EVANS & PECK

think through the future

National Emissions Trading Taskforce

Possible Design for a Greenhouse Gas Emissions Trading System

Further definition of the auction proposals in the NETT Discussion Paper

August 2007

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UPATED TERMS OF REFERENCE

The Terms of Reference of the National Emissions Trading Taskforce have evolved since this report was commissioned. The current details are available from the NETT's website at www.emissionstrading.net.au.

Accordingly, detailed discussion of some issues such as coverage including transitional arrangements, relevant at the time of the preparation and initial issue of this report, have been deleted from this version of the report to avoid confusion with subsequent work by the NETT in accordance with the updated terms of reference.

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ABBREVIATIONS

AGO	Australian Greenhouse Office
ARP	Acid Rain Programme
BAT	Best Available Technologies
CAIR	Clean Air Interstate Rule
COAG	Council of Australian Governments
CER	Certified Emission Reduction
CDM	Clean Development Mechanism
ETS	Emissions Trading Scheme
EPA	Environmental Protection Agency
ERU	Emissions Reductions Units
EUAs	European Union Allowances
EC	European Commission
EU	European Union
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
IPV	Independent Private Valuations
JI	Joint Implementation
NAP	National Allocation Plan
NEM	National Electricity Market
NETT	National Emissions Trading Taskforce
NETS	National Emissions Trading Scheme
NO_x	Generic term for mono-nitrogen oxides
RGGI	Regional Greenhouse Gas Initiative
TEEII	Trade Exposed Energy Intensive Industries
US	United States of America
UNFCCC	United Nations Convention on Climate Change

EXECUTIVE SUMMARY

NATIONAL EMISSIONS TRADING TASKFORCE

Ministers of State and Territory Governments in Australia have responded to the climate change challenge by establishing a National Emissions Trading Taskforce (NETT) mandated to develop a national emissions trading scheme (NETS). In 2006 the Taskforce released a Discussion Paper setting out a possible design for such a scheme and outlining a number of design propositions for further investigation and analysis.

The Discussion Paper proposes that emission permits be allocated through a combination of methods including free allocation to electricity generators, free allocation to trade-exposed energy intensive industries (TEEII) to compensate for rising electricity prices and auctioning of the remainder of the permits.

To inform the further definition of the auction proposals in the Discussion Paper the Taskforce engaged Evans & Peck to provide qualitative advice on a preferred auction model under which permits might be allocated.

Based on feedback from many stakeholders, and findings from continued analysis, State and Territory Governments agreed to expand the NETT's Terms of Reference. The NETT was asked to consider a scheme with broader coverage than that specified in its original Terms of Reference, and to investigate whether it was appropriate for a national emissions trading scheme to include other sectors – beyond the stationary energy sector – or to have economy-wide coverage

WHY AUCTIONING?

Theoretically there should be no difference in the market price and the final allocation after voluntary trade whether permits are allocated for free or whether they are auctioned because the need for permits does not depend on the way permits are allocated. However, the distributional effects are different and depend on how the auction revenue is used and who gets the permits allocated for free.

Macroeconomic efficiency will increase if revenues of the auction are used to reduce other distortional taxes.

From a microeconomic perspective, conducting auctions will positively affect efficiency because:

- An auction will award permits in line with individual incentives. A bureaucratic procedure, constrained by imperfect information, will result in inefficient allocation and will depend for success on a well functioning secondary market.
- A significant auction share will enhance dynamic efficiency by focusing management attention on the commercial issues of emissions and abatement.
- Early auctioning permits will generate early and transparent price signals, helping companies in their investment decisions.
- Auctions might reduce price volatility in new and illiquid markets.

- Transaction costs of an auction are less than those of negotiating free allocation.
- Free allocation to new entrants and closure rules might distort and reduce allocative efficiency.

AUCTION OBJECTIVES

The objectives of an auction for greenhouse gas emission permits are:

- Allocating permits efficiently to those who value them most;
- Discovering and revealing marginal abatement costs; and
- Raising public revenue.

Only a proportion of the total allocation of permits will be auctioned and so auctions alone will not be able to achieve an efficient allocation of all permits. . The free allocation of permits to TEEIIs will decrease efficiency since those companies will more than likely have no private use for the permits and will need to sell them. A well functioning secondary market will be vital for ongoing efficiency of the ETS.

By generating price signals, auctions reveal marginal abatement costs. Well designed auctions pool the beliefs of all participants regarding the future value of the permits and thus inform decisions on investments in abatement measures. Early and accurate price signals let emitters implement the least-cost abatement measures available.

Free allocation procedures provide no early abatement cost information.

Raising public revenue by auction is generally less counterproductive to economic activity than the dead weight losses caused by taxes on profits. Initial allocation methods in theory have no effect on the later output and pricing decisions of companies. However auctions have an advantage over free allocation in that they generate public revenue and offer the potential to reduce distortional taxes.

A BACKGROUND TO AUCTIONS

In a GHG emission permits auction, multiple homogeneous items are auctioned, being perfect substitutes for each other. Where permits of several vintages are traded, the items are no longer equal and the auction becomes more complex.

Establishment and concise description of the rules of an auction are important for its operation, as prospective bidders will adopt strategies based on the declared rules. In an **auction to buy**, the auctioneer buys from sellers. In an **auction to sell**, the auctioneer sells items to bidders. The latter is the nature of the proposed Australian emission permits auctions. The auction determines the clearing price.

In a **one-sided auction**, there is one seller. In a **two-sided auction** there are several buyers and sellers. The US SO_2 auction is an example of a two-sided auction; a stock exchange is another. In an emissions trading system if companies that have already received permits by free allocation can offer their permits in the same auction, the mechanism is a two-sided auction.

An **open auction** is characterised by an open, iterative bidding procedure in which bidders have the opportunity to take into account the information revealed by other earlier bids. Intra-round bidding allows bidders in each round to express a series of bids during one bidding round. In a **sealed-bid auction**, there is only one round of bidding.

