NERA
ECONOMIC CONSULTING

Assessment of Alternative Auction Designs

Final Report for the APA Group

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Project Team

Richard Marsden (Vice President)

Ann Whitfield (Associate Director)

Katherine Lowe (Senior Consultant)

Soren Sorensen (Peer Reviewer)

NERA Economic Consulting
Level 16
33 Exhibition Street
Melbourne 3000
Tel: +61 3 9623 9800
Fax: +61 3 8640 0800
www.nera.com

Contents

1 Introduction

This report has been prepared by Richard Marsden (Vice President), Ann Whitfield (Associate Director), and Katherine Lowe (Senior Consultant) of NERA Economic Consulting (NERA) at the request of the APA Group, the owner of the Roma-Brisbane Pipeline (RBP).

1.1 Background

This is the second report that NERA has been asked to prepare by APA on alternative approaches to allocating capacity on the RBP. In our original report (*Assessment of Alternative Queuing Requirements),* we were asked to consider whether the allocation of spare existing capacity or developable capacity on the RBP on either (i) a first-come-first-served basis; or (ii) via a publicly notified auction, would be more likely to lead to economically efficient outcomes. In short, we concluded that a publicly notified auction (with bids ranked according to the net present value (NPV) of the total bid) would yield a more efficient allocation of scarce pipeline capacity than a first-come first-served approach, if there is no effective secondary trading market for that capacity.

In keeping with this advice, APA has proposed moving away from the existing first-come-first-served queuing arrangement for existing capacity to a publicly notified auction process.[1] APA has also proposed that developable capacity be allocated through either bilateral negotiations or through a publicly notified auction. One possible design for such auctions is set out in section 6 of APA's proposed access arrangement and can best be characterised as a single round, sealed-bid auction with bids ranked on the basis of the NPV of the total bid. [2]

To inform its consideration of APA's revised queuing arrangements, the Australian Energy Regulator (AER) held an industry workshop on 12 January 2012. Prior to this workshop, the AER released a discussion paper entitled, *Roma to Brisbane Pipeline Access Arrangement 2012-17 Queuing Industry Paper.* One of the more significant issues considered in this discussion paper was the proposed design of the auction. The Queuing Industry Paper contained an overview of the approaches used in a number of other industries to auction existing capacity, and described a range of individual auction design elements, which the AER noted could be used when auctioning scarce pipeline capacity.[3] We understand that these issues were discussed at length at the workshop and that in this context the AER also raised the potential for the auction process to be coupled with either (i) a rebate mechanism; or (ii) the offset of some of the auction proceeds against future capital expenditure.

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1 In accordance with APA's proposed access arrangement, an auction for existing uncontracted capacity will only be conducted if the unutilised capacity is greater than 2 TJ and the demand for this capacity exceeds the available supply. If the unutilised capacity is less than 2 TJ, APA has proposed that the capacity will be placed on a spare capacity register. Where unutilised capacity is greater than 2 TJ, APA has proposed that an 'open season' be conducted to determine whether the demand for unutilised capacity can be met with the available existing capacity. If the demand can (can not) be met with existing supply, APA has proposed that the uncontracted capacity will be allocated through bilateral negotiations (a publicly notified auction). See clauses 6.2.3-6.2.6 of the proposed access arrangement.

2 APT Petroleum Pipelines Limited, *Access Arrangement Effective 12 April 2012 – 30 June 2017,* October 2011, clauses 6.2.3-6.2.6 and clauses 6.3.4-6.3.8.

3 AER, *Roma to Brisbane Pipeline Access Arrangement 2012-17 – Queuing Industry Paper,* January 2012, pp. 18-22.

1.2 Questions addressed in this report

A decision is yet to be made by the AER in relation to the auction format for scarce capacity on the RBP. However, given the AER's Queuing Industry Paper, the range of matters canvassed in the industry workshop, submissions from interested parties and the level of interest currently surrounding this issue, APA has asked us to provide independent advice addressing the following two questions:

1. *What form of auction design is likely to lead to outcomes consistent with the National Gas Objective in the case of the auction of scarce capacity on the Roma to Brisbane Pipeline (RBP)?*
   a) *What factors are relevant in determining the optimal auction design?*
   b) *How do the specific circumstances of the RBP affect the choice of optimal auction design?*
2. *If the proposed auction process was to be coupled with one or both of the following:*
   a) *a rebate mechanism; or*
   b) *the offset of some of the auction proceeds against future capital expenditure*

   would this give rise to any distortions of economically efficient outcomes? Identify any such distortions.

In considering these questions, APA has asked us to have regard to:

- the AER's Queuing Industry Paper, and in particular the discussion of alternative auction designs in that paper;
- the National Gas Law (NGL) and the National Gas Rules (NGR) and, in particular, the provisions relating to:
  – queuing requirements (Rule 103);
  – the National Gas Objective (NGO) (section 23 of the NGL);
  – capacity trading (Rule 105), extensions and expansions policy (Rule 104) and access disputes (Chapter 6 of the NGL and Part 12 of the NGR);
- the general approach to regulating gas pipelines set out in the NGR and the NGL, which accommodates bilateral contractual arrangements between service providers and users for negotiated services at negotiated tariffs, as well as for the provision of reference services at the reference tariff;
- the specific circumstances of the RBP, including, amongst other things:
  – the nature of the product most likely to be demanded as part of the auction of capacity on the RBP;
  – the nature of current and prospective shippers on the RBP who are likely to participate in the auction of capacity;
  – the fact that existing capacity on the RBP is currently fully contracted;

  - the predominance of bilateral contracts on the RBP, and the fact that the majority of contracts for existing capacity are for services other than the reference service and at tariffs other than the reference tariff; and
  - the relevant provisions in the proposed access arrangement for the RBP for the next access arrangement period.
- such information that, in our opinion, should be taken into account to address the questions.

1.3 Structure of this report

To address the questions set out above, we have structured the report as follows:

- Section 2 focuses on the choice of auction format, and addresses the first question;
- Section 3 explores the rebate issue, and addresses the second question; and
- Section 4 contains a summary of our conclusions.

1.4 Statement of credentials

This report has been prepared by Richard Marsden, Ann Whitfield and Katherine Lowe, and has been peer reviewed by Soren Sorensen.

Richard Marsden is a Vice President based in NERA's London and New York City offices and holds an MA with distinction in international political economy and a BA in economics and international relations from the University of Warwick, United Kingdom. Richard has particular expertise in relation to auctions, where he has advised in relation to policy advice, auction design, software implementation, and bidder support. Richard has undertaken auction projects across a wide range of sectors, including airport slots, broadcasting, mobile telephony, power generation and renewables, retail sites, and wireless broadband. His project experience includes the design and implementation of combinatorial auctions (both multiple-round and sealed bid) for radio spectrum in Denmark, Ireland, the Netherlands, Nigeria, and the UK, and simultaneous multiple round auctions in Hong Kong and Norway. He has provided strategy advice to bidders in spectrum auctions worldwide, including Canada (AWS, 2008 and PCS, 2001), Finland (2.6GHz, 2009), and 3G/cellular mobile awards in Egypt, Germany, Ireland, Italy, the Netherlands, Switzerland, Taiwan, and the UK. In Australia, Richard has undertaken auction advisory projects for both the ACMA and private clients.

Ann Whitfield is an Associate Director based in NERA's Sydney office and holds a Master of Economics from the London School of Economics and a Bachelor of Philosophy, Politics and Economics with first class honours from Oxford University. Ann has nineteen years experience working as an economist for both private consultancies and government. Ann's particular areas of experience include utility regulation and market design, in both gas, electricity and water. Ann has advised across a range of regulatory issues in both Western Australia and the National Electricity Market in the eastern states, with particular focus on the arrangements for capital investment, price control mechanisms and efficiency incentive arrangements. Ann has worked for a range of Australian clients, including both regulators and utility businesses, and has also managed a number of large international projects.

Katherine Lowe is a Senior Consultant based in NERA’s Melbourne office and holds a Master of Economics from the University of Sydney, a Master of Applied Finance from Macquarie University and a Bachelor of Business (majoring in economics and finance) from the University of Technology Sydney. Katherine has over nine years experience as an economist working within the areas of energy, infrastructure regulation, securities litigation, competition, consumer protection, personal injury related liabilities and commercial macroeconomics. Katherine has particular experience in relation to the application of regulatory economics to gas pipelines, and has provided advice as part of the assessment of proposed Access Arrangements and as part of arbitration proceedings in relation to gas supply agreements. Prior to joining NERA, Katherine was employed as an economist within the Gas Group of the Australian Competition and Consumer Commission (ACCC).

Dr Soren Sorensen is a Senior Consultant based in NERA’s London Office and holds a PhD in economics from the University of Aarhus, Denmark. Dr Sorensen specialises in game theory and industrial economics and has particular expertise in auction design, bidding strategies and auction implementation. As a Senior Consultant in NERA’s Communications Practice, Dr Sorensen has been involved in the design and implementation of several auctions including: the implementation of an auction of FWA licenses for PTS, Sweden; design and implementation of auctions of natural gas and gas storage capacity for the Danish gas company DONG; design and implementation of an electricity procurement auction for Italian Acquirente Unico. Examples of other projects that Dr Sorensen has been involved in include: providing advice on bidding strategies in first-price auctions as part of the preparatory work for Ofcom's renewal of the Channel 3 Licence; providing advice on the design of energy capacity auctions for US system operators; undertaking a study for the European Commission on the feasibility of auctioning airport slots using combinatorial auctions.

In preparing this report, we have made all the inquiries we believe are desirable and appropriate and no matters of significance that we regard as relevant have, to our knowledge, been withheld from this report. We have been provided with a copy of the Federal Court guidelines *Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia*, dated 1 August 2011. We have reviewed those guidelines and this report has been prepared consistently with the form of expert evidence required by those guidelines.

2 Alternative Auction Designs

In this section we address the following question posed by APA:

1. *What form of auction design is likely to lead to outcomes consistent with the National Gas Objective in the case of the auction of scarce capacity on the RBP?*

    a) *What factors are relevant in determining the optimal auction design?*

    b) *How do the specific circumstances of the RBP affect the choice of optimal auction design?*

To enable these questions to be fully explored, we start by providing an overview of the alternative auction designs referred to in the AER's Queuing Industry Paper (section 2.1) and the factors that influence auction design (section 2.2). We then proceed to identify a number of candidate auction formats and consider their strengths and weaknesses in the context of the auction of scarce capacity in the specific circumstances of the RBP (section 2.3). Finally, a short conclusion (section 2.4) summarises our view on which auction format best meets the NGO in the case of the auction of scarce capacity on the RBP.

To aid the discussion that follows, Table 2.1 contains an overview of the terminology used in this section to distinguish specific auction formats (and their pricing rules) suitable for the simultaneous award of multiple items (where an item could be defined as a product or as a unit of quantity, such as pipeline capacity).

2.1 AER's Queuing Industry Paper

In its Queuing Industry Paper, the AER refers to the following examples of the approaches used to auction capacity in other industries:[4]

- the sequential[5] sealed bid approach used to allocate monthly access rights to gas transmission pipeline capacity in the UK gas transmission network;
- the dual round (non-binding and binding rounds) sealed bid capacity auction design that has been proposed for the Nabucco gas pipeline, which extends from Turkey to Austria;
- the simultaneous multi-round ascending price auctions and combinatorial ascending price clock auctions that have been used in telecommunications spectrum auctions; and
- the ascending price clock auction adopted in Co-operative Bulk Handling Limited's (CBH) access undertaking for grain handling ports in Western Australia.

Further detail on the key design features of each of these auctions is set out in Appendix A.

