equivalent. These parameters may reflect:

- expectations of new investment bids received in future auctions;
- expectations of future clearing prices;
- a discount rate for future expenditure.

If it is infeasible to make such a judgement, it would be possible to modify the auction design to as to eliminate the need to do so, e.g. by allowing only a single contract length and lead time. However, this has obvious costs in terms of restricting bidder flexibility.

Annex 1: Treatment of tied BM bids and consequences for the SS auction

Possibility of 'tied' bids in the BM

With contingent commitment there is the possibility of 'tied' bids from SS auction winners within the BM. For example, in any scenario where the TSOs need to increase the supply of available system services and there are multiple SS auction winners contractually obliged to make BM offers at the energy price, the TSOs may be able to choose from multiple non-energy actions that have equivalent cost implications, in terms of the overall payments made through the BM and system service payments.[96] The treatment of such ties could potentially affect incentives within the SS auction, as we discuss below, so tie-breaking rules need to be set appropriately.

In particular, we show that the use of a random tie-breaking rule is likely to be superior to one based on, say, sorting by cost. Even though the latter rule might appear desirable *ex-post* in terms of selecting the most efficient provider, there could be adverse *ex-ante* impacts on bidding incentives within the SS auction.

We acknowledge that in many cases the TSOs' choice of provider may be dictated by certain priorities or constraints (e.g. priority dispatch of renewable energy sources, transmission constraints or SNSP constraints), which may lessen the importance of ties in practice. Furthermore, many providers might supply a bundle of various system services, which might significantly reduce the likelihood of being in identical situations. Nevertheless, in this annex we consider those instances in which there are multiple equivalent options that could feasibly be chosen (e.g. tied bids from providers within the BM that have the same technical characteristics and who have been awarded DS3 contracts for the same set of system services).

Choosing between tied BM bids

Tied BM bids from SS auction winners could either be sorted to reflect their cost structure or simply be picked at random. The decision between these two is relevant as they each have different effects on the risks faced by the SS auction winners and so their SS auction bids.

[96] For example, suppose that several SS auction winners are positioned in the market at full load and are contracted for reserve, so they make DEC offers at the energy price. The TSOs need to increase the available volume of reserve and can choose from multiple providers that can be decremented at exactly the same overall cost per MW/h unit of reserve.

In the case of tied DEC bids, in order to maintain the highest possible energy generation efficiency the TSOs would prefer to decrement marginal providers whose costs are relatively close to the energy price, rather than providers whose costs are substantially lower than the energy price.[97] The TSOs would decrement first those providers that submitted relatively high bids in the energy market.

Implication for SS auction bidding incentives

The likelihood of a SS auction winner being decremented now depends on its cost structure. Providers with very low marginal costs may now anticipate that they are relatively less likely to be decremented, meaning that they are less exposed to the potential costs of contingent commitment and therefore that they can bid lower in the SS auction.

A similar logic applies to the INC case, if we require INC bids to be submitted at the energy price. Providers with very high marginal costs may now anticipate that they are relatively unlikely to be constrained on, meaning that the expected costs of contingent commitment are lower and therefore that they can bid lower in the SS auction.

In fact, there is a further problem if we require INC bids at the energy price. Suppose the TSOs need to increase the supply of system services and providers A and B are SS auction winners, contracted to provide exactly the same volumes of system services. A and B have the same energy costs and both are not in the schedule at gate closure. In this case, the TSOs would prefer to constrain on the provider with the lower minimum generation level, as this provider will be easier to accommodate in the overall energy mix. However, if SS auction winners with relatively low minimum generation levels are more likely to be constrained on and 'forced' to export at a loss, then they will anticipate greater costs in complying with contingent commitment, making them less competitive in the SS auction and less likely to win contracts. This would be an undesirable consequence, given that the TSOs favour obtaining system services from providers with low minimum generation levels and indeed wish to incentivise reductions in minimum generation levels.

[97] A possible proxy for costs could be the bids submitted in the energy market (DAM/IDM), subject to ensuring that this does not distort bidding incentives in the energy market. For example, if a provider sees from the DAM that the clearing price for energy is high relative to its costs, it expects to be in the schedule at full load. To reduce its chances of getting decremented, it may want to make artificially low IDM bids in order to reduce its likelihood of being decremented. Therefore, one might only take the DAM bids as a proxy, rather than any subsequent bids in the IDM.

In summary, when there is sorting amongst SS auction winners' tied BM offers, the resulting SS auction incentives may no longer favour those providers that are most often marginal in the energy market. When we sort SS auction winners' bids in the BM, the resulting SS auction incentives for these 'marginal providers' depend on the net effect of several factors:

- marginal providers are less likely to deviate from the contracted reserve position;
- marginal providers are likely to face smaller costs when they do deviate and subsequently there is TSO action; but
- marginal providers are now more likely to face TSO action when there are tied bids amongst SS auction winners.

The table below summarises SS auction bidding incentives once we sort winners' bids in the BM.