In a single-unit auction, one indivisible item is auctioned. In multi-unit auctions several homogenous units of the same good are auctioned and in multi-item auctions several heterogeneous items are auctioned. For the sale of multiple units of homogeneous items, the **uniform-price auction** and the **pay-as-bid auction** are two formats. Emission permits can generally be thought of as homogeneous goods unless different vintages are considered.

When different vintages are to be sold, several auctions can be conducted **simultaneously** or in **sequence**. Alternatively, a **combinatorial** auction might be applied in which bidders can bid on combinations (bundles) of vintages.

Participants in auctions can have **independent private values** or a **common value** for the item. Some auctions are hybrids of both models. If buyers have independent private values, they each know exactly the worth of the item to them but may not know how much it is worth to others. For emission permits, this presumes quite extensive corporate knowledge of abatement costs, future demand, future output and their need for emission permits. If buyers have a common value for the item, the emission permit is worth the same to every bidder but no-one knows that value with certainty. The common value model would hold for similar power generators with the same abatement costs. Emission permits have a common value character if bidders participate only for speculation.

In an emission trading system both private values and common values can apply. For a permit of a particular vintage, the earlier the auction the more relevant is the common value model. The common value component diminishes as the reconciliation period for that vintage draws closer. In the secondary market it is the private value component of the permit that drives trade. A hybrid approach is most appropriate to model decision analysis in an ETS context.

PREVIOUS HISTORY OF EMISSION PERMIT AUCTIONS

THE ACID RAIN PROGRAMME IN THE USA

This auction system aimed to achieve reductions in annual emissions of SO_2 and NO_x from energy generating activities. The scope progressively widened from large coal-fired energy generators to include lesser coal, oil and gas generators. Most permits were free allocated, a small proportion was auctioned. Trading was activated by the auction. Auctions started in 1993 and comprised annual spot auctions and 7 year-in-advance auctions. The auctions are conducted as a two-sided sealed-bid pay-as-buyer-bid call auction. The auction is open to the public, as both buyers and sellers, with no limits on volume.

The auction design provided buyers and sellers with an incentive to 'shade', their valuation of the permits leading to an inefficient auction generating lower revenues than might have occurred. The auction set a more accurate early price signal than that from earlier studies. Spot auction prices closely approximated the prevailing price in the secondary market. The auction permit was influenced by the secondary market rather than the other way round.

Later, regulatory change rendered meaningless the earlier forward signals.

AUCTIONING NOX ALLOWANCES IN VIRGINIA

This program was designed to mitigate the effect of NO_x, a precursor of ozone depletion. Virginia decided to raise revenue by auctioning 5% of the state's total permits. The auctioned permits were not homogenous since they were comprised of different vintages. Of the various auction types assessed, the sequential English clock auction was selected so as to enhance participation. As a revenue raising exercise, the auction was successful. Implementation was rapid and operationally inexpensive.

UK ETS AUCTION

The EU ETS was launched in 2005. In advance of it, the UK established in 2002 the first economy-wide scheme to limit GHG emissions using emissions trading. An auction was run to allocate money against voluntary GHG emissions reductions. A descending clock auction with a permit price starting at 100 £/t CO_2-e proceeded in a series of rounds. Intra-round bids were used. At the end of each round the auctioneer determined whether there was an excess supply of emission reductions at the price point and proceeded until a clearing price was reached where no more supply of emission reductions was available at the price.

The auction design was intended to lead to an allocation of permits to a reasonable number of participants to avoid accusations of state aid, illegal under EU rules.

It successfully achieved broad participation with only one bidder constrained by a 20% cap. Higher reductions than initially forecasted were achieved. Market power was not exercised by any of the participants. However the auction performed poorly with regard to price discovery and may well have paid for reductions that might have occurred without the incentive. The importance of good baseline data was revealed.

EU ETS

Building on the Kyoto mechanisms, the EU established in 2005 a scheme for trading in emissions of GHG. It covers the emissions of more than 11,000 installations and 6,546 entities from the energy and most other carbon-intensive industries. It covers approximately half of the total EU emissions.

Each Member State is required to prepare a National Allocation Plan (NAP) which determines the total available permit volume (Emissions Trading budget) and specifies the allocation method across installations and entities. Four EU members (Denmark, Hungary, Ireland and Lithuania) decided to auction off small parts of their emissions budget. Of those four countries, only Ireland and Hungary have actually conducted auctions.

The Irish auction was intended to cover administrative costs of the scheme. A sealed-bid uniform price auction was used. Bidders submitted demand schedules. A non-disclosed reserve price was set. A qualification process was implemented requiring a deposit. Practical implementation lessons were learned regarding settlement period, size of deposit and implementation platform.

In Hungary, two auctions were conducted in order to finance the administrative costs of the emissions trading scheme. The auctions were operated at short notice, were uniform price in nature and conducted through an electronic platform.

In mid 2007 Germany announced an intention to sell or auction approximately 40 million CO_2 allowances per year during the 2008-2012 period of the EU ETS. Equal shares will be auctioned through the year, each announced at latest two months in advance and set so as not to overlap with auctioning in other member states. The announced intention is that auction rules should be objective, comprehensive, non-discriminatory and avoid any market power or collusion.

SUMMARY OF LESSONS LEARNED FROM HISTORY

On the basis of previous auctions:

- There is no experience of auctioning more than 5% of the total emission permits.
- The US Acid Rain Program is a useful reference as its aim was to improve efficiency of the scheme and ensure liquidity for new entrants rather than raising revenue.
- Early auctions are important to reveal marginal reduction costs.
- Changes in regulatory framework invalidate price signals of advance auctions.
- Ascending clock auction with intra-round bidding is feasible for auctioning emissions permits.
- Technical design lessons have been learned. For example security bonds need to be linked to settlement periods which should be short.
- Transparency of the auction process is important to ensure credibility.

ETS DESIGN AND AUCTION IN THE AUSTRALIAN CONTEXT

Auction design must consider coverage, cap, free allocation volumes, compliance protocols, international linkages, non-compliance penalties imposed and mechanisms for revenue recycling.