4 AER, *Roma to Brisbane Pipeline Access Arrangement 2012-17 – Queuing Industry Paper*, January 2012, pp. 18-19.

5 We note that this has been incorrectly characterised in the AER's Queuing Industry Paper (p. 18) as a 'multi-round' approach. The auction would be better characterised as a sequential series of single-round sealed bids, with 25% of capacity sold in each round. See National Grid website: http://www.nationalgrid.com/NR/rdonlyres/4AF03478-F2BD-473E-BA88-230F29B8573C/23489/CapacityManagementUpdate.pdf

Table 2.1
Auction Design Terminology

Terminology			Description
Auction Formats	**Sealed bid (single round)**	First price (pay your bid)[6]	Winning bidders pay the amount of their winning bid, so unit pricing varies across users. Winner determination may be by ranking or combinatorial (see below).
		Second price	Winning bidders pay an amount less than or equal to their winning bid, which is based on the opportunity cost of denying the strongest losing bidder. Depending on how the price rule is implemented, this could result in a uniform price across winning bidders. Winner determination may be by ranking or combinatorial (see below).
		Ranking	Winner determination is based on a ranking approach. Each bid is ranked on the basis of a common metric (usually price) and the highest bids are accepted until a point is reached where there is insufficient supply to accommodate further users. Typically, bidders may be limited to one bid each, but multiple non-exclusive bids may be allowed. A first or second price rule may be used.
		Combinatorial (or conditional bidding) with optimisation of bids	Combinatorial and/or conditional bidding allows auction participants to place bids on combinations of items (or, put differently, to make their bid for one item conditional upon obtaining other items). For the purposes of this report, we define a combinatorial auction has having two distinct features which differentiate it from the more basic ranking auction: (1) Bidders may submit multiple, exclusive bids, each representing a package of demand that is accepted or rejected in its entirety; and (2) An optimisation algorithm is used to identify the highest value combination of bids, taking at most one bid from each bidder. The algorithm can consider multiple capacity constraints. Again, a first or second price rule may be used, although determining second prices can be complex.
	Open (multiple round)	Ascending price (English Auction)	Under an ascending price auction, the price is progressively raised over multiple rounds until demand falls to the level that matches supply. Bidders pay the amounts of their bids in the final round. A common multi-unit version of this format is the 'simultaneous multiple round auction' (SMRA), used for example in previous Australian spectrum auctions.
		Descending price (Dutch Auction)	Under a descending price auction, the auctioneer announces a price and this is progressively lowered over multiple rounds until all supply has been matched to demand. Winning bidders pay the amounts of their successful bids.
		Clock auction	The clock auction, which may be run using an ascending or descending price rule, is a widely used format for selling multiple units that are homogenous, such as electricity generation. Within each category of supply, a 'clock price' is set that ticks up (or down) over multiple rounds until price and supply are balanced. A distinct feature of this format is that winning bidders pay the same uniform price within supply categories, although in practice some variation of this rule is possible.
		Combinatorial (or conditional bidding)	A number of variants of multiple-round auctions with combinatorial bidding have been proposed, borrowing either from the clock or SMRA formats. An increasingly popular format is the CCA (combinatorial clock auction) which combines an open clock bidding process with a final round in which a bidder may submit multiple bids; it is typically implemented with a second price rule. This is sometimes referred to as a hybrid auction format, as the final round resembles the sealed bid combinatorial auction, except that a bidder's bid choices and amounts are constrained by their behaviour in the earlier clock bidding rounds.

6 Note: In a sealed bid (single round) auction, a 'pay your bid' rule is analogous to a 'first price' auction in economic theory, as bidders determine their own price through their bid. By contrast, in a multi-round auction, a 'pay your bid' rule is closer to a 'second price' rule, as the prices that prevail for winning bidders when the auction ends are set by the decisions of other bidders to drop demand and/or exit the auction.

The AER also identifies a number of generic auction design elements, which it notes could be used on their own or in combination. The various design elements referred to by the AER can be broadly categorised as follows:[7]

- *Product design* – the options referred to by the AER in relation to the RBP include defining the product to be auctioned as either the right to access a defined volume of capacity (eg, single TJ lots) and/or the right to access capacity over a defined period of time (eg, 6 months).
- *Auction formats* – the alternative formats identified by the AER include:
  - multiple round (open) auctions and sealed bid auctions;
  - ascending price (English auction) and descending price (Dutch auction) auctions;
  - ascending volume and descending volume auctions; and
  - combinatorial and/or conditional bidding.
- *Ranking criteria* – the criteria referred to by the AER include ranking on the basis of the NPV of the total bid, the NPV per unit of capacity and the NPV per time period.
- *Information release* – transparent or non-transparent auction processes with respect to price and participation information released to bidders before, during and after the auction.
- *Nature of bids* - requiring bids to be made on a binding (irrevocable) basis in each round(s) or allowing a non-binding round(s) to be conducted before a binding round(s).

In this section, we address all of these issues to a greater or lesser extent. Our primary focus is on identifying the optimal auction format for the RBP. Product design is a key input into our analysis. We address the other issues in the context of analysing the product and auction format. As the approach to specific auction rules, such as release of information and nature of bids, are partly dependent on the choice of auction format, these other issues would merit further analysis once a decision has been made on the auction format.

2.2 Factors influencing auction design

As highlighted by the AER in its Queuing Industry Paper, there are several alternative ways in which an auction can be conducted. The identification of the most appropriate auction format will depend on a number of factors, including:

- the nature of the product to be auctioned;
- the level and nature of industry demand; and
- the objectives of the auction.

We consider the influence that these factors may have on auction design in further detail below. In each case we consider the relevant factors at a general level, before considering how each factor relates to the specific circumstances of the RBP.

7 AER, *Roma to Brisbane Pipeline Access Arrangement 2012-17 – Queuing Industry Paper*, January 2012, pp. 19-22.

2.2.1 Nature of product to be auctioned

The design of an auction depends critically upon the nature of the product(s) to be auctioned. In particular, the appropriate choice between alternative auction formats will depend on whether:

- the product (in this case: pipeline capacity) can be divided into homogeneous units, or must be sold in differentiated units; and
- the core product can be defined as a single dimension, or has multiple dimensions.

In cases where the product has multiple dimensions, a further level of analysis is required to determine whether and to what extent each dimension is critical to determining the allocation of capacity. In general, a dimension only matters for auction design if it could impose binding constraints on allocation outcomes in situations where demand for all other dimensions can be satisfied.

Homogenous versus differentiated products

A completely homogenous product is one where all units have exactly the same dimensions. Accordingly, bidders should be entirely indifferent between one unit and another. Bidders can therefore submit a single price in relation to a quantity of the product, without also needing to specify other product attributes. Naturally homogenous products include basic commodities such as fruit and vegetables, grains and oil, and also electricity. By contrast, an example of a fully differentiated product might be antique grandfather clocks; each one is a potential substitute, but they are too different to sell on a generic basis; each one should be a separate lot.

In practice, many products may be classed as quasi-homogeneous. Radio spectrum is a good example. Within a frequency band, one block of spectrum can typically be used in much the same way as another, but bidders may still have small preferences between them, for example because they want contiguous blocks or some parts of the band are more vulnerable to signal interference from neighbouring spectrum use. Accordingly, sometimes spectrum is sold on a generic basis and sometimes on a specific frequency basis, with the choice of approach often depending on the specific circumstances of the frequency band.

Another example of a quasi-homogeneous products is power generation: end-users are completely indifferent between one kilowatt and another; however, the reliability of supply varies by type of generation (e.g. wind versus oil), and demand varies by time of day. Accordingly, auctions for power generation supply often define multiple products that reflect different guarantees on supply for peak and off-peak time periods.

Single versus multiple dimensions

Auctions are most straightforward when products can be defined as a single dimension, such as the number of units or volume of capacity. This facilitates a simple two-dimensional auction, in which price and demand are traded off. In this case, the nature of the product does not vary across different bidders. The only differences between the bids submitted by auction participants are the price they are willing to pay for that product, or the quantity of the product they are willing to acquire at a particular price. In these circumstances, simple ascending or descending auction formats, based on price or price/volume, such as the clock auction format, may be appropriate. Sealed bids are also possible, but multiple round formats are often more popular as buyers and sellers are often more comfortable with the gradual price discovery possible in a multi-round process.

A multi-dimension product is one where demand cannot be expressed as a single metric, but has a number of features. A classic example of a multi-dimensional product is a landing slot at a congested airport. This has at least four dimensions: time of arrival, time of departure, stand access and passenger terminal capacity, any one of which could potential constrain allocation. Designing auctions for products with multiple dimensions is more challenging, because bidders must submit more complex bids, and there are many more checks to consider if a bid may be acceptable.

In general, auction designers typically adopt one of three approaches to dealing with multiple dimensions:

- Focus on one critical dimension, and only consider other dimensions in the second order;
- Define lots that links together two or more dimensions within a single bid and/or scoring systems that combine bids across multiple dimensions into a single dimension for purposes of comparison; or
- Combinatorial bidding and algorithms to optimise across multiple dimensions.

Often, one dimension is much more important than others, and much more likely to pose a binding constraint on allocation. For example, suppose our congested airport has a big new terminal but only one runway. In this case it may be that stand access and terminal capacity are hardly ever a constraint on airlines, so it may be a reasonable compromise not to consider these in bids, except as a second-order check on auction outcomes. Some dimensions may lend themselves to being linked together. For example, in any situation where time of access is a dimension, it may be practical to redefine the product as the right to access a certain level of capacity within a specified time period. In our landing slot example, the auctioneer could sell the right to a number of arrival slots within a specified period, e.g. one hour.

Examples of products with multiple dimensions that are auctioned on the basis of a single dimension include the following (both of which are referred to in the AER Queuing Industry Paper):

- the right to inject a specified volume of gas at a particular entry point in the UK gas transmission pipeline network for a defined period of time; and
- the port capacity sold by CBH, which is divided into lots and sold for a period of time.

These approaches simplify the allocation problem, making it possible to use basic auction formats. However, they are not without cost. By constraining the bids that each bidder can make and potentially constraining the associated range of allocation outcomes, the auction can generate a sub-optimal outcome in terms of the efficient allocation of scarce capacity.

An alternative approach that avoids the risk of sub-optimal outcomes is to use a combinatorial auction format. This approach enables bidders to submit bids which capture all of the dimensions, thus capturing the full range in which the resulting product may differ depending on the bidder. The bids submitted by auction participants will therefore fully reflect differences in the nature of the product being bid on and the prices that bidders are willing to pay. The product to be auctioned by the owners of the Nabucco gas pipeline is an example of a differentiated multi-dimensional product, with bidders able to define the capacity requirement, the distance gas is to be transported and the entry/exit points as part of their bids. Combinatorial auctions are necessarily more complex than the simple formats possible with single dimension products, but most of this complexity is focused on the auctioneer side.

Defining the product in the case of the RBP

The product to be auctioned in the case of the RBP is the right to access scarce transportation services provided by APA (using either existing uncontracted capacity or developable capacity), with bidders able to specify:

- the capacity (Maximum Daily Quantity (MDQ)) required;
- the load factor (ie, ratio of Maximum Hourly Quantity (MHQ) to MDQ);
- the entry and exit points to be used; and
- the term over which the capacity is to be provided (ie, both start and end dates).

Accordingly, the product being auctioned in the case of scarce capacity on the RBP can be defined as a differentiated product with multiple dimensions: four dimensions for the product and five for the bid (including price). However, not all dimensions carry equal weight. In particular, in any particular auction, capacity (MDQ) is likely to be identified as the most important metric. While load factors and entry-exit points affect the level of capacity available at any given point in the pipeline, they need not always form independent binding constraints. Further, absent these additional constraints and the issue of the contract term, capacity would be a homogenous product. Put differently, the available product on the RBP can be considered as quasi-homogenous, but with additional dimensions that may need to be taken into account.

In the Queuing Industry Paper, the AER noted the potential for the product to be auctioned by APA to be redefined as either:

- capacity for a defined period of time; or
- a defined volume of capacity for a pre-defined period of time.

The re-defining of the product to be auctioned in this manner would potentially enable the auction to proceed on the basis of a single dimension. This would open up the possibility of adopting auction formats suitable for homogeneous products, such as an ascending or descending price or volume based auction.

However, we think that ‘collapsing’ the multi-dimensional nature of the product into a single dimension in the case of the RBP is problematic, for two reasons:

1. Load factor and entry/exit points will need to be designated by bidders, and must be taken into account when determining winning bids. As described below, a format that initially identifies winning bids only on the basis of capacity and considers these factors only as second order constraints may not lead to an efficient use of capacity.

Specifically, lower ranked bids that might initially be identified as potential winners may have to be denied if their load factors are incompatible with higher ranked bids. Meanwhile, other bids that could be accommodated may be mistakenly rejected.

2. There are likely to be differences in the *duration* for which prospective users of the RBP will want to seek capacity. Users are likely to have a strong preference to define their own contract term rather than purchase capacity on the RBP for a pre-defined period of time, as suggested by the AER, given:

    i) the nature of their end-use requirements (ie, retail gas supply, electricity generation and industrial production) which gives rise to a need for users to be able to have access to a secure supply of gas over the medium to long term;

    ii) the long term nature of users' upstream gas supply contracts; and

    iii) the existing capacity constraints on the RBP.[8]

Another way of simplifying product design not directly identified in the AER's Queuing Industry Paper but considered in one of the academic articles referred to by the AER, is a pro-rata allocation mechanism.[9] Under this approach, winning bidders may be allocated less than their demand. The advantage of this approach is that it potentially eliminates the risk that capacity goes unallocated because winning bids and supply fail to match exactly. However, one of the more significant shortcomings with this type of allocation process is that it can provide bidders with an incentive to submit a bid for a greater volume of capacity than their actual capacity requirement and, in doing so, distort bidding behaviour and the overall auction outcome. Another shortcoming of this approach is that winning bidders may end up with a sub-optimal level of capacity because their actual requirements are ignored in favour of a simple pro-rata allocation. We would *not* therefore recommend allocating capacity from the auction on the basis of a pro-rata approach. If it is the case that bidders may be willing to accept variable levels of capacity, then a combinatorial approach would represent a more appropriate means of ensuring the optimal use of spare capacity based on a range of bids.

In summary, there may be significant benefits in terms of the economic efficiency of the auction outcome from using an auction format for the RBP that can accommodate all of the product dimensions.