Table 12: Bidding incentives in the SS auction (with sorting amongst winners in the BM)

Provider type	Increased payoff when price of reserve > energy margin[98]	Incentive to deviate from contracted reserve position	Potential loss when there is TSO action	**When there are ties, likelihood of being 'picked'**	Bids in the SS auction
Very low energy costs	Sometimes	Often (to earn large energy margin)	High (lose large energy margins)	**Rarely**	? (the net effect is ambiguous)
Moderate efficiency (often marginal)	Often	Less often	Low	**Often**	? (the net effect is ambiguous)
Very high energy costs	Sometimes	Often (to avoid exporting at a large loss)	High / moderate (depends on INC commitment option)	**Rarely**	? (the net effect is ambiguous)

For the above reasons, if we sort BM offers from SS auction winners on the basis of cost, we risk undermining the bidding incentives in the SS auction. It may therefore be preferable to avoid any

[98] And it is profitable to export, i.e. $p_e(Qmin) + p_r(R) > 0$

systematic sorting mechanisms for SS auction winners in the BM in the case of ties and to simply choose at random in such cases.[99]

It must be noted that the downside of choosing at random is that there may be a risk of inefficient BM outcomes in some cases. For example, a very low energy cost provider might be constrained down when a provider with higher energy costs could have been chosen instead. However, the incentives this provides in the SS auction should help minimise the risk of such occurrences, because the very high cost and very low cost providers will be relatively less competitive in the SS auction and therefore less likely to become SS auction winners in the first place.

[99] In practice, it may be necessary for EirGrid to put a transparent mechanism in place (i.e. a 'bingo machine') that demonstrates it is choosing at random, when relevant, rather than picking according to some preferential approach. However, consideration would need to be given as to whether such a mechanism could work in practice with the TSOs' scheduling and dispatch tools.

Annex 2: Computational tractability

This annex provides a brief assessment of the likely computational complexity of solving the winner determination problem.

The winner determination is a Binary Integer Linear Programme (BILP). This is a subgroup of mixed-integer linear programme in which all variables are binary. These types of problems are NP hard, meaning that there is thus no guarantee that these problems can be solved in polynomial running time; rather the worst case computational load increases exponentially with the scale of the problem.

In practice, there are a number of free and commercial solvers that can solve most BILPs within a reasonable time using a Branch-and-Bound (B&B) approach. Actual runtime depends on a number of factors and can be greatly improved by pre-processing the problem and tailor the B&B algorithm to the specific type of BILP at hand. However, there is still no guarantee that any given BILP can actually be solved quickly.

The complexity of a BILP depends on the number of variables and constraints. The number of bids and the number of volume requirements directly affect the complexity:

- In the winner determination BILP, each bid adds a binary variable.
- Each bidder adds a bid constraint that is a set-partitioning constraint.
- Equally, for each volume requirement, we need to add a supply constraint in the form of a knapsack constraint.

This means that as the number of bids increases, the problem will have a lot more variables than constraints.

The Zuse Institute Berline (ZIB) maintains a set of problems that are used for benchmarking commercial and free linear solvers. Table 13 provides the list of BILPs with set-partitioning and knapsack constraints (amongst others):

- Problems highlighted in green are relatively easy and quick to solve. These problems can be solved within an hour on a contemporary PC with a state-of-the-art solver.
- Problems highlighted in orange are hard. These problems are solvable but take a longer time or require specialised algorithms.
- The problem highlighted in red is the only problem in the database for which no known solver could produce a solution.

These results suggest that BILPs with many variables but fewer constraints are generally solvable even if the number of variables is very large (>500k). Winner determination problems with up to 100k variables should generally be solvable without specialist hardware. This means that for the purposes of the winner determination, we could accept up to 100k bids from all bidders.

Table 13: MIPLIB - BILPs only

Problem name	Number of variables	Number of constraints	Solvability
mspp16	561,657	29,280	Easy
rail03	253,905	758,775	Hard
bley_xl1	175,620	5,831	Easy
ns1663818	172,017	124,626	Hard
rail02	95,791	270,869	Hard
rail01	46,843	117,527	Easy
bab3	23,069	393,800	Open
neos-941313	13,189	167,910	Easy
ns1696083	11,063	7,982	Hard
neos-1337307	5,687	2,840	Easy
ns1769397	5,527	3,772	Easy
neos-957389	5,115	6,036	Easy
bab5	4,964	21,600	Easy
ns1745726	4,687	3,208	Easy
ns1688347	4,191	2,685	Easy
ns1686196	4,055	2,738	Easy
co-100	2,187	48,417	Easy
ivu52	2,116	157,591	Hard
harp2	112	2,993	Easy

Source: ZIB, MIPLIB-2010, http://miplib.zib.de/miplib2010-BP.php

Annex 3: List of acronyms

Acronym	Meaning
B&B	Branch-and-Bound
BILP	Binary Linear Integer Programme
BM	Balancing Mechanism
CCGT	Combined Cycle Gas Turbine
CRM	Capacity Remuneration Mechanism
DAM	Day-ahead market
DEC	Decrement
DRP	Dynamic Reactive Power
DS3	Delivering a Secure, Sustainable Electricity System
DSR	Demand-Side Response
FFR	Fast Frequency Response
FPFAPR	Fast Post Fault Active Power Recovery
IDM	Intra-Day Market
INC	Increment
LP	Linear Programme
POR	Primary Operating Reserve
RM#	Ramping Margin (# hours)
RO	Reliability Option
RRD	Replacement Reserve De-Synchronous
RRS	Replacement Reserve Synchronous
SOR	Secondary Operating Reserve
SEM-C	Single Electricity Market Committee
SIR	Synchronous Inertial Response
SS	System Services
SSRP	Steady-State Reactive Power
TOR	Tertiary Operating Response
TSOs	Transmission System Operators