Coverage refers to the range of installations and/or operators that are liable for emissions and thus defines the companies which are potential auction participants as well as the volume of permits to be auctioned. Simple auction design will encourage participation of small emitters. Complex auction design increases the cost of participation and deters small companies. If the auction share of the total ET budget is small, fewer companies will tend to enter the auction since they are unlikely to acquire sufficient permits.

Abuse of market power is more likely to occur if only a small number of bidders participate. Collusion is more likely if there are relatively few bidders who are all from the same or similar sectors. Market power can exist either as an attempt to generate profits by understating demand and lowering the permit price, by overstating demand and increasing the price, or by cornering the secondary market to act as monopolistic supplier of permits. The Australian electricity market is not concentrated: the top companies each account for between 4.1% and 11.6% of the electricity and associated GHG emissions. The likelihood of collusion is very low. The wider the pool of potential auction participants, including speculators and intermediaries, the less likely is an effective collusive coordination of strategies.

Cornering the market will not be possible if offset credits are allowed through abatement in other sectors or international linkages recognising abatement in other countries. This would effectively cap the price on the secondary market.

If advance auctions are to be conducted they will need to be run on a regular basis using pre-determined auction dates so as to give companies enough time to prepare the necessary information for bidding. The first auction should take place before the start of the trading scheme but not before companies have started monitoring their emissions and are aware of potential abatement measures and costs. The streamlined reporting approach of COAG, still under development, will likely require that companies report their 2008/2009 emissions at the end of October 2009. Thus the first auction could be conducted in November 2009.

The latest date for the last auction of a specific vintage is just before compliance assessment, during a reconciliation period and during final disposition of the residual of the TEEII reserve which will only be known at the end of the trading year.

The reporting period should be linked to the Australian financial year and staggered relative to the EU ETS trading years. This will assist market liquidity if linking is permitted: small companies trade more for compliance and this happens usually at the end of a trading year during reconciliation periods.

The dates of the auction should be synchronised with auctions of related markets such as electricity settlement residues in Australia which are auctioned quarterly (August/ November/ February/ May).

A single advance auction is not recommended.

A mixture of spot auctions and some advance auctions of future vintages is appropriate.

Banking means that the vintage date determines only the first date on which permits can be used for compliance. After the vintage date of a permit has passed they all rank equally. Borrowing of permits is generally not allowed: the NETT advises that only 1% of the next vintage can be used for the preceding year.

Permits have only a limited compliance use before their vintage date. Permits which are of consecutive vintages are highly (though not perfectly) substitutable. A simultaneous auction format is appropriate if, as is the case in the proposed Australian ETS, units are highly substitutable.

Splitting the auction of permits for a vintage should allow for front-loading to allow companies the option of purchasing permits early and thus mitigating risk. This will also permit early secondary market trading without a risk premium, compared to future or forward trades. A short to medium term horizon suits existing generators so that auctioning is recommended to be 20% for each of three years and one year out from a vintage, plus quarterly spot auctions of 15% each during a vintage year. The residual of the TEEII reserve will be auctioned in the reconciliation period.

A penalty would work as a price ceiling: the auction price would not go beyond the penalty rate.

Recycling auction revenue might affect the bidding strategy of bidders and thus the efficiency of the auction. Recycling of the revenue should be independent and not include factors which would interact with the bidding strategy.

RECOMMENDED AUCTION TYPE AND DESIGN FEATURES

The recommended system for auctioning emission permits has the following characteristics:

- ascending clock auction with iterative sealed-bidding in multiple rounds;
- uniform pricing;
- aggregate demand revealed in each round;
- simultaneous auctions of different vintages;
- allow other recipients of free permits to sell these permits in the auction;
- allow proxy bids to accommodate small participants;
- internet auction platform; and
- review after three years operation

The recommended timetable can be summarised as follows:

Auction date Year	Qtr	Financial Year of Emission Permit Vintage 10/11	11/12	12/13	13/14	15/16	16/17	17/18	18/19
2009	Aug								
	Nov	20%							
2010	Feb								
	May	20%	20%		20%				
	Aug	15%							
	Nov	15%							
2011	Feb	15%							
	May	15%	20%	20%		20%	4 products available at auction		
	Aug	S_i	15%						
	Nov		15%						
2012	Feb		15%						
	May		15%	20%	20%		20%		
	Aug		S_i	15%					
	Nov			15%					
2013	Feb			15%					
after review	May			15%		20%		20%	
	Aug			S_i	15%				
	Nov				15%				
2014	Feb				15%				
after review	May				15%		20%		20%
	Aug				S_i	15%			
						etc			

An ascending clock auction is a simple procedure that is easy to understand. Implementation is web-based and transaction costs are low.

Uniform pricing scheme provides a strong signal regarding the participants' aggregated estimates of the future value of a permit and thus the economy's marginal abatement costs.

Revealing demand at the end of each round improves transparency and increases the information available to participants.

By allowing bidders to shift their demand from one vintage to another, a simultaneous auction offers the necessary flexibility to deal with highly substitutable items and picks up the advantages of the simultaneous multiple-round ascending bid auction.

If the government is the only seller of permits at an auction, only those companies, which have relatively high abatement costs have an incentive to participate in the auction. If bidders do not take this issue appropriately into account, the auction will be more competitive than the later secondary market and its closing price may overestimate the future development of the market price and the resulting allocation may be inefficient. Quantity available at auction can be increased by adopting a double auction extension.

This would potentially bring to the market the permits allocated to TEEIIs. These companies privately value emission permits at zero and will be net sellers.

Proxy bids provide a bidder the option of simply entering a demand curve at the beginning of the auction.

An internet bidding platform is recommended in which internet access as well as a standard web browser should be the only technical requirements. State-of-the-art security is now fully supported by the standard web browsers.

Since little experience with regard to auction timing, frequency and distribution of permits across auctions is available, the design recommendations should be reviewed after three years of implementation.

Intra-round bidding smooths out the ending and pricing rule by reducing the probability that more than one bidder becomes rationed. It allows the clock auction to be conducted more quickly, with minimal or no loss in efficiency. It has a partial downside of reducing the information feedback.