Defining price for RPB bids

The bid amount (price) is a key dimension in most auctions. For the RPB, APA has proposed that bids be compared on the basis of the net present value (NPV) of a flow of promised annual capacity reservation payments, rather than a unit price. This makes sense, as APA can

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8 In relation to the latter point it is worth noting that if the RBP had sufficient capacity for the foreseeable future, then the commercial risk that sales of capacity on the basis suggested by the AER would create for users would be far lower, and users may be willing to purchase capacity on that basis. In cases where capacity is scarce, however, which reflects the current reality on the RBP, the risk arising from a short term contracting arrangement is likely to be viewed as too great by users.

9 Pickl, M. and Whirl, F., *Auction design for gas pipeline transportation capacity – The case of Nabucco and its open season*, Energy Policy 39 (2011), pp. 2143-2151.

be expected to place a premium on longer term contracts, so it would not make sense to compare them on an annual fee basis. Moreover, in using an NPV, APA would apply a discount rate, such that it can take account of the value of having long-term contracts, and the risk to buyer and seller from potential changes in future capacity pricing. In addition, requiring bids in the form of annual payments rather than a lump sum payment for the duration makes sense, as the term of a contract may vary, and requiring upfront payments would place an undue burden on buyers.

In the Queuing Industry Paper, the AER notes that bids could be evaluated on the basis of: [10]

- the NPV of the total bid;
- the NPV per unit of capacity; or
- the NPV per time period.

The latter two of these alternatives appear to be related to the AER's suggestion that the product to be auctioned by APA could be defined as the right to access a defined volume of capacity on the RBP (eg, single TJ lots) and/or the right to access capacity on the RBP over a defined period of time (eg, 6 months). Put differently, they are ways of simplifying the product design to enable use of simpler auction formats.

If the product to be auctioned by APA could be defined in the manner suggested by the AER, then there may be some merit in comparing bids on the basis of the NPV per unit of capacity or the NPV per time period. However, if prospective bidders are able to submit bids that differ across a number of different dimensions,[11] then the use of these alternative metrics would be redundant.

Based on our understanding of the nature of the product that is likely to be sought by the market in the case of the auction of scarce capacity on the RBP, it would appear that prospective bidders will want to submit bids that differ across a number of dimensions, including duration. We are therefore of the opinion that bids should be evaluated on the basis of the NPV of the total bid.

In summary, the key product features that the auction format for the RBP should ideally be able to accommodate are:

- Quasi-homogeneous capacity (many small fungible units);
- Multiple dimensions (capacity, load factor, entry/exit, term); and
- Comparison of bids on an NPV basis.

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[10] AER, *Roma to Brisbane Pipeline Access Arrangement 2012-17 – Queuing Industry Paper*, January 2012, p. 20.

[11] For example, capacity, load factor, the use of particular entry/exit points and/or the duration of the contract.

2.2.2 Industry demand

The anticipated level and structure of demand for the product being auctioned is also of great importance when considering the choice of auction format.

In situations where there are many bidders who place significant common value on the product available, multi-round auction formats are commonly used, because of the scope for bidders to benefit from price discovery. However, under situations of low or asymmetric demand, first price, sealed bid formats are typically preferred because the greater price uncertainty acts as a barrier to collusion and/or increase incentives for potential weaker bidders to take on an incumbent rival.

Another key issue is the scope for bidder demand to vary depending on price. If bidder demand is flexible, then auction formats that allow them to express this variation are typically preferred. The more information obtained through bids, the more scope to identify the most efficient market solution. Multiple round auctions are better than simple sealed bids in this respect, because bidders can adjust their demand. However, combinatorial approaches that allow bidders to submit multiple, mutually exclusive bids (whether in a sealed bid or over multiple rounds) are likely to be best of all in this respect.

Sellers also need to be sensitive to participation costs for bidders. Sealed bids require less participation time than multi-round auctions, although there are ways to structure multiple rounds to reduce the time burden of participation. We understand from APA that industry participants at the AER workshop noted the difficulty in getting successive bids in a multi-round process approved by their respective boards. A single round requires one Board approval process and may therefore lower administrative and auction participation costs to bidders.

In the case of the RBP, the demand for capacity is likely to be heterogeneous across bidders. Demand is likely to vary across multiple dimensions, such as capacity, entry/exit points and term of contract. An efficient auction format needs to be flexible enough to capture this heterogeneous demand. It may also be that bidders have some flexibility in their demands. That is, they may ideally like X MDQ, but would also be satisfied if they received Y MDQ or Z MDQ.

The RBP is an example of a partial common value setting. Bidders vary in how they will use the gas that is transported, but many operate in the same markets (eg, gas retailing, electricity generation), and all have some degree of common costs. Thus, while each bidder will have its own private valuation, the bid activity of rivals would be relevant information to them when assessing their own values. In this situation, there are potential benefits from price discovery, which may be facilitated by a multi-round process and/or the release of information about prices.

However, in the case of the auction of scarce capacity on the RBP, it is anticipated that only a modest sub-set of total capacity will be auctioned at any one time, ie, capacity associated with contracts that are due to expire in a particular time period. While there are many different users of the pipeline, the number of bidders for any particular auction could be modest, and could vary significantly between auctions. The auction format therefore needs to be robust to potential low competition. This concern may well be sufficient to offset any benefits from price discovery associated with a multi-round process or greater information revelation.

There are also likely to be significant asymmetries between bidders. Demand varies across users of the pipeline, and in any particular auction, there may be one or more bidders with significantly higher demand for scarce capacity than others. In the case that the bidders are the same companies as those whose contracts are expiring, there may be predictable asymmetries between them. Large, long-term bidders potentially have a significant advantage over smaller ones, especially in an NPV-based auction where various terms are possible, as the absolute value of their bid may be much greater than their rivals. This is not necessarily a problem *per se*, but raises potential concern about strategic behaviour, such as large bidders exaggerating their demand for capacity or small bidders being deterred from participating because they think their chances of winning are too low.

In summary, the key demand issues that the auction format for the RBP must be able to accommodate are:

- Heterogeneous demand: capacity requirements are likely to vary greatly across bidders, and bidders themselves are likely to have some flexibility in their demand;
- Partial common value: bidder valuations are related but not identical, so there may be some benefits from price discovery;
- Variable competition: competition is likely to be low for some particular auctions of RBP capacity; and
- Bidder asymmetries: some auctions are likely to include one or more bidders who can be identified as clear front runners, potentially competing against much smaller rivals.

2.2.3 Objectives of the auction

APA has asked us what form of auction design is likely to lead to outcomes consistent with the NGO, in the case of the auction of scarce capacity on the RBP.

The NGO is "to promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas."

There are typically multiple objectives when running an auction. Typically, the three primary objectives are:

- Promoting efficient outcomes that maximise benefits for society;
- Maximising revenues for the seller; and
- Facilitating competition in the auction and in downstream markets

Public bodies typically prioritise efficiency and downstream competition, while private sellers often prioritise revenues.

In terms of the NGO, the primary objective of the auction is to ensure that there is efficient pipeline utilisation, whilst achieving a base level of revenues to cover the costs associated with the provision of pipeline capacity. The implication of this is that an auction should prioritise efficiency over revenues, except that there should be safeguards (such as suitable reserve prices) to protect the service provider against unduly low revenue outcomes. It may well be the case that an efficient auction results in higher revenue generation, but this should be the result of more efficient use of capacity.

In addition, in the case of the auction of scarce capacity on the RBP, a secondary concern is likely to be simplicity, cost and speed of the process. Other things being equal, keeping the bid submission process as simple and quick as possible is likely to promote participation. However, this simplicity should not be at the expense of any significant drop in the efficiency of the allocation of scarce pipeline capacity.

In summary, the key objectives that the auction format must be able to accommodate are:

- Efficient allocation of capacity;
- Adequate revenue generation;
- Promotion of participation within the auction; and
- Simplicity, cost and speed of the process.

2.3 Identification of candidate auction formats

At the start of this section, in Table 2.1, we identified eight broad types of auction format. The table below explores the suitability of formats derived from this earlier table in addressing the key issues related to product design, demand and auction objectives identified in section 2.2. The analysis is necessarily high level - sufficient only for the purposes of identifying formats likely to be more attractive in the case of the RBP.

The following key applies to the table

- A ✗ indicates that the format is not well suited to addressing the issues;
- One or more ✓s indicate that the format can address this issue. A simple scale of one to three ✓s is used to assess the relative effectiveness of the format in addressing the issue, with ✓✓✓ being the best.

We note at the outset that in most cases no single auction format will be perfectly suited to addressing all of the issues arising in a particular circumstance, including being the optimal design in relation to product design, industry demand and meeting the auction objectives. There will typically need to be trade-offs between the benefits and potential shortcomings of different designs.

On the basis of the initial screening of alternative auction formats set out in Table 2.2, we have eliminated the more standard ascending and descending price auctions, as they are not well suited for selling products with multiple dimensions. Specifically, these formats lack functionality for conditioning winner determination on multiple capacity constraints.

Table 2.2
Comparison of auction formats against key issues for this process

	Product design			
	Quasi-homogeneous capacity (many small fungible units)	**Multiple dimensions**	**Comparison of bids based on NPV, not price**	
Ranking sealed bid, 1st price	✓	✓	✓✓✓	
Ranking sealed bid, 2nd price	✓	✓	✓✓✓	
Combinatorial sealed bid, 1st price	✓✓✓	✓✓✓	✓✓✓	
Combinatorial sealed bid, 2nd price	✓✓✓	✓✓✓	✓✓✓	
Simultaneous multiple round	✓	×	✓	
Descending price (Dutch Auction)	✓✓	×	✓	
Clock auction	✓✓✓	✓	✓	
Combinatorial multi-round	✓✓✓	✓✓✓	✓✓✓	
	Industry demand			
	Heterogeneous demand	**Partial common value**	**Variable competition**	**Bidder asymmetries**
Ranking sealed bid, 1st price	✓✓	×	✓✓✓	✓✓✓
Ranking sealed bid, 2nd price	✓✓	✓	✓	✓
Combinatorial sealed bid, 1st price	✓✓✓	×	✓✓✓	✓✓✓
Combinatorial sealed bid, 2nd price	✓✓✓	✓	✓	✓
Simultaneous multiple round	✓	✓✓	✓	✓
Descending price (Dutch Auction)	✓✓✓	✓✓	✓✓	✓✓
Clock auction	✓✓✓	✓✓	✓✓	✓✓
Combinatorial multi-round	✓✓✓	✓✓✓	✓	✓
	Auction objectives			
	Efficient allocation of capacity	**Adequate revenue generation**	**Promotion of participation within auction**	**Simplicity, cost and speed of process**
Ranking sealed bid, 1st price	× / ✓	✓✓	✓✓✓	✓✓✓
Ranking sealed bid, 2nd price	✓	✓✓	✓	✓✓
Combinatorial sealed bid, 1st price	✓	✓✓	✓✓	✓✓✓
Combinatorial sealed bid, 2nd price	✓✓✓	✓✓	✓	✓✓
Simultaneous multiple round	✓	✓✓	✓	✓
Descending price (Dutch Auction)	✓	✓✓	✓	✓
Clock auction	✓	✓✓	✓✓	✓✓
Combinatorial multi-round	✓✓✓	✓✓	✓✓	× / ✓

This leaves a list of four possible formats:

- Sealed bid ranking auction, first or second price;
- Sealed bid combinatorial auction, first or second price;
- Ascending price clock auction; or
- Multi-round combinatorial auction.

Table 2.2 highlights that these four remaining auction formats all vary in terms of how well they are suited to different industry demand contexts, and different auction objectives. In the following section we describe each of these auction formats in turn, and contrast the relative strengths and weaknesses of each of these auction formats in the circumstances of the auction of scarce capacity on the RBP.

2.4 Comparison of candidate auction formats

2.4.1 Sealed bid ranking auction

The auction design proposed by APA for scarce capacity on the RBP can best be characterised as a 'single round, sealed bid ranking auction'. All bids are ranked according to their NPV value, and the highest ranked bids that can be accommodated in available capacity are selected.

The basic format proceeds as follows:

1. Bidding takes place within a specified time window (single round), and no bids are opened until after the round is closed. Each bidder submits a single bid for their desired capacity on the pipeline for a term beginning on a date specified by the bidder. As part of the bid, bidders specify an annual capacity reservation charge, term duration, capacity, load factor and entry-exit points.

2. The bids are arranged in rank order, according to their NPV, which is calculated as the expected value of a flow of annual payments based on the price and term length.

3. Each successive bid from the top down is selected as a winning bidder until a point is reached where the next highest bid cannot be accommodated in the available capacity, taking into account contract term, MDQ, load factor and entry/exit points.

4. Each winning bidder is allocated the capacity in their winning bid, and must pay an annual capacity reservation charge equal to their winning bid amount (first price).

The most attractive feature of this auction is its simplicity. The auction format is straightforward to understand and to implement, and the time required by bidders to participate in the auction is minimal. However, this simplicity comes at the expense of potential losses in efficiency. In particular, there is a real risk that existing capacity on the RBP is not fully utilised, or that a suboptimal selection of bids is accepted. This could happen for several reasons. Firstly, the highest ranked bids are not necessarily the set of bids that maximises use of the capacity; there may be higher value combination involving some smaller bids. A particular problem is that winners are determined in the first order by ranking NPV, with capacity applied only as a second order constraint. Secondly, the limit of one bid prevents bidders expressing their full range of demand. Allowing bidders to submit just one bid may result in them submitting a large bid which includes both the capacity which they value the most (ie, their core demand) and also incremental capacity which they value less highly, and which may more efficiently be allocated to another bidder.

Some variation of the format would be possible to ease these weaknesses. For example:

- if there was excess capacity at the point when the highest losing bidder is found, the Auctioneer might be allowed to proceed further down the ranking to see if there are any bids that could be accommodated; or

- if there was a bidder whose demand could only be partially satisfied, they might be offered the option to accept a lower capacity.

However, even these approaches do not allow for the possibility that a more efficient allocation of capacity may result from dropping one or more higher bids to accommodate multiple smaller bids. Generally, this problem of inefficiency could only be addressed by moving to combinatorial bidding (see below).

Another adaptation could be to allow bidders to submit multiple bids, covering different tranches of capacity at different prices. That is, a bidder could submit a bid covering its core demand, and also a further bid covering incremental capacity, with the latter being at a lower price as the bidder values it less highly. As bids are ranked in descending order of NPV, bidders could be confident that they would only win incremental capacity in the case they had already won their core demand. Provided that bidders made use of this functionality, the scope for efficient outcomes would be improved. However, bidders may still have incentives not to break up their bids in this way, as their likelihood of winning the incremental capacity would be greater if it is incorporated into a single (higher NPV) bid, together with the bidder’s core demand. An example of this incentive under the ranking approach is provided in Box 2.1.

A further potential drawback is that the sealed bid approach does not allow for price discovery. Specifically, bidders must ‘bid blind’, with no information from others (except what has been revealed from previous auctions of capacity on the RBP) to guide their decision-making. This may be challenging for bidders in a partial common value setting (ie, where bid values across bidders are at least partially related), as it makes it harder for them to price the asset they are buying. If a first price, pay-your-bid rule is used, bidders are vulnerable to paying more than they need to win. This will encourage them to ‘bid shade’, reducing the amount of their bid in the hope of getting more surplus, which can lead to inefficient outcomes if strong bidders accidentally shade too much. Allowing bidders to bid multiple ‘tranches’ at different prices can help bidders to manage this risk, as they could bid shade less for core demand and more for incremental capacity.

Concerns about bid shading may be addressed by using a second price rule, in which prices for all bidders are based on the opportunity cost of denying the strongest losing bidder. This approach would make it a dominant strategy to bid your value, as no bidder would ever pay more than necessary to win their bid. However, we do not think a second price is appropriate with the ranking format for a number of reasons:

- It is not obvious how a 'second price' might be calculated, given that bidders may be pursuing very different amounts of capacity. Some form or price per unit of capacity would have to be introduced to avoid prices becoming completely delinked from capacity.
- In predictably low or asymmetric competition scenarios, a second price rule might 'advantage' larger bidders. Participation in the auction process may actually be greater if larger/strong bidders face some uncertainty about what to bid, and smaller/weak bidders see some greater opportunity to displace their bids.
- Setting a common price for capacity is likely to be inappropriate, given the varying demands of bidders. Furthermore, a common price would be incompatible with infilling any unallocated capacity using smaller, more lowly ranked bids.

More generally, a potential concern that exists with both the first or second price rule, but is strongest with the second price rule, is that strong bidders may be advantaged because bids are ranked based on NPV, not price per unit of capacity. Specifically, if one bidder was very confident that it was uniquely larger than other bidders, it may be able to shade its bid much more aggressively than smaller rivals because it knows it will still have the largest NPV. Further, the large bidder could potentially leverage this strength to try to win more capacity than it really needs. A robust approach to reserve prices, which would need to be linked in some way to capacity (such as setting the reserve price equal to the reference tariff, as proposed by APA), would be necessary to prevent gross abuse.

In summary, we consider that the first price, sealed bid ranking format is a viable option for this process. However, it has significant limitations. In particular, there is a real risk that some auctions may result in inefficient outcomes, in which capacity utilisation and also revenues are sub-optimal.

2.4.2 Ascending price clock auction

The ascending price clock auction provides a multiple-round alternative to the sealed bid ranking approach. Its chief benefit versus the sealed bid is that the multi-round format with escalating prices provides an opportunity for price discovery. In a quasi-common value setting, such as the circumstances of the RBP, bidders may value such information, and may even bid higher, because they gain confidence about (and can revise upwards) their valuations. Although a pay-your-bid rule is used, it is more equivalent to the second price rule than a first price rule, as prices are set at the point when the strongest losing bidder exits the auction.

An ascending price auction might proceed as follows:

1. Bidding takes place over multiple rounds. In each round, the 'annual payment' per unit of capacity is set by the Auctioneers. Each bidder submits a single bid for their desired capacity on the pipeline as the specified price. As above, they specify: term duration, capacity, load factor and entry-exit points.

2. At the end of each round, the Auctioneer determines if there is enough capacity to accommodate all bids. If not, the price is increased for the next round, and a new set of bids are requested.

3. The auction continues in this way until there is a round where all remaining bids can be accepted. All three capacity constraints can be considered when determining whether the clock rounds can be closed.

4. Each winning bidder is allocated the capacity in their winning bid, and must pay an annual capacity reservation charge based on the price associated with their bid.

This is a very popular auction format for allocating heterogeneous items. A key benefit is that bidders may adjust downwards their demand for capacity in response to price, which may facilitate more efficient outcomes than a static sealed bid. However, the clock approach has some significant drawbacks in the specific circumstances of the RBP:

- In each round, it is necessary for the Auctioneer to specify a single price point per unit of capacity. Given the complexity of defining capacity on the RBP, this may not be considered a particularly fair or desirable way of setting prices. Although, in principle, prices could be set differently for different types of capacity (eg, according to entry or exit points, or load factor), this would be rather complex in practice.

- As demand is 'lumpy', there is a real risk of 'overshoot' in which demand at final prices falls below supply, which implies that the outcome could be inefficient and revenues sub-optimal (and potentially below the efficient costs of the service provider, ie, inconsistent with the Revenue and Pricing Principles in Section 24 of the National Gas Law). As with the ranking auction, rules could be applied to try to backfill this capacity using bids from earlier rounds (or specified exit bids by bidders that dropped demand), but this is only a partial solution and may distort bidder behaviour.

- The process is necessarily longer that the single sealed bid. The number of rounds could be minimised by using larger bid increments, but this increases the risk of overshoot. Smaller bidders, in particular, may be deterred by the longer process.

- We understand from APA that many potential RPB bidders regard their bids as commercially sensitive, and have expressed concerns that a multiple-round process may give out too much information about their willingness to pay. Many of the large users of the RBP (ie, AGL, Origin and TRUenergy) are competitors in the downstream gas retail market. There are also competing electricity generators using the pipeline.

In conclusion, we think the simple ascending clock auction is not appropriate in the specific circumstances of the RBP; the extent of benefits relative to the sealed bid ranking auction are ambiguous, and appear insufficient to justify the extra complexity.

2.4.3 Sealed bid combinatorial auction

The sealed bid combinatorial auction provides an alternative to the ranking auction that has the potential to guarantee a more efficient allocation of pipeline capacity. The two key advantages of this approach are that: (a) it is possible for bidders to make multiple bids, thus revealing their trade-off between price and capacity; and (b) the winner determination process can take account of all constraints on allocation simultaneously in the first order.

The basic format proceeds as follows:

1. Bidding takes place within a specified time window (single round), and no bids are opened until after the round is closed. Each bidder may submit multiple, mutually exclusive bids, each one specifying a bid combining the five dimensions: annual payment, term duration, capacity, load factor and entry-exit points.

2. An optimisation process, undertaken using a bespoke computer algorithm, is used to determine the combination of bids that maximises value (the sum of NPVs), subject to (a) taking at most one bid from each bidder; and (b) there being sufficient capacity, taking account of all dimensions, to accommodate associated demand.

3. The winning bids are the set of bids in the combination that maximises value.

4. Each winning bidder is allocated the capacity in their winning bid, and must pay an annual charge equal to their winning bid amount (first price).

When compared to the ranking approach, this format combines a more sophisticated approach to winner determination (ie, optimisation) with a more flexible approach to bid submission. Although it is possible to amend the ranking bids process to allow multiple bid submission, as discussed above, bidders may have weak incentives to actually use this facility. By contrast, in a combinatorial process, bidders have relatively good incentives to reveal their true value on incremental capacity through multiple bids.

An example of how a sealed bid combinatorial auction works is provided below. The example illustrates how the efficiency of the auction outcome in terms of pipeline utilisation may be improved by using an optimisation process.

The potential efficiency benefits are significant. Firstly, the multiple bids approach allows winners to be determined from a much richer set of information about demand. Secondly, the risk of capacity going unallocated inefficiently when there are bids that could fill it is eliminated. Accordingly, absent concerns about strategic bidding behaviour (discussed below), the combinatorial format is more likely to deliver an efficient outcome than the ranking auction and, thus, higher revenues.

Concern is sometimes expressed about the transparency of outcomes that rely on computer algorithms for optimisation of bids to determine winners. Our experience from multiple spectrum auctions that use such processes are that this should not be an undue concern. The concept underpinning the optimisation algorithm is easily understood, and the process is usually straightforward to audit. The recent decision by the Australian Communications and Media Authority (ACMA) to adopt a combinatorial format, using optimisation algorithms, for the forthcoming award of radio spectrum for mobile broadband, highlights the growing popularity of such approaches.[12] We do consider, however, that an important role for APA would be to run a bidder education process prior to conducting the auctions, to facilitate understanding by all auction participants of the combinatorial auction format.

We have only identified one reservation about recommending the sealed bid combinatorial format for the auction of scarce capacity on the RBP. This concerns the potential for bid strategy opportunities to distort how bidders behave, especially in low competition scenarios:

- *Threshold risks* – small bidders who think that their demand is a good fit with other bidders may be tempted to shade down their bids in an attempt to 'free ride' on complementary bids submitted by others. If too many small bidders behave like this, their coalition may inefficiently lose.
- *Leverage* – large bidders who can predict that their demand is a large proportion of all demand, may be able to leverage their strength to inefficiently grab incremental capacity at low additional cost. They might achieve this by not submitting smaller bids, thereby not revealing the true value of their incremental demand. Alternatively, such bidders may be so confident that they will be in the winning combination, they may aggressively shade their bids.

Such concerns are very specific to the competitive conditions of each auction. Accordingly, we consider that they would be best addressed through detailed rules – such as restricted information about participation and robust reserve prices – rather than the adoption of a different auction format. With respect to larger bidders for scarce capacity on the RBP, there could be a case for obliging them to make multiple capacity bids, within certain bounds. However, a decision on the appropriateness of imposing such an obligation would require more detailed investigation, in order to better understand the flexibility of individual user demands for capacity.

Again, as with the ranking format, a second price could be used. In this case, an algorithm would be used to identify a unique second price for each winning bidder, based on the opportunity cost of the winning combinations that they are denying. There is more merit in using this approach with the combinatorial format than with the ranking auction, given that the first price rule may have less impact in addressing concerns about low competition. However, we are unconvinced that a second price rule would be either practical or desirable for this process. Firstly, in low competition conditions, prices can be very sensitive to selection of bids that other bidders put in, leading to erratic outcomes with wide or small gaps between bids and values that are unrelated to the amount of a bidder's own bid(s), and revenue uncertainty. Secondly, given the commercial sensitivity over pipeline payments, we think bidders would be reluctant to bid their full value, meaning that the benefits of the second price rule are not likely to be fully realised.