Auctioning and emissions trading are complex mechanisms where little experience yet exists. Laboratory tests are useful in coming to a better informed decision. Further research is required for intra-round bidding, simultaneous vs sequential multi-clock auctions, permit quantity and quantity distribution over time.

1 INTRODUCTION

Climate change resulting from human activity is one of the most pressing environmental issues facing the world's population. The magnitude of this problem requires that the international community works together to substantially reduce greenhouse gas (GHGs) emissions.

Economic growth will continue to drive increases in power consumption and corresponding emissions. Emission reductions to restrain climate change require policy instruments that specify and enforce targets. One such instrument is a cap and trade scheme, capping total emissions but facilitating trade of permits among companies, thus allowing for GHG emission reductions at a lowest achievable cost.

Ministers of State and Territory Governments in Australia have responded to this challenge by establishing a National Emissions Trading Taskforce (NETT), mandated to develop a national emissions trading scheme (NETS). In August 2006, the Taskforce released a Discussion Paper (NETT, 2006), which sets out a possible design for such a scheme. In February 2007 all Premiers and Chief Ministers of the States and Territories in Australia committed to introduce such a scheme by the end of 2010 if the Commonwealth refused to do so[1]. The Discussion Paper outlines a number of design propositions for further investigation and analysis.

The key to an emissions trading system is the commodity that is traded: the emission permit. Of critical interest are the mechanisms under which the emission permits are distributed to the covered installations of the private sector.

The Discussion Paper proposes that permits be allocated as follows:

- free allocation of some permits to electricity generators estimated to be adversely affected by the scheme;
- free allocation of some permits to trade-exposed, energy intensive industries (TEEII) to compensate for rising electricity prices, both existing and new installations; and
- auctioning of the remainder of the permits.

To inform the further definition of the auction proposals in the Discussion Paper the NETT engaged Evans & Peck to provide qualitative advice on a preferred auction model under which emission permits might be allocated.

This report discusses the potential designs of auction mechanisms to allocate emission permits in an efficient way and makes preliminary recommendations for the auction design for a NETS. Some of the auction design recommendations will need further investigation including by experiments.

In this report:

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[1] Communiqué by the Council for the Australian Federation, from a meeting held 9 February 2007, available at www.dpc.vic.gov.au .

- This Chapter 1 provides a background introduction to the report.
- Chapter 2 describes the general benefit of auctioning and sets out the objectives of the auction.
- Chapter 3 provides a short introduction to auction types.
- Chapter 4 describes international experiences to date on the auctioning of emission permits.
- Chapter 5 examines the interdependencies between the emissions trading design and auction.
- Chapter 6 recommends a preferred auction type.
- Chapter 7 discusses future actions to validate the recommendation with respect to the preferred auction type.

2 GENERAL BENEFITS AND OBJECTIVES OF AUCTIONING

This Chapter 2 identifies and discusses the objectives of an emission permit auction.

2.1 Why auctioning?

The NETT's Discussion Paper and the auction Background Paper[2] (2007, henceforth "Background Paper") propose that the majority of emission permits will be allocated for free with a minor portion allocated using an auction. We have not conducted a detailed literature survey of the relative merits of free allocation against auction allocation however some preliminary observations are worth noting.

According to theory there should be no difference in the market price and the final allocation after voluntary trade whether permits are allocated for free or auctioned.[3] This is because individual valuations and the need for permits, such as an individual's exposure to marginal abatement costs, do not depend on the way permits are allocated. However, the distributional effects are different and depend on how the auction revenue is used and who gets the permits allocated for free. If revenues of the auction are used to reduce other distortional taxes it is likely to increase efficiency from a macroeconomic perspective (so called double dividend effect, see e.g. Cramton and Kerr 2002).

From a microeconomic perspective, conducting auctions will positively affect efficiency for the following reasons:

- An auction awards permits in line with individual incentives. Conversely a bureaucratic procedure will not have available all the relevant information and is thus unlikely to result in an efficient allocation of permits and will depend for effectiveness on a well functioning secondary market.
- A significant auction share will bring emissions management and opportunities for abatement to the attention of top management. This is likely to increase the dynamic efficiency of the system.
- Auctioning permits (including future vintages) before the start of the scheme is a device well suited to generating early and transparent price signals and is likely to help companies in their investment decisions regarding abatement measures. This might also increase the dynamic efficiency of the system. In this context another question arises: which of the institutions (primary or secondary market) will lead to more robust price signals? Auctions (primary market) will reveal price signals. Bi-

[2] The National Emissions Trading Taskforce provided a background briefing paper to Evans & Peck with additional information to assist in preparation of this report.

[3] This is only the case if the free allocation mechanism has no "updating" element (allocation is independent of future output). If future allocation depends on future output there might be a paradoxical incentive to produce more emissions in order to get more permits allocated in the next phase.

lateral trading on the secondary market may not provide price signals as the prices might not be disclosed to anybody apart from those involved in the contract. However, other trading platforms of the secondary market such as over the counter trading and exchanges may also reveal price information.

- Auctions might also assist in new and illiquid markets to reduce price volatility, thus enhancing further investor confidence.
- Based on European experience, the transaction costs of negotiating the free allocation mechanisms – including all lobbying costs of industry – is expected to be relatively high compared to a simple auction mechanism. If policy makers can accept and implement auctioning notwithstanding substantial lobbying from industry groups in favour of grandfathering, lower transactions costs in the implementation stage will be achieved.
- Free allocation to incumbents will make it more likely that new entrants will be allocated permits for free or that permits are withdrawn after closure of a plant. The EU ETS has shown that free allocation to new entrants and closure rules have the potential to create distortions in the incentive structure which might reduce efficiency: free allocation acts like a subsidy for pollution encouraging too many companies to enter the market (Graichen and Requate, 2005); closure rules might motivate to keep polluting (Diekmann and Schleich 2006).[4]

The actual effect of auctioning and increase in allocational efficiency of the factors listed above will depend on the amount auctioned. If only small amounts are auctioned and the vast majority of permits is given out for free, allocational efficiency is likely to be relatively low compared to a situation where a substantial proportion is auctioned.