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[12] ACMA announced in November 2011 that it would use a combinatorial clock auction (CCA) format to allocate valuable radio spectrum at 700 MHz. The CCA uses an optimisation algorithm to determine both winners and prices. The ACMA's decision followed an extensive review of potential auction formats, including both combinatorial and non-combinatorial approaches. See: http://www.acma.gov.au/WEB/STANDARD/pc=PC_312315

Box 2.1
Example of a Combinatorial Auction

Worked example of efficiency gains from using an optimisation process

Assume a simple example of a pipeline with 100 units of capacity over a fixed timeframe (no other dimensions) and suppose that bidders make the following bids:

Bidder	*Quantity*	*Price per unit*	*Bid amount*
Adam	*50*	*$10*	*$500*
Bob	*30*	*$8*	*$240*
Chris	*25*	*$9*	*$225*
Derek	*15*	*$10*	*$150*
Edith	*15*	*$9*	*$135*
Fred	*10*	*$10*	*$100*
Ginger	*10*	*$9*	*$90*

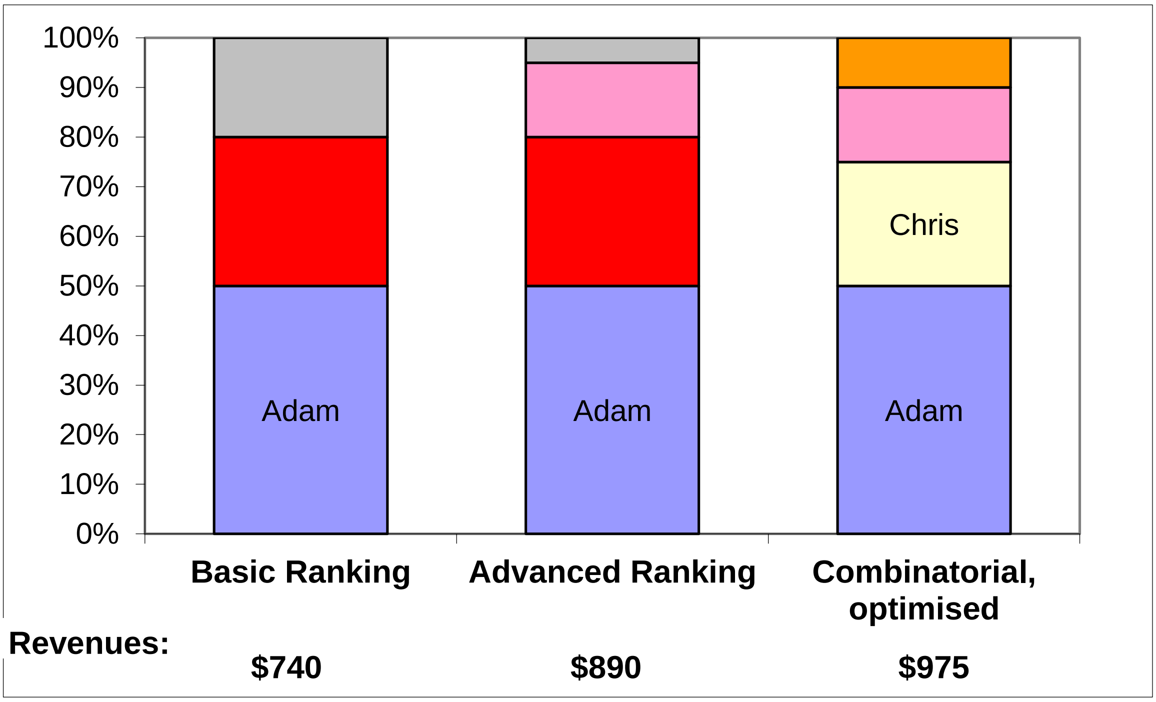
The diagram below compares the outcome under three different auction approaches:

- ***Basic ranking approach.*** *Bids are ranked in descending order. Capacity is awarded to highest ranked bidders until the point where the next highest bid cannot be accommodated. In this case, only Adam and Bob win capacity, as Chris's bid is too large to be accommodated alongside their bids. Utilisation is 80% and revenues are $740.*

- ***Advanced ranking approach.*** *Bids are ranked in descending order. Capacity is awarded to the highest ranked bidders. If a point is reached where the next highest bid cannot be accommodated, capacity is offered to the next highest ranked bidder that can be accommodated. In this case, Adam and Bob again win capacity, and Derek's bid can also be accommodated. Utilisation improves to 95% and revenues are $890.*

- ***Combinatorial.*** *An optimisation algorithm identifies the highest value combination of bids that can be accommodated. The winners are: Adam, Chris, Derek and Fred. Note that Bob's bid is rejected because, despite its larger absolute size, there is a more efficient alternative allocation. Utilisation improves to 100% and revenues are $975.*

Assuming that bids accurately reflect the relative valuations that the bidders place on the capacity, then revenue should be a perfect proxy for efficiency, ie, the highest revenue outcome is the most efficient. The optimisation approach always maximises efficiency. It does not necessarily maximise capacity utilisation but (as in this example) it often will, because higher revenue outcomes will tend to be associated with high capacity utilisation.



Now, suppose that Adam has an incremental demand for 10 units at a price of $30 ($3 per unit). In either ranking format, his best bid strategy is to simply replace his bid for 50 units with a bid for 60 units at a price of $530. This is true irrespective of whether he is allowed to make multiple bids. In the ranking auction formats, his new bid is a certain winner, but his behaviour distorts outcomes and efficiency:

- ***Basic ranking approach.*** *Adam and Bob again win capacity. Utilisation is up to 90% and revenues improve from $740 to $770, but observe that Adam has won an extra 10 units of capacity even though there are other bidders (e.g. Fred or Ginger) that value this much more highly.*

- ***Advanced ranking approach.*** *Adam and Bob again win capacity. Derek's bid can no longer be accommodated, so Fred wins instead. Utilisation improves to 100% but revenues actually decline from $890 to $840. This is because Adam is winning extra capacity at the expense of Bob who valued it more highly.*

Such distortions may be avoided with a combinatorial format. In this case, Adam would still be expected to make his bid for 60 units, but he would be foolish not to also submit his original bid for 50. This is because his bid for 60 units is not a certain winner in an optimisation process. In fact, if Adam only submitted a bid for 60 units, he would lose, as the highest value combination including his bid would be only $915, compared to a value of $940 for a combination of all six other bidders. Provided he still submits both bids, his bid for 50 units is still a winner and the outcome is unchanged from that in the diagram.

Although a very large bidder may still have some scope for distorting bids even in an optimisation process, this example illustrates how using a combinatorial format improves incentives for honest bidding regarding incremental capacity and thus offers a greater likelihood of an efficient outcome.

2.4.4 Multiple-round combinatorial auction

The combinatorial clock auction (CCA) is a multiple round process that combines the price discovery benefits of the ascending bid clock auction with a sealed bid combinatorial finale. This approach was recently adopted by the Australian Communications and Media Authority (ACMA) for its forthcoming mobile spectrum auction. However, given the specific circumstances of the RBP, we do not consider this approach further because we think that the potential incremental benefits over the sealed bid combinatorial auction are too modest to justify the extra complexity of this format. In particular, given that each auction may be quite modest in size and some participants quite small, we consider that a CCA – which requires two different stages of bidding – would impose too great a time burden on bidders.

2.5 Binding versus non-binding bids

One further auction design element flagged in the AER's Queuing Industry Paper is the potential addition of a non-binding round in advance of the auction, in order to improve the information available to participants.[13]

We are sceptical about the effectiveness of non-binding bidding rounds. There may be little incentive for bidders to 'tell the truth' about their demand level, and no incentive at all to reveal information about their willingness to pay in an initial non-binding round. In an auction where there are a larger number of bidders with similar demand profiles, the information benefits to a bidder of hiding its demand may well be minimal, so asking for non-binding bids could possibly (but may not) solicit useful information. However, where the number of bidders is limited or bidder demand is asymmetric, there are likely to be strong incentives for bidders to hide useful information from competitors, so non-binding rounds are typically ineffective.

We note that the auction design proposed for the Nabucco pipeline includes a non-binding round for informational purposes, followed by a commitment round (ie, binding offers). Prospective shippers must participate in the non-binding round to be included in the binding round. A participation fee must be paid to be involved in the non-binding round, but this will be refunded if the prospective shipper confirms or increases their bid for capacity in the commitment round. If the size of the capacity bid is reduced in the commitment round then the participant fee will be retained by the pipeline owner. This feature of the auction has been included to discourage prospective shippers from reducing their capacity based bids.

We are concerned that even the Nabucco approach may fail in the case of some auctions of capacity on the RBP, given that there may be only a modest number of bidders in some cases. One concern is that bidders could have an incentive to understate their real demand, in the hope of influencing rivals to believe that capacity is less scarce than it really is, and then shade their prices too much. In fact, unless the same bidders will be taking part in regular repeat auctions (as is the case with Nabucco), it could well be a dominant strategy for bidders to lie about their true demand, meaning that non-binding bids reveal no useful information. We also note that the proposed Nabucco auction format is one in which bidders are not competing on price, which is a key difference with the proposed RBP auction.

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13 AER Queuing Industry Paper, p. 19.

As an alternative to non-binding bids, some auctions have been run with so-called 'demand evaluation' rounds, in which binding bids are invited at specified reserve prices. If demand does not exceed supply, then all bids become winning bids. If demand exceeds supply, then participants qualify to take part in the auction. This approach is quite common in the spectrum world as a device for determining whether an auction is really necessary. We note that APA has proposed that an 'open season' would be conducted ahead of any auction of existing scarce capacity, to determine whether the demand for unutilised capacity can be met with the existing capacity. A 'demand evaluation' round would be similar to this proposed process, but would require the bids made to be irrevocable.

It would be quite plausible to add a demand revelation round to the auction. Although setting reserve prices for bidders pursuing differentiated multi-dimensional products would be challenging, this is likely to be necessary anyway, to protect against unduly low-revenue auction outcomes. Such an approach might be welcomed by bidders as a safeguard against 'over-bidding' in a first price auction. Careful thought would be required as to how much information to release about the level of excess demand after the demand evaluation round, in case there was concern about gaming behaviour in a low competition scenario.

2.6 Conclusion on choice of auction format

This section has considered the factors that influence the appropriate design of an auction. The appropriate format should reflect the product to be auctioned and the nature of demand, as well as take account of the auction objectives and the extent of potential competition in each auction process.

In the case of the auction of scarce capacity on the RBP, the product likely to be sought by the market is multi-dimensional, with bidders able to specify the capacity (MDQ) to be provided, the term over which the capacity will be provided, the load factor and the entry/exit points to be used. The demand for capacity is also likely to be heterogeneous across bidders. For multi-dimensional products with heterogeneous demand, a combinatorial auction format (involving an optimisation algorithm) is particularly attractive. The combinatorial auction approach has the potential to elicit much more information about demand, and deliver a more efficient allocation of capacity and more robust revenues, compared with a ranking format. Given the multi-dimensional nature of the product to be auctioned, and in particular the difference in the term for which capacity is sought, we recommend that bids are evaluated on a total NPV basis.

Each auction of capacity on the RBP will consist of only limited capacity and may attract only a limited pool of bidders, of varying sizes. Competition is unpredictable, and it therefore appears likely that it will sometimes be low and asymmetric. In these conditions, a sealed bid format is the most appropriate. This approach minimises implementation and participation costs, and is less vulnerable than a multi-round process to having the outcome gamed by larger bidders.

We propose a first price, pay your bid rule. In a context where bidders are sensitive about revealing price information and there are constraints on transparency, setting payments equal to price avoids any difficulties in explaining price outcomes to bidders. Further, the first price, sealed bid is a robust auction format to use for situations where competition could be low.

Our conclusion is therefore that a single round, combinatorial auction design based on irrevocable sealed-bids represents the most appropriate approach for the auction of capacity on the RBP. Careful consideration will need to be given to detailed rules, such as the reserve prices, information released about participation, and potential role of a demand evaluation round, to ensure any format is adequately protected against unduly low revenues and/or gaming behaviour, especially by larger bidders. We also recommend that APA conducts a bidder education process prior to the auction to enable all participants to gain an understanding of the key features of the auction format, especially the efficiency rationale underpinning the use of an optimisation approach.

3 Rebate or Offset Mechanisms

The final question that APA has asked us to consider is reproduced below:

> *3. If the proposed auction process were to be coupled with one or both of the following:*
>
> *i. a rebate mechanism; or*
>
> *ii. the offset of some of the auction proceeds against future capital expenditure*
>
> *would this give rise to any distortions of economically efficient outcomes? Identify any such distortions.*

One of the submissions made in response to APA's proposed access agreement expressed the view that APA should not be allowed to retain revenues arising from the auction process above regulated returns.[14] We understand that the issue of the appropriate treatment of 'additional' revenues was discussed at the industry workshop convened by the AER to discuss APA's revised queuing arrangements.

The concept of 'additional' revenue implies a comparison with the revenue received by APA as a result of the auction and the revenue that would otherwise have been received by APA under alternative circumstances.[15] Given that capacity on the RBP allocated by the auction may relate to either reference services or negotiated services, there may be a practical difficulty in terms of establishing a firm counterfactual for the revenue that would otherwise have been received by APA for services provided by the auctioned capacity.

Notwithstanding this potential practical difficulty, we have been asked to consider the implications for economically efficient outcomes if such 'additional revenue' (however determined) were to be either rebated to users, or used to off-set the cost of future capital investment. We understand that both of these mechanisms were discussed at the industry workshop convened by the AER in January 2012.

In this section, we begin with a discussion of the examples included in the AER's Queuing Industry Paper of auctions which incorporate some form of rebate or offset mechanism, and the specific circumstances which appear to us to be relevant in considering the appropriateness of extending similar mechanisms to the auction of scarce capacity on the

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[14] BP, *Submission on the proposed Roma to Brisbane Pipeline (RBP) Access Arrangement (AA) from APT Petroleum Pipeline Limited (APTPPL / Service Provider)*, 16 December 2011, p. 5.

[15] Currently, the price paid by users for use of capacity on the RBP is determined by either: (i) the regulated reference tariff, as proposed by APTPPL and approved by the AER as part of its approval of the Access Arrangement, where the user is requesting the reference service; or (ii) a negotiated tariff, arising out of bilateral negotiations between the prospective user and APTPPL, where the user is requesting a negotiated service. Under the auction process proposed by APTPPL for existing capacity on the RBP, the price paid by the successful bidder(s) for the use of capacity allocated via the auction would be determined by the outcome of the auction process itself. 'Additional' revenue would arise as a consequence of prices determined by the auction process being above those that would otherwise have been determined for the use of the existing capacity.

RBP. In the remainder of the section, we consider in turn the potential for distortions to arise under each of the two suggested mechanisms, in each case commencing with an overview of our understanding of how either a rebate or capital expenditure offset mechanism may operate.

3.1 Examples of rebate mechanisms

In our experience, the inclusion of rebate mechanisms is not a common feature of auction design. However two of the examples of auction processes cited by the AER in its Queuing Industry Paper do incorporate rebate/off-set mechanisms as part of the auction design:

- *the UK gas transmission network monthly capacity auctions* –National Grid is required to refund any over-recovery of auction revenue to shippers through the entry capacity buy-back offset mechanism (which is designed to offset the costs of entry capacity buy-back that would otherwise be borne by shippers), in the first instance. If there is any over-recovery amount still remaining, then an entry commodity charge rebate is used. Any under-recovery of auction revenue is recovered from shippers through the imposition of a commodity charge.
- *the CBH grain handling ports capacity auctions* –CBH is required to rebate the auction premium (less CBH's administration costs) to exporters that ship through CBH's ports at the end of the season on a pro rata basis.

We note that the specific circumstances applying in these two cases are quite different to those prevailing in the context of the RBP.

National Grid is subject to a revenue cap form of regulation. This would appear to explain why the rebate mechanism has been included in the auction design, and why the mechanism works to both rebate revenue above the revenue cap to shippers, but also to raise additional revenue from shippers when there would otherwise be a revenue shortfall against the cap. In contrast, APA is subject to a price cap for the RBP, rather than a revenue cap regime, and an overall negotiate-arbitrate approach to the regulation of its charges. This regime has been adopted under the NGR in order to incentivise the pipeline owner to seek opportunities to further develop the market.

CBH is a co-operative and its members include all of the grain growers in Western Australia. The rebate provided to exporters in this case provides a mechanism by which any returns generated by CBH above its administrative costs are returned, first to exporters in the form of lower charges, but then ultimately flowing through to CBH's members in terms of the prices which exporters are then willing to offer for their grain. In contrast, APA is a private-sector entity seeking a commercial return on its substantive investment in fixed-cost pipeline assets.

3.2 Rebate mechanism

Our understanding of a 'rebate mechanism' is that this would be a mechanism used to return revenues received by APTPPL over and above a given level as a result of the auction outcome to other users, or groups of other users.

The concept of 'rebating' revenue received from one service to users of reference services is one which we note does already have a precedent in the current regulatory arrangements applying to the gas sector. In particular, the NGR includes the concept of a 'rebateable service'.[16]

3.2.1 Application of a rebate mechanism

The auction process will determine the price paid by the successful bidder(s), the quantity of existing capacity which they are allocated and the term for which they are allocated capacity. As a result, APTPPL will therefore receive a stream of payments from the successful bidder(s) over time, rather than a one-off 'lump sum' payment at the conclusion of the auction. We have therefore assumed that any rebating of a portion of the revenue received by APTPPL as a result of the auction would also reflect a rebate over time, rather than a one-off payment. As such, the 'rebate' would be likely to reflect an effective reduction in either the capacity reservation rate ($/GJ MDQ/day) or the per GJ throughput rate paid by other users of the RBP.

There are several options for the parties to which the rebate payment could apply, including:

- all users of the RBP (ie, both those taking reference services and those taking negotiated services);
- all users of reference services on the RBP; or
- only those users who are successful in the auction.

On the assumption that not all users would participate in every auction for spare existing capacity, the level of rebate to any individual shipper would be higher where rebates are only paid to successful bidders in the auction, rather than to all users (all else equal). In addition, given that most users of the RBP are using a negotiated service, rebates would be higher where they are made to users of reference services, rather than all users of the RBP.

3.2.2 Potential distortions associated with a rebate mechanism

Rebating a portion of the auction revenues to users appears to have the potential to distort:

- the efficiency of the outcome of the auction;
- the efficiency of the investment and usage decisions made in relation to the pipeline; and
- the competitive position of users of the pipeline who are also competing in downstream markets.

3.2.2.1 Efficiency of auction outcomes

The rebating of a portion of the auction revenues to users has the potential to affect the price that the user is prepared to bid in the auction. Users should take into account that the effective price they will pay for capacity (if successful) will be reduced by the extent of the

16 NGR 93(4). We note that the AER has submitted a Rule change proposal to the AEMC which would broaden the scope of services which may be considered to be rebateable services (AER, *National Gas Rule change proposal in relation to reference service and rebateable service definitions and criteria*, 5 August 2011). The AEMC is expected to issue its draft determination on the proposed Rule change by 15th March 2011.

rebate, and so are likely to be prepared to submit a higher bid than they would in the absence of the rebate mechanism.

This distortion of bids has the potential to affect the efficiency of the auction outcome. Each bidder will make an assumption about the extent of revenue that will be rebated, which in turn depends on the prices and quantities sought by others (and potentially the overall number of successful participants in the auction, if rebates are restricted to successful bidders only). If the actual auction outcome turns out to imply a lower rebate amount than that assumed by the bidder, then the bidder may have factored in too great a discount into its bid, with the consequence that the price it has paid is too high. Conversely, if the bidder has underestimated the amount of revenue that will be rebated, it may have under bid, compared to the true value it places on access to the scarce capacity. In both cases there is a distortion between the true value that the bidder places on the scarce capacity and the amount that it is prepared to bid in the auction, due to the presence of the rebate.

This distortion will be greater, the smaller the number of users to whom the rebate is expected to be paid, and the greater the proportion of the rebate expected to be received by a particular user. If the rebate is restricted to only successful bidders, then the impact of the rebate on any one user's bidding strategy is likely to be larger (as they will receive a larger amount back via the rebate), all other things equal. Where only a few users are expected to be awarded capacity in any particular auction on the RBP, they would have an incentive to submit bids significantly in excess of their true valuations, as they would factor in having a large portion of their bids rebated to them. Similarly, the larger the user, the greater would be the share of the rebate that that user would receive, all other things equal, again with the consequence that their bidding strategy is more likely to be affected by the rebate. Where bids are only rebated to the small number of users who take the reference service, a bidder who is also a user of the reference service also stands to obtain a greater share of any rebate; with the consequence that its bidding strategy is more likely to be affected.

One of the objectives of moving to an auction approach as part of the queuing policy for RBP is that an auction is expected to result in a more efficient allocation of scarce capacity than the current first-come-first-served approach. However, as discussed above, rebating auction proceeds to winning bidders would likely distort bidding strategies to such an extent, that any benefits may be completely lost.

3.2.2.2 Efficiency of usage and investment decisions

In addition to the impact on the efficiency of auction outcomes, the rebating of auction proceeds would alter the effective charges faced by users, through lowering the effective capacity reservation charge they face and/or the effective throughput charge.[17] The potential distortion in price signals will be more widespread where the rebate is extended to all users, including those that did not participate in the auction.

Where the rebate lowers the effective capacity reservation charge, users may reserve more capacity than they would otherwise, which in turn may bring forward the time at which

[17] The actual capacity reservation rate and throughput rates would be likely to remain unchanged, but rebating a portion of auction proceeds on a $/GJ MDQ/day or $/GJ basis would result in an *effective* reduction in the price faced by users.

expansion of the pipeline is needed. Similarly, a lowering of effective throughput charges may affect the usage decisions made by users. In both cases, the impact on charges may affect the efficiency of usage and investment decisions in the RBP in a manner inconsistent with the National Gas Objective.

3.2.2.3 Competition in downstream markets

The RBP is characterised by a number of large users, many of whom are competing with each other in downstream markets, in particular the gas retail market. In this context, a further consequence of rebating a portion of auction revenue to two or more shippers is that participants in the auction will be aware that ultimately the price they bid for scarce capacity could affect their competitive position vis-à-vis their competitors, if they are successful in the auction. That is, a shipper bidding a premium in order to secure capacity could, by virtue of that premium, be providing a rebate to its competitor.

The AER has noted in the context of its Rule change proposal on rebateable services that users of the rebateable service may subsidise other users of pipeline services.[18] The AER considers that it would need to retain a broad discretion to impose conditions, where it had concerns that rebating some or all of the revenue would lead to an inappropriate cross subsidy between pipeline service users. We consider that a similar concern would arise in the context of a rebate being applied to a portion of auction proceeds.

3.3 Offset mechanism

The second mechanism which we have been asked to consider is the use of ‘additional’ revenue (however determined) received by APA as a result of the auction of scarce capacity to offset the cost of future investment in the RBP.

3.3.1 Application of an offset mechanism

We understand that the possibility of an ‘offset mechanism’ was raised at the Queuing Workshop convened by the AER. BP also alludes to this type of mechanism in its submission to the AER in response to APTPPL’s access arrangement proposal:

> If APTPPL had proposed that this additional revenue would be used specifically for the benefit of all RBP Users (in some form or another - perhaps to fund additional investment) then BP would be more supportive of the proposed pricing mechanism for constrained existing capacity.[19]

As discussed above in relation to the rebate mechanism, APA will earn revenue in relation to the auction of scarce capacity on the basis of the prices paid for the use of that capacity (reservation charge, throughput charge plus any miscellaneous charges) over the duration of the capacity agreement with the successful bidder(s).

For the purposes of providing advice in this report, we have assumed that under an offset mechanism a portion of this future revenue stream would be used to offset the cost of future

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[18] AER, op cit, p. 11.

[19] BP, *Submission on the proposed Roma to Brisbane Pipeline (RBP) Access Arrangement (AA) from APT Petroleum Pipeline Limited (APTPPL / Service Provider)*, 16 December 2011, p. 6.

investment in the RBP. The investment eligible for such an offset would relate to new assets (ie, extensions or expansions)[20] used to provide services to a number of users, the most obvious candidate being reference services. We note that under APTPPL's proposed extensions and expansions policy for the 2012-2017 Access Arrangement period, APTPPL will elect whether access to incremental services provided by an expansion of pipeline capacity will be offered as part of the reference service at reference tariffs or as a negotiated service at a negotiated tariff.[21]

We have assumed that the auction proceeds would be treated in the same manner as a capital contribution in offsetting the cost of eligible investment, thereby reducing the revenue which is required to be recovered from users to cover the return on and of the capital associated with that investment.

3.3.2 Potential distortions associated with an offset mechanism

Under an offset mechanism, the auction proceeds would be used to offset the cost of future expansion of the RBP, rather than current charges. It therefore would not affect bidders' strategies and distort the efficiency of auction outcomes in the same way that the direct rebate mechanism would.

However an offset mechanism may indirectly distort the efficiency of the auction outcomes. It is possible that the incentive for bidders to participate in an auction for scarce existing capacity could be affected by the prospect that the outcome of that auction may bring forward the timing and lower the cost of further expansion of the pipeline. Some prospective users may find it preferable to wait for the future capacity to become available (at a subsidised price), rather than pay a premium to acquire existing capacity now. Users' expectations about the amount of auction proceeds that would be used to offset the cost of that future capacity, and the timing and quantum of capacity expansion, may not turn out to match actual outcomes. This would again have the consequence that the efficiency of auction outcomes would be adversely affected. However it is not clear the extent to which, in practice, users would choose to 'wait' for new developable capacity and not participate in the auction for existing capacity. Moreover, they could choose to participate in the auction, but seek only a short term contract, in the expectation that there will be new, subsidised developable capacity in future.

An offset mechanism as described above also has the potential to distort efficient outcomes in the following ways:

- the efficiency of the investment and usage decisions made in relation to the pipeline; and
- the competitive position of users of the pipeline who are competing in downstream markets.

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20 If the offset were applied to the cost of existing capacity (ie, in determining reference tariffs for the existing pipeline configuration) then this would become equivalent to the rebate mechanism discussed in section 3.2, as it would effectively lower the reference tariff paid for existing capacity.

21 APA Proposed Access Arrangement, Section 7.

The use of a portion of the auction proceeds to offset the capital costs associated with new investment in the RBP will reduce tariffs applicable to the expansion capacity from the level that they otherwise would have been. As a result, the quantities reserved by users and/or their usage decisions may be affected, which in turn may bring forward the timing of the next tranche of additional investment required on the pipeline.

In addition, similar to the rebate mechanism discussed above, this mechanism would in effect result in the successful bidder(s) partially funding investment in future capacity that may well benefit their competitors, and would result in a cross-subsidy from the successful bidder to other users. As discussed earlier, the large users of the RBP are competing in the downstream gas retail market, and therefore the prospect of such potential cross-subsidy may be significant in practice.

4 Conclusion

APA has asked us our opinion on the following questions:

1. *What form of auction design is likely to lead to outcomes consistent with the National Gas Objective in the case of the auction of scarce capacity on the Roma to Brisbane Pipeline (RBP)?*

   a) *What factors are relevant in determining the optimal auction design?*

   b) *How do the specific circumstances of the RBP affect the choice of optimal auction design?*

2. *If the proposed auction process was to be coupled with one or both of the following:*

   a) *a rebate mechanism; or*

   b) *the offset of some of the auction proceeds against future capital expenditure*

   would this give rise to any distortions of economically efficient outcomes? Identify any such distortions.