2.2 Auction objectives of the NETT

The Background Paper notes that achieving an efficient allocation of permits is the key objective of an auction. It also states that "*it will be important (…) that market prices or permits are accurately discovered*". Revenue maximisation, on the other hand, is not declared as "a primary goal of the proposed auction(s)".

For the purpose of this report, we assume that the objectives of an auction for GHG emissions permits are:

- allocative efficiency;
- discovery and revelation of marginal abatement cost; and
- raising public revenue.

The primary objective is to ensure that **permits are allocated efficiently**, meaning that they flow to the bidders who value the permits the most. To achieve this goal participation in the auction needs to be maximised so that any potential for abuse of

[4] If a closure leads to a stop in allocation, old plants may be operated too long and new investments postponed, since the opportunity costs of the closures are not accounted for properly. In fact, such a procedure subsidises output, since there are too many companies in the market.

market power is avoided. Moreover, efficiency is more likely to be achieved if the auction mechanism is simple and has low transaction costs for participants and the administrative body.

In contrast to allocation mechanisms which are based on historic emissions or benchmarks[5] or political objectives[6], an auction links the allocation to the bidder's willingness to pay as expressed in the auction. Since the auction bids are driven by an individual bidder's expected future value for the permits, it is probable that an auction allocates permits more efficiently than other allocation mechanisms as these do not take into account the costs of reducing emissions.

By generating price signals, auctions address the second objective: that of **revealing marginal abatement costs.** A well designed auction mechanism aggregates the beliefs of all participants regarding the future value of the permits and thus provides valuable information for decisions regarding investments into abatement measures. In fact the efficiency of an ETS as a whole is determined by the total costs to the economy for reducing its emissions and these costs are determined by the abatement measures implemented by the industry. It is crucial that the economy implements the cheapest abatement measures available. Due to the timing of investment decisions and trading on the secondary market, identifying the appropriate abatement measures is the most difficult and most important task. Later trading on the secondary market will then reflect the earlier investment decisions mixed with the more immediate effects of fluctuations in demand for electricity and other emission intensive goods as well as the actual weather.

In contrast, free allocation procedures do not provide any information to the market participants at an early stage with respect to abatement costs and consequently do not give any guidance on investment decisions.

Raising public revenue by means of an auction is generally less counterproductive to economic activity than taxes on profits that lead to so-called deadweight losses (cf. e.g. Ballard et al., 1985 or Feldstein, 1999). Since, at least theoretically, the method of initial allocation has no effect on the later output and pricing decisions of companies, auctions have the advantage over free allocation procedures in that they also generate public revenue and offer the potential to reduce distortional taxes.

At a workshop meeting in Sydney on 4th of April 2007, the NETT clarified the indications in the Background Paper noting that revenue maximisation, while not a primary objective of the auction design, is of some interest. Further, while revenue maximisation should not be pursued at the expense of efficiency, revenue does remain an important consideration.

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[5] Emissions per output.

[6] Such as subsidies to selected industry branches that are affected by an ETS.

3 A SHORT INTRODUCTION TO AUCTION THEORY AND AUCTION TYPES

The Discussion Paper proposes the distribution of emission permits into the economy using a combination of free allocation and auctions. The selection of an appropriate auction mechanism must take into consideration both the nature of the good being auctioned, the existence and scale of other allocation procedures of the same good as well as the characteristics of the prospective bidders.

In a greenhouse gas emission permits auction, multiple items are being auctioned. For emission permits of a particular vintage, the auctioned items are homogeneous meaning they are perfect substitutes. However, in an emissions trading scheme, permits of several vintages are being traded. The design of such a scheme must address the more complex issue of how permits of different vintages, which are substitutable only to a certain degree, will be auctioned.

This Chapter 3 provides an overview of various types of auctions and the principal conclusions of auction theory and lays the basis for assessing the suitability of particular auction designs in the Australian context.

3.1 Introduction

In general, any auction is governed by a set of rules, set by the auctioneer and should be constructed so as to achieve the objectives of the seller (see Section 2.2). In the Australian ETS, the primary objective of the auction is an efficient allocation of permits, meaning that the permits are allocated through the auction to the bidders who value them the most. Another objective is to reveal marginal abatement costs through auction price signals. The NETT has also indicated that maximisation of revenue, while not a primary objective, is also relevant.

Establishment and concise description of the rules of an auction are important for its operation, as prospective bidders will adopt strategies based on the declared rules. The rules of an auction are openly declared before the auction and cannot be changed once the auction has started.

In bidding at an auction, each bidder engages in competition with the other bidders. The strategic analysis of auctions and the interactions of bidders is a field of game theory. Bidders apply concepts of this theory to derive promising bidding strategies. The auctioneer uses the same tools to design, test, and implement an auction mechanism that best serves its objective, taking the strategies into account that bidders are likely to adopt given particular auction designs.

3.2 Auction types

3.2.1 Sell or purchase auctions

In an **auction to sell**, the auctioneer sells one or several items to one or several interested bidders. The goods change hands from the seller to the bidder(s) in exchange for payment from the bidder to the seller. This is the case for the proposed Australian emission permits auctions.

In an **auction to buy** (a procurement auction), the auctioneer offers to buy one or several items from several interested sellers. Again, the price is determined by the auction. The money, however, flows from the auctioneer to the bidding party.

3.2.2 One-sided or two-sided auctions

In a **one-sided auction**, there is one auctioneer who also serves as the seller (or the buyer in the case of a procurement auction). In a **two-sided auction**, on the other hand, there are several buyers and sellers. The US SO_2 auction (see Section 4.1.1) is an example of a two-sided auction; a stock exchange is another example.

If an Australian government auctions emission permits to companies, it is conducting a one-sided auction. If companies, that have already received permits by other allocation procedures or acquired permits on the market, can also offer their permits in the same auction, the mechanism is a two-sided auction. Secondary markets are often organised as a two-sided auction.

3.2.3 Open or closed bidding

Open auctions are characterised by an open, iterative bidding procedure in which bidders have the opportunity to take into account the information revealed by earlier bids. The most prominent open bidding procedure is the English auction (also called ascending-bid or oral auction) and its ascending-clock variant. In this auction type, the price is raised until only one bidder remains. The item is then allocated to this bidder at the final price offered. These auctions can be operated by a seller announcing prices, bidders calling out prices or electronic submission and posting of bids.

In **sealed-bid auctions**, there is only one round of bidding in which bidders simultaneously submit their bids without knowing the bids of other bidders. Examples are the first-price and second-price auctions[7]. In both formats, all bidders simultaneously and independently submit exactly one bid and the bidder who has submitted the highest bid is awarded the item. In the first-price sealed-bid auction, the item is sold at the price of the highest bid, whereas, in the second-price auction, the high bidder only has to pay the price of the second-highest bid. Subject to some assumptions both formats yield the same expected revenues. Relaxing these assumptions invalidates the general equivalence (cf. Section 3.4.1 for details).

[7] The latter format is also called a Vickrey auction.

3.2.4 Single-unit versus multi-unit versus multi-item auctions

In a **single-unit auction**, one indivisible item is auctioned. In **multi-unit auctions** several homogenous units of the same good are auctioned. In **multi-item auctions** several heterogeneous items are auctioned. All auction formats described above (English, first-price sealed-bid, second-price sealed-bid) are single-item auctions.

One common format of a multi-unit or a multi-item auction is a sequence of several single-unit auctions. Auction events conducted by auction houses fall into this category. The individual single auctions can fall under any of the single-unit auction formats. Variations arise when the valuations of the individual goods are interdependent (e.g. several pieces of antique china or furniture) or equal (e.g. sequential sale of several bottles of wine of the same vineyard and vintage).

For the sale of multiple units of homogeneous items, the **uniform-price** and the **pay-as-bid** (also called **pay-your-bid** or **discriminatory**) auction are two other formats which are widely applied, such as by central banks for selling treasury bills. The internet auction provider eBay also offers multi-unit auctions, based on the uniform pricing scheme (misleadingly called "Dutch" on ebay.org or "Powerauktion" on ebay.de).

In both uniform-price and pay-as-bid auctions, all bidders simultaneously submit demand schedules which consist of individual bids stating price and respective quantity that the bidder wishes to purchase. After collecting the bids, they are ordered by their unit price and the items are awarded to the respective bidders, starting with the highest bid, until demand equals supply. In a pay-as-bid auction, successful bidders pay the price of their bid for any unit they are awarded. This means that different bidders may pay different prices, and even an individual bidder may pay different prices for different units she acquires, as can be seen in Figure 3.1.

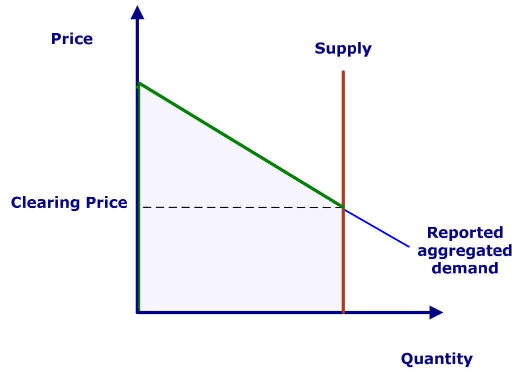

Figure 3.1: Pricing rule of a pay-as-bid auction

In contrast, in a uniform-price auction, all bidders pay the same price per unit (clearing price). This price is determined either by the lowest successful or the highest rejected bid, as seen Figure 3.2.

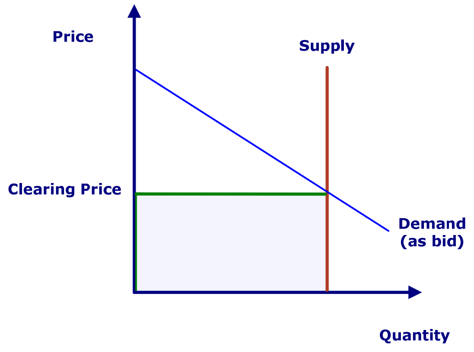

Figure 3.2: Pricing rule of a uniform price auction

In an emissions permit auction, multiple permits are auctioned. Emission permits can generally be thought of as homogeneous goods although non-homogeneities arise if permits for different vintages are considered. The auction formats described above can be used for permits of the same year. For auctioning different vintages, several uniform-price or pay-as-bid auctions can be conducted either simultaneously (as it has often been done for spectrum auctions, cf. e.g. Cramton, 1997) or in sequence.

Other multi-item auction formats are combinatorial approaches such as the generalised Vickrey auction (Cramton et al., 2006). In a **combinatorial auction**, bidders bid on packages of items, rather than just individual items. Broadly speaking, a combinatorial auction design is preferable if the auctioned items have strong complementary characteristics; however a simpler **simultaneous auction** format is better if the dominant characteristic is that the items can substitute for each other. For example combining the puppets 'Punch' and 'Judy' into a package of items would lead to a better outcome than auctioning them either sequentially or simultaneously.

3.2.5 The ascending clock auction

For auction of emission permits in an ETS context, the ascending clock auction is the most appropriate format and is discussed here in greater detail. It is relevant to note that the RGGI[8] proposes to adopt an ascending clock auction format.

An ascending clock auction resembles an English auction. Different to the open-outcry format often used by auction houses, in the ascending clock variant, it is only the auctioneer who controls the pace of the auction. Over several rounds, he announces a current price that he increases from round to round and the bidders indicate whether they are willing to acquire the item at this price. Once a bidder declines the offer in a particular round, she cannot re-enter the auction again in a later round. In a single-item application, the auction stops as soon as only one bidder remains and the price to pay is the price of either this last or the second to last round.

8 The Regional Greenhouse Gas Initiative is a cooperative effort of 9 Northeast and Mid-Atlantic states of the US for a proposed regional cap and trade program initially covering CO_2 emissions from power plants.