Auction design

In relation to the first question, we have concluded that a sealed-bid auction format, incorporating irrevocable bids and a combinatorial, single-round approach is likely to be the most appropriate format, given the specific circumstances of the RBP. We propose that this format be implemented with a first price, pay your bid, rule.

We recommend this format for the following reasons:

- Capacity on the RBP is a multi-dimensional product. In this context, a combinatorial auction format promises the most efficient allocation, as it is possible to optimise across all constraints on allocation of scarce capacity, including MDQ, load factor, entry/exit points and term length. By contrast, simpler formats, such as the ranking auction or clock auction, require the auctioneer to focus on just two dimensions (NPV and MDQ in this case) in the first order, and can only consider other dimensions as second order constraints.

- A ranking or clock approach are both problematic because they prioritise the highest bids, while ignoring the possibility that there may be smaller bids that could fill otherwise unsold capacity, and or combinations of bidders that in aggregate would use the capacity more efficiently than a simple list of highest bidders.

- A further advantage of the combinatorial approach is that bidders may submit multiple, mutually exclusive bids. This may provide a much more complete picture of demand, with the potential that each unit of incremental capacity is allocated to the appropriate bidder.

- With a sealed bid process, there is no price discovery during the auction. While this can be considered a disadvantage in a partial common value setting (such as the RBP) , we understand from APA that many potential RPB bidders regard their bids as commercially sensitive, and accordingly may prefer a sealed bid process over a multiple-round process that would necessarily reveal more information about the willingness to pay of bidders.

- The level of competition is likely to vary by auction, and there is a risk that some auctions could be affected by modest and predictable competition and asymmetries between bidders. This raises concerns about potential distortions to bidding behaviour and gaming strategies. The sealed bid combinatorial auction is a relatively robust format against gaming, and – coupled with a first price rule – provides good incentives for participation by all types of bidders.
- The sealed bid process requires only a single round of bidding. The process is simple, quick and low cost for participants. Although the optimisation algorithm required for winner determination may be quite complex, this can be entirely managed by the Auctioneer. Moreover, the underlying efficiency rationale underpinning the optimisation process is easy to understand, and there is wide precedent for use of such processes (e.g. the ACMA's recent decision to use a combinatorial format for its next mobile broadband spectrum auction).

Including a non-binding round of bids as part of the auction design would add no value, given that bidders would have no incentive to 'tell the truth' about their demand. It is therefore appropriate for bids to be irrevocable. Careful consideration will need to be given to detailed rules, such as the reserve prices, information released about participation, and potential role of a demand evaluation round, to ensure any format is adequately protected against unduly low revenues and/or gaming behaviour, especially by larger bidders.

We also recommend that APA conducts a bidder education process prior to the auction of capacity on the RBP, to enable all participants to gain an understanding of the key features of the auction format, in particular the optimisation process.

Rebate or offset mechanism

In answer to the second question, we have concluded that a rebate mechanism has the potential to significantly affect users' bidding strategies, and therefore the efficiency of the auction outcome itself. Indeed, a rebate approach risks completely undermining the benefits from conducting an auction.

A mechanism which offsets some or all of the auction proceeds against future capital expenditure would not result in the same direct distortion of bidding strategies as a rebate mechanism. However, it may still indirectly affect bidders' strategies, and therefore the efficient allocation of capacity.

The efficiency of usage and investment decisions would be affected under both mechanisms, as prices faced by users for use of the RBP would no longer reflect underlying costs. In addition the efficiency of competition in downstream markets would also be affected under both mechanisms, with the successful bidder(s) potentially cross-subsidising their competitors.

Appendix A. Alternative Auction Approaches: Key Design Features

Table A.1
Examples of Alternative Auction Approaches in the AER's Queuing Industry Paper: Key Design Features

Auction	Product Being Auctioned	Auction Type	Key Features
UK gas transmission pipeline[22]	Right to inject gas at a given entry point for one month (monthly system entry capacity auction)	Sequential, sealed bid auction	▪ Single vs multi product auction – multiple products but homogenous product (ie, total capacity available at each entry point is divided equally and sold in lots). ▪ Frequency of auctions – bi-annual. ▪ Rounds of bidding at each auction – at least four rounds separated by one business day. 25% of available capacity sold in each round. ▪ Auction formats – sealed bid with a reserve price set by reference to the Long Run Marginal Cost of gas transmission. ▪ Refund mechanism – the auction process allows for any over-recovery of auction revenue to be returned to users through an entry capacity buy-back offset mechanism plus (if there is any amount outstanding) an entry commodity charge rebate. Any under recoveries are charged through the imposition of a commodity charge on users. See discussion in section [3.2].
Nabucco pipeline (*proposed* auction design)[23]	Rights to pipeline capacity to be sold on long and short term basis *(note that the auction process was due to commence in 2011 but as of February 2012 does not appear to have been conducted).*	Dual round sealed bid auction (bids based on capacity) with tariff to be determined after all bids have been received.	▪ Single vs multi product auction – single product but with multiple dimensions, ie, flow, exit/entry points, years and distance. ▪ Frequency of auctions – one auction to be conducted for long term transportation agreements. ▪ Rounds of bidding at each auction – non-binding round for informational purposes followed by a commitment round (ie, binding offers). Prospective shippers must participate in the non-binding round to be included in the binding round. A participation fee must be paid to be involved in the non-binding round but this will be refunded if the prospective shipper confirms or increases their bid for capacity in the commitment round. If the size of the capacity bid is reduced in the commitment round then the participant fee will be retained by the pipeline owner. This feature of the auction has been included to discourage prospective shippers from reducing their capacity based bids. ▪ Auction formats – Prices fixed by pipeline owner (ie, uniform price) so bids based on capacity, load factor and contract term. An indicative tariff is to be published at the commencement of the non-binding phase, a 'maximum tariff' is to be published at the start of the commitment phase while the final tariff is to be determined once the capacity allocation has been completed and long term transportation contracts are entered into.

22 Information obtained from McDaniel, T. and Neuhoff, K., *Auction to gas transmission access: The British experience*, November 2002; Joint Office of Gas Transporters, *Uniform Network Code – Transportation Principal Document*, January 2011; and National Grid, *Capacity Management Overview Presentation*, undated.

23 Information obtained from Pickl, M. and Whirl, F., *Auction design for gas pipeline transportation capacity – The case of Nabucco and its open season*, Energy Policy 39 (2011), pp. 2143-2151 and Nabucco website: http://www.nabucco-pipeline.com/portal/page/portal/en

Auction	Product Being Auctioned	Auction Type	Key Features
			▪ Refund mechanism – none.
Spectrum auctions[24]	Spectrum licences across a range of geographic areas and different band segments (complements / substitutes)	Simultaneous, multiple round auction (SMRA)	▪ Single vs multi product auction - Multiple products sold on a simultaneous basis. ▪ Frequency of auctions – when licences become available. ▪ Rounds of bidding – multiple rounds. ▪ Auction formats – Bidders bid individually on each lot and (depending on the product) may make multiple non-exclusive bids. At the end of each round, high bids are disclosed and all bidders can bid again in the next round to become the highest bidder. After a round with no more bids, the highest bidders in the previous round secure the item. ▪ Refund mechanism –none.
		Combinatorialclock auction (CCA)	▪ Single vs multi product auction - Multiple products sold on a simultaneous basis. ▪ Frequency of auctions – when licences become available. ▪ Rounds of bidding – multiple rounds. ▪ Auction formats – ascending clock auction with flexibility to bid on different combinations of the auctioned products (combinatorial). During the primary rounds, the price for each item in each category is set and bids are based on the quantity of each item that will be purchased at that price. After the primary round a second phase of bidding may occur, which allows the bidders to make their best and final offer for all the combinations of lots they want. ▪ Refund mechanism – none.
		Sealed bid combinatorial auction	▪ Single vs multi product auction - Multiple products sold on a simultaneous basis. ▪ Frequency of auctions – when licences become available. ▪ Rounds of bidding – multiple rounds. ▪ Auction formats – A single round version of a CCA, in which bidders may submit multiple mutually exclusive bids.. ▪ Refund mechanism – none.
Co-operative Bulk Handling Limited Port Terminal Services[25]	Port terminal capacity (appears to be a relatively homogenous product although it is noted that some shipping slots may be valued more highly than others)	Ascending clock auction	▪ Single vs multi product auction – multiple products but homogenous in nature (ie, total capacity of port available over a particular shipping window is divided into tranches). ▪ Frequency of auctions – three auctions held through the year. ▪ Rounds of bidding at each auction – as many as required to equate demand and supply. ▪ Auction formats – ascending clock with prices based on a uniform $ per tonne basis and bids made on the basis of capacity that will be purchased at that uniform price. Prices rise by one increment in each round, with the increment defined ahead of the auction. The price continues to rise in these increments until total demand matches supply. ▪ Refund mechanism – auction premium rebated to exporters at the end of the season on a pro-rata basis less administration costs.

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24 Information obtained from ACMA website, Types of auctions, accessed 5 February 2012: http://www.acma.gov.au/WEB/STANDARD..PC/pc=PC_300178

25 Information obtained from ACCC, *Co-operative Bulk Handling Limited Port Terminal Services Access Undertaking*, 29 September 2011; CBH Operations, *Notes on Port Terminal Rules Variation Notice*, undated and CBH website. https://www.cbh.com.au/our-members/the-principles-of-co-operatives.aspx

Appendix B. Curriculum Vita: Richard Marsden

Richard Marsden

Mr. Marsden has 15 years of experience in microeconomics, political economy, and business consulting. He has managed projects on regulation, competition, public policy, and business strategy for a diverse client base, including regulators and private companies in more than 25 countries across Europe, Asia, Africa, and the Americas. He has particular expertise in auctions and in applying economics to the telecommunications and media sectors. Many of his recent projects have involved policy advice, auction design, software implementation, and bidder support related to the current wave of spectrum awards worldwide.

Mr. Marsden has undertaken auction projects across a wide range of sectors, including airport slots, broadcasting, gas pipeline capacity, mobile telephony, power generation and renewables, procurement, retail sites, and wireless broadband. His project experience includes the design and implementation of combinatorial auctions (both multiple-round and sealed bid) for radio spectrum in Denmark, Ireland, the Netherlands, Nigeria, and the UK, and SMR auctions in Hong Kong and Norway. He has provided strategy advice to bidders in spectrum auctions worldwide, including Canada (AWS, 2008 and PCS, 2001), Finland (2.6GHz, 2009), Spain (800MHz, 2011) and Switzerland (multi-band, 2012), and 3G/cellular mobile awards in Egypt, Germany, Hungary, Ireland, Italy, the Netherlands, Switzerland, Taiwan, and the UK.

Prior to joining NERA, Mr. Marsden spent 10 years at DotEcon, as Director and Managing Consultant, where he was responsible for business development for auctions, public policy, and strategy projects. While there, he regularly managed projects involving teams of programmers, econometricians, academics, and technology consultants. Notably, he managed the project teams advising Ofcom on UK spectrum auctions between 2005 and 2010. He also completed major studies for the European Commission on allocation of the digital dividend, and on spectrum trading and liberalization. Previously, he worked for Oxford Analytica as an editor and consultant.

Mr. Marsden presents and publishes frequently on the topics of spectrum management and allocation. He is the co-author of a book on broadband regulation (Springer, 2005). He holds an MA with distinction in international political economy and a BA in economics and international relations from the University of Warwick, United Kingdom.

Education

University of Warwick, United Kingdom
MA (distinction) International political economy, 1994

University of Warwick, United Kingdom
BA (Hons) Economics and International Relations, 1993

Professional Experience

NERA Economic Consulting
2010- Vice President

DotEcon Limited
Director, Economic Consulting
1999-2010 Previously managing consultant and senior consultant

Oxford Analytica
1997-1999 Consultancy and Research Manager

1994-1997 Editor, Asia Pacific Daily Brief

Selected Project Experience

Selected auction projects:

- Switzerland (2010-12) – Lead strategy advisor to Orange Switzerland participating in a multi-band award for all mobile spectrum with a combinatorial clock auction format.
- Canada (2011) – For an incumbent operator, a paper examining the impact of spectrum caps on revenues from the forthcoming 700 MHz auction
- Italy (2011) – Senior advisor to a mobile network operator participating in a simultaneous multiple round auction for 800, 1800 and 2600 MHz spectrum.
- Hungary (2011) – Advice to a Telenor Hungary on first price, sealed bid auction strategy for radio spectrum to be used for mobile services.
- Spain (2011) – Lead strategy advisor to Telefonica in the auction of 800MHz, 900MHz and 2.6GHz spectrum. On-site support throughout the five-week auction.
- Bangladesh (2011) – Lead strategy advisor to an incumbent operator in responding to government proposals for renewal of 900MHz and 1800MHz spectrum licences
- Malaysia (2010) – Member of team developing the bid book for a participant in a beauty contest for 2.6GHz spectrum
- Australia (2010) – Report for the ACMA analyzing potential new auction formats, including various designs with combinatorial bidding, and drafting proposing details.