In a multi-unit extension, prior to the start of the auction, the auctioneer determines and announces the total available quantity (supply s) and a reserve price p_0. The auctioneer then opens the auction (t = 0) by inviting all bidders i = 1, 2, … n to each submit a bid $d_i(p_0)$ that specifies the quantity of units (demand) the bidder wishes to acquire at the reserve price. If the total demand is not larger than the total supply (i.e. $\sum_i d_i(p_0) \leq s$), the auction ends. All bidders receive the units they requested and have to pay the reserve price for each unit obtained. Any remaining supply is not sold.

If the total demand exceeds total supply, the auctioneer increases the price and opens a new round $t := t + 1$ of bidding. The new price is indicated by p_t. Again, the bidders respond by submitting their demand $d_i(p_t)$ at this price. This process continues as long as the total demand by all bidders exceeds the offered supply. As the announced *current price* p_t increases from round to round ($p_t > p_{t-1}$), bidders cannot increase their demand ($d_i(p_t) \leq d_i(p_{t-1})$). Thus, the total demand is sloping downward over the course of the auction.

The auction ends once the total demand is no longer larger than the supply being auctioned. If the total demand in the last round t^* exactly equals supply ($\sum_i d_i(p_{t^*}) = s$), then the final price p^* is set to the last round's current price ($p^* := p_{t^*}$) and all bidders i receive the quantity $d_i(p_{t^*})$ they requested in their last bid. Alternatively if total demand in the last round t^* is lower than the supply, the final price p^* is set to the price of the second to last round t^*-1 ($p^* := p_{t^*-1}$). Again, all bidders are awarded the quantity $d_i(p_{t^*})$ demanded in their last bid. In addition, the residual supply $s - \sum_i d_i(p_{t^*})$ is allocated to the bidders in equal proportions to the residual demand with respect to the bids $d_i(p_{t^*-1})$ in the second to last round. This means that a particular bidder j receives in addition to $d_j(p_{t^*})$ units an amount given by:

$$\left(d_j(p_{t^*-1}) - d_j(p_{t^*})\right)\frac{s - \sum_i d_i(p_{t^*})}{\sum_i d_i(p_{t^*-1}) - \sum_i d_i(p_{t^*})}$$ **Equation 3-1**

The following example illustrates the closing and pricing rule. Assume a total supply of 100 units is auctioned. There are two bidders A and B. In the second to last round A submits a bid of 70 units and B a bid of 40 units, and in the last round A bids 61 and B 34. Both bidders are awarded the quantities specified in their last bid. Since these bids add up to 95 units, there is a residual demand of 5 units. Based on the bids of the second to last round, A has a residual demand of 70 – 61 = 9 units and B a residual demand of 40 – 34 = 6 units and the total residual demand is 15. Thus 5 / 15 = 1/3 of the residual demand is served and A receives a total of 61 + 9/3 = 64 units and B a total of 34 + 6/3 = 36 units.

The above described closing rule ensures that the total supply is exactly allocated among the bidders. Moreover, no bidder is awarded more units than specified in the demand bid at the final price p^*.

Figure 3.3 illustrates the course of process of an English clock auction.

In many practical applications, a bidder's initial demand is restricted by her so-called bidding eligibility. The eligibility also defines the security the bidder has to deposit in order to be allowed to bid in the auction. An auction can, for example, rule that in order to become eligible to bid on x units in the first round, the bidder has to deposit a security of x times the reserve price p_0.

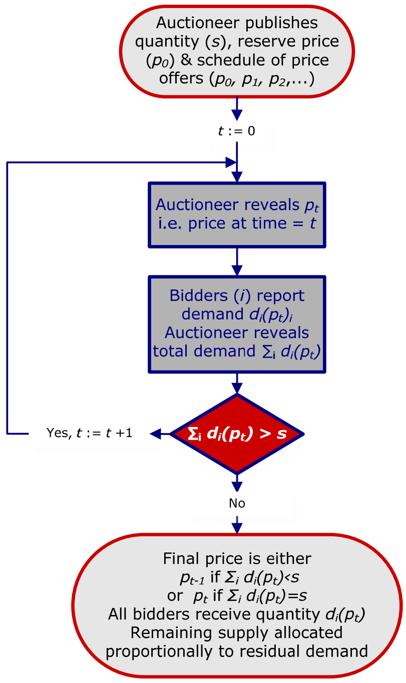

Figure 3.3: Process Flow - English clock auction

3.2.6 The simultaneous ascending clock auction for heterogeneous items

In the proposed Australian ETS, GHG permits will differ in the year (vintage) for which they allow the emission of GHG. At several stages of the ETS, particularly in the beginning, permits of different vintages will be allocated in parallel. This section describes an auction format suited to the auction of multiple units of several heterogenous items in one auction event.

Denote the different item (e.g. emission permit vintages) by j = 1, 2, …, m and the total supply of each item (vintage) j by s_j. For each item j, there is a separate clock that ticks in (pre-determined) price levels $p_0^j, p_1^j, p_2^j, \ldots$. These price levels can be different for different items. All bidders i = 1, 2, …, n have individual bidding eligibilities $e_1^j, e_2^j, \ldots, e_n^j$ for each item j. These bidding eligibilities define the maximum amounts for which a bidder may bid. Bidding eligibilities can be used as a means to effectively enforce bidding activity and to speed up the auction.

In the first round, all clocks start at their respective reserve prices $p_0^1, p_0^2, \ldots, p_0^m$ and the bidders i = 1, 2, …, n respond by reporting their demand bid $d_i^j(p_0^j)$ for each item j. At the end of the auction round, the total demand per item is determined and the clocks of all items in which total demand exceeds supply of this item tick to their next price level with all bidders again reporting their demand. This process continues as long as at least one clock ticks to the next price level.

When submitting bids in a particular round, each bidder *i* is constrained by the following rules:

- The bidder's total demand for a particular item may not exceed the respective bidder's eligibility for this item ($d_i^j(p_t^j) \le e_i^j \ \forall i, j$).
- A bidder's total demand for all items may never increase from one round to the next ($\sum_j d_i^j(p_t^j) \le \sum_j d_i^j(p_{t-1}^j) \ \forall j$).[9]
- If a clock did not tick to the next price level from the previous to the current round (i.e. the total demand for this particular item was lower than the supply of that item), any bidder, who submitted a positive demand bid for that item in the previous round, has to submit a demand for that item of at least the same amount in the current round.