- Germany (2010) – Member of the team supporting a leading incumbent bidder on their successful bid for radio spectrum at 800MHz and other bands.
- Denmark (2009-10) – For NITA, design and implementation of a combinatorial clock auction for spectrum in the 2.6GHz band. Leader of the joint DotEcon-Analysys Mason team advising on valuation, licence terms, rules design and software implementation.
- Netherlands (2008-10) – For the Ministry of Economics, advice on the design of the 2.6GHz auction and drafting of auction rules. For Agentschap Telecom, support with software implementation and secondment to auction team for the award.
- UK (2007-2010) – Advice to Ofcom on the design of various versions of the forthcoming UK spectrum awards involving the 2.6GHz band and the 800MHz band.
- Finland (2009) – Lead strategy advisor to Elisa for the 2.6GHz auction, including on-site support throughout the auction.
- Malaysia (2009) – Workshop on auction design for spectrum awards in Kuala Lumpur for the local wireless industry.
- Portugal (2009) – Author of the auction rules for the Portuguese BWA auction, featuring a two-stage sealed bid process with package bidding.
- Canada (2008) – Lead strategy advisor to Rogers Wireless for the AWS auction. A one-year project involving in-depth competitor analysis, price benchmarking and auction simulation. On-site support throughout the auction.
- UK (2005-09) – For Ofcom, advice on licence design, competition, auction formats, design and testing of auction rules, and software implementation for UK spectrum awards from 2005, including: the GSM-DECT guard bands (2005), 412-424MHz (2006), L-band (2008); 10-40GHz (2008); and geographic interleaved UHF spectrum (2009).
- Hong Kong (2008) – Member of DotEcon team developing a generic framework for implementing multiple-round spectrum auctions.
- Ireland (2007) – Development of a novel sealed combinatorial auction and reserve price setting for the 26GHz award.
- Denmark (2005) – Design and implementation of a sealed bid auction for a 3G auction.
- Sweden (2004) – Report for the regulator PTS on the use of auctions for spectrum assignment.
- Norway (2004) – For the NPT, design and implementation of the auction of 3.5GHz regional spectrum licences.
- Nigeria (2002) - Co-design and implementation of a sealed bid combinatorial auction (the first in the world for radio spectrum) for fixed wireless services.

- Worldwide (1999-2010) - Advice to bidders in 3G, cellular mobile and FWA spectrum auctions and beauty contests, including: Bangladesh, Canada, Egypt, Germany, Hungary, Ireland, Italy, Malaysia, Pakistan, Netherlands, Serbia, Switzerland, Taiwan and the United Kingdom.

Other spectrum allocation projects:

- Europe (2011) – For the European Defence Agency, development of a model for valuing radio spectrum used for military purposes by European states.
- France (2011) – For the GSMA, a study on the French process of spectrum refarming.
- Ireland (2011) – For a mobile operator, a study examining the case for rolling extension of spectrum license terms.
- Greece (2011) – Member of a team advising an incumbent mobile operator on responding to the Greek government’s proposals for refarming and renewal of 2G spectrum licences.
- Ireland (2010) – For ComReg, a report proposed new prices for local area FWA licences in the 3.5GHz band based on a benchmarking methodology.
- Hong Kong (2009) - Report for the Hong Kong regulator OFTA on the competition implications of introducing spectrum trading.
- European Commission (2009) – Lead economist in the Analysys Mason team advising the Radio Spectrum Policy Unit on allocation of the digital dividend.
- Denmark (2007) – Development of a new approach to setting administrative charges for spectrum licences in Denmark.
- UK (2007) – Study for Ofcom on the economic and social value of releasing UHF spectrum for different uses, including mobile broadband technologies and HDTV.
- European Broadcasters (2007) – Commissioned through the European Broadcasting Union on behalf of selected members, a report investigating the economic value of competing uses for UHF spectrum (with Oliver & Ohlbaum).
- UK (2006) – Study for Ofcom on the economic and social value of releasing UHF spectrum for different uses, including mobile broadband technologies and HDTV. This included a study of candidate auction formats (with Analysys Mason and Aegis).
- Denmark (2006) – Advice to NITA on the introduction of new instruments in spectrum management, including auctions, trading and liberalization.
- UK (2004-06) – Advice to Channel 4 on responding to public consultations on radio spectrum issues, including trading, liberalisation and pricing.
- UK (2005) - A major report for Ofcom exploring the costs and benefits of liberalising spectrum for use by mobile services (with Analysys).

- European Commission (2004) – Senior economist in the team advising the Radio Spectrum Policy Unit on pan-European policy coordination of spectrum trading and liberalization (with Analysys and Hogan & Hartson).

- Norway (2004) – For the Telecommunications Ministry, an analysis of methodologies and recommendation on setting renewal prices for 2G licences.

Selected other projects:

- Australia (2012) – Advice to a gas pipeline owner on the use of auctions to promote more efficient use of scarce capacity

- UK (2012) – Part of a team peer reviewing Environment Agency proposals for an auction of subsidies to manage water pollution

- USA (2010) – Advice to a defendant in a litigation case concerning corporate procurement, and the interaction between procurement auction design, bidding strategy and competition.

- USA (2010) - Member of team implementing auction in New Jersey for Solar Renewable Energy Credits.

- USA (2010) – Member of team implementing auction for Penelec and Met-Ed to obtain supply for their retail customers in Pennsylvania.

- UK (2007) – For Channel 4, an investigation of future funding options for public service broadcasters.

- UK (2006) – For the Office of Fair Trading, a report investigating the role of bidding markets in competition assessment.

- Europe (2004) – For a European energy client, a briefing paper outlining the key steps and requirements to undertake an auction of electricity capacity.

- Europe (2004) – For a leading European cable operator, a review of competitive conditions in their respective markets including analysis of inter-platform competition and arguments for and against designation of cable operators with SMP.

- Netherlands (2001-03) – Advice to Shell on its response to the Dutch government proposals to auction usage rights to motorway petrol stations.

- UK (2003) – A major report on mass market broadband access and take-up for a forum of leading European telecoms operators and equipment manufacturers, analysing the current and prospective level of competition and drawing implications for regulatory policy.

- UK (2003) - For UK government agencies, projects on modeling demand for wireless broadband; and the use of hedonic pricing techniques to measure the benefits to Britain from regulation of ultra-wide band technology.

- New Zealand (2002) – For the Commerce Commission, member of a team advising on the new regulatory framework for telecoms following the new Telecommunications Act.
- UK (2001) - Study for HM Treasury on the scope for using market mechanisms in the allocation of airline slots at UK airports.

Publications

How Brussels Can Wire the Information Society (Springer, 2005)

with Maldoom, D., Sidak, J and Singer, H.J., XIV, 220 p., Hardcover, ISBN: 978-0-387-25386-2

A Gap in the Market: Technological barriers to entry in mobile spectrum markets (DotEcon Perspectives, Autumn 2010)

Fixed or Flexible: A survey of 2.6GHz spectrum awards (DotEcon, June 2010 with Sexton, E and Siong, A)

The first combinatorial spectrum auction: Lessons from the Nigerian auction of fixed wireless access licences (DotEcon, Sept 2003, with Koboldt, C and Maldoom, D)

Speeches and Presentations

1st The Americas Spectrum Management Conference (Washington DC, Oct 2011)

Co-founder and lead knowledge partner for the event; Presenter and chair of sessions on radio spectrum auctions.

GSMA Members Annual Spectrum Seminar (Armenia, Colombia, Sep 2011)

Presentations on New approach to spectrum auction design and case studies of spectrum auctions

6th European Spectrum Management Conference (Brussels, Jun 2011)

Advisor on the conference agenda; Chair for the sessions on spectrum auction design, and promoting competition in spectrum awards.

Radio Spectrum Strategies in Central and East Europe (Bucharest, May 2011)

Keynote presenter and chair for the session "Contest Design for Licensing the 800/2600 MHz Bands -- A Regional Approach." The panel examined European trends in licensing spectrum bands and implications for ten countries across the region.

5th European Spectrum Management Conference (Brussels, Jun 2010)

Advisor on the organiser on conference agenda; Presenter at pre-conference workshop on spectrum auctions; Presentation on European 2.6GHz auctions; Summariser/Presenter for conference wrap-up session.

European Digital Dividend Strategy, one-day policy forum (Brussels, Nov 2009)

Chair for the final session on "Where next? How do we move forward to allow Europe to reap the benefits of the digital dividend as soon as possible?"

Industry workshop on spectrum trading (Hong Kong, Sep 2009)

Presenting proposals on eligibility to trade, licensee rights and obligations, and addressing competition, windfall gains and other concerns about trading.

Industry presentation on roadmap for Europe's digital dividend (Brussels, Sep 2009)

Presenting the results of the study for the European Commission by Analysys, DotEcon and Hogan & Hartson titled "Exploiting the digital dividend: a European approach" to representatives of industry and regulators in Brussels.

4th European Spectrum Management Conference (Brussels, Jun 2009)

Presentation on "Technology-neutral auctions" and panellist for discussion on "Implementing a framework & instruments for flexible and efficient spectrum licensing & allocation".

SKMM Malaysia industry workshop on spectrum economics (Kuala Lumpur, Apr 2009)

Presentation on "Auction Design and Implementation: Why Auction Design and Spectrum Packaging Matter" and mock auction for participants using electronic auction system.

Future use of the UHF spectrum and impact on broadcasting (Brussels, Feb 2008)

Presentation to members of the European Parliament

Workshop on spectrum auctions for Telenor and affiliates (Oslo, Sep 2007)

Organising and running one-day workshop, involving presentations and participatory mock auctions for representatives of mobile companies from Europe and Asia.

1st European Spectrum Management Conference (Brussels, Jun 2006)

Panel chair and introductory presentation for session on “future use and change factors” in spectrum management.

Workshop on using market mechanisms in spectrum management (London, Apr 2006)

A one-day workshop involving presentations and participatory mock auctions for employees of the UK regulator, Ofcom.

CEPT Conference (Barcelona, Apr 2005)

Co-presenter (with Janette Dobson of Mason) on value-creation associated with introducing ultra-wideband technology.

Visiongain conference on spectrum liberalisation (London, Mar 2005)

Presentation on "Implications of Ofcom's approaches to liberalisation for businesses using spectrum"; Panellist for discussion workshop.

Industry workshop on Ofcom's policy on spectrum awards (London, Mar 2005)

Presentation on role of auctions in spectrum awards.

Public workshop on EC study on spectrum trading (Brussels, Jul 2004)

Co-presenter on options available for liberalisation of spectrum use and the implementation of spectrum trading and recommendations for action at the European level.

FCS Spectrum Forum (London, Jul 2004)

Presentation on the scope for spectrum trading to stimulate innovation in the development of wireless services and technologies.

14th ITS European Regional Conference (Helsinki, Aug 2003)

Paper on lessons from Nigeria's 2002 FWA auction of fixed wireless access licences. The Nigerian spectrum auction was the first of its kind to use a sealed bid combinatorial format.

Published reports (selected)

Exploiting the Digital Dividend – a European Approach (European Commission, Oct 2009)

Available at: http://www.analysysmason.com/EC_digital_dividend_study

The award of the UK digital dividend cleared spectrum (Ofcom, June 2008)

Available at: http://www.ofcom.org.uk/consult/condocs/clearedaward/

The effect of a Market-Based Approach to spectrum Management of UHF and the Impact on Digital Terrestrial Broadcasting (EBU, Feb 2008)

Available at: http://www.uer.net/en/union/news/2008/tcm_6-57750.php

Auction model and electronic system for the Dutch 2.6 GHz auction (Nov 2007)

Available at: www.rijksoverheid.nl

Preparatory study for UHF Spectrum Award (Ofcom, Dec 2006)

(including annexes on external value, spectrum packaging and auction design, and market and regulatory failures)

Available at: http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/

New instruments in spectrum management for Denmark (NITA, Aug 2006)

Available at: www.dotecon.com

Allocation options for selected bands (Ofcom, February 2005)

Available at: http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/band/

The use of auctions for spectrum assignment, implications for Sweden (PTS, May 2004)

Available at: www.dotecon.com

Value of ultra-wideband (UWB) personal area networking services to the UK (Dec 2004)

Available at:
http://www.ofcom.org.uk/research/technology/research/archive/cet/uwb/uwbpans/

Allocations options for the VHF band and L-band (Ofcom, Dec 2004)

Available at: http://www.ofcom.org.uk

Introduction of spectrum trading in Europe (European Commission, May 2004)

Available at www.dotecon.com

Spectrum management strategies for licence exempt spectrum (UK RA, Nov 2001)

Available at www.dotecon.com

Feasibility of airport slot auctions (DETR & HM Treasury, March 2001)

Available at: www.dotecon.com

NERA Economic Consulting
Level 16
33 Exhibition Street
Melbourne 3000
Tel: +61 3 9623 9800
Fax: +61 3 8640 0800
www.nera.com

NERA Australia Pty Ltd, ABN 34 092 959 665