The above rules allow in particular, that bidders may bid on any item irrespective of whether the respective clock ticked forward in the current round or not. They allow also that a bidder may increase demand for a particular item from one round to the next (subject to the bidder's initial eligibility for that item). This gives bidders the possibility to shift demand from one item to another if either of the items meets their needs. Thus, the simultaneous ascending clock auction is well suited for auctioning heterogeneous items which have strong substitutive characteristics which is the case for emission permits of closely adjacent vintages.

3.2.7 Proxy bidding

With the advent of online bidding platforms, the concept of proxy bids has become very popular. With proxy bidding, a bidder can delegate bidding actions to the system. Rather than entering the bids themselves, bidders specify rules according to which they wish to bid. The system places the bids on their behalf. A well-known example is the online auction provider eBay: on eBay bidders specify maximum bids and the system then bids for each bidder up to the maximum specified amount in a mechanism that is similar to an English auction.

3.2.8 Intra-round bidding

Another recent development in electronic auctions is intra-round bidding. In emissions trading it has successfully been implemented in the UK ETS auction (c.f. Section 4.2.1).

The goal of intra-round bidding is to smooth out the ending and pricing rule by reducing the probability that more than one bidder becomes rationed. Intra-round bidding effectively minimises the impact of the bid increment as the auction's closing price is

[9] Depending on the characteristics of the items, some transformation rules might be applied in order to make demand for different items comparable. In the context of a permit auction, where all bids express quantities in terms of tons of CO_2, such rules are not necessary.

determined by one of the bids rather than the price schedule determined by the auctioneer.

Intra-round bidding allows the clock auction to be conducted more quickly, with minimal or no loss in efficiency. The potential downside of the intra-round bid approach is that by reducing the number of auction rounds the information feedback through the auction process is also reduced.

The impact of intra-round bidding can be illustrated by an extreme example: consider an ascending clock auction with an initial reserve price of zero and a bid increment that is larger than the highest valuation. Without intra-round bidding the auction stops in the second round in which no bidder submits positive quantities. The auctioned items will then be allocated to the bidders proportional to their first round bid at the reserve price of zero. However allowing for intra-round bids, the auction becomes basically equivalent to a static uniform-price auction. Efficiency is high and the auctioneer's revenue is positive, although in this extreme example there is no additional information feedback that might help the bidders refining their bidding strategies.

Consider again the numerical example from Section 3.2.5, in which a total supply of 100 units was auctioned. Two bidders *A* and *B* submit in the second to last round bids of 70 units and 40 units, respectively. In the last round *A* bids for 61 and *B* for 34 units. Assume the price in the second to last round was $40 and that of the last round was $50. Without intra-round bidding, *A* receives 64 units and *B* 36 units each for a price of $40. Assume now that intra-round bidding is allowed. Let, for example, *A* submit in addition the following (price, quantity) intra-round bids: ($44, 68), ($48, 64). Then the final (uniform) price would be set to $44. Based on their quantities in the last round, *A* receives 61 units and *B* 34 units. The residual supply of 5 units is allocated to the intra-round bids, starting with the highest. Thus, *A* receives the remaining supply of 5 units due to her intra-round bid.

3.2.9 The ascending clock double auction

In Chapter 6 a double (two-sided) auction extension of the ascending clock auction will be recommended. This is based on a premise that not only the government, but also companies with an excessive endowment of permits may sell their permits in the auctions.

In an ascending clock double auction, before buyers start bidding, all participants that wish to sell items in the same auction are invited to submit a supply curve indicating the quantity they wish to sell at various prices. As in a multi-unit procurement auction (refer to Section 3.2.4) these supply schedules consist of sell offers $s_i^j(p_t^j)$ which specify the quantity of the item j, that the respective seller i is willing to sell at the price p_t^j or higher. The auction then works as in the one-sided case, but the aggregate supply curve is no longer vertical: now, total supply increases for higher prices. In order to avoid complicated strategic bids, the individual supply functions must be sloping upward and a participant who offers to sell a certain quantity at a particular price, may not submit any demand bid at this or a higher price. The non-vertical aggregate supply curve improves the performance of the auction by reducing incentives for demand reduction (c.f. Section 3.4.4).

The process of the auction itself is very similar to the one-sided simultaneous ascending clock auction. The only difference is that the supply is not constant, but may increase during the course of the auction. Total available supply will be announced at the beginning of each round.

Due to the increasing supply, the pricing and allocation rule must be slightly adopted to deal with the double auction setting: as before, the auction ends once total demand no longer exceeds total supply. If the total demand in the last round t^* exactly equals the total supply, then the final price p^* will be set to the last round's current price ($p^* := p_t^*$). In this case, all bidders receive the quantity $d_i(p_t^*)$ they requested in their last bid and all suppliers sell the quantity $s_j(p_t^*)$ they offer in their last bid. In the event that the total demand in the last round is lower than the supply, special rules apply that determine the final price p^* in the interval between the price of the last round p_t^* and the price of the second to last round p^*_{t-1}, depending on the development of the demand and supply in the last two rounds.

3.3 Modelling the information available to bidders

Auctions are generally applied if the auctioneer is not completely informed about the bidders' valuations of the items being auctioned. In this case, the bidders may not know how much the items are worth to other bidders and it is quite feasible that an individual bidder may not know exactly how much the item will be worth to her. Thus, incomplete information is a key characteristic of almost any auction environment.

Incomplete information also holds for the case of auctioning emissions permits. If the government knew the exact value of permits to the emitters of CO_2 (i.e. the actual abatement costs), there would be no need for an auction. In fact, a tax would possibly be easier to implement and achieve the same goals. However knowledge of abatement costs is imprecise.

For the analysis of auctions, two basic models regarding the bidders' information have evolved. The approaches of the two models are very different and a real auction environment typically has characteristics of both of them.

3.3.1 The independent private values model

Participants in auctions can have **independent private values** (IPV) or a **common value** for the item.

If buyers have independent private values, they each know exactly the worth of the item to them but may not know how much it is worth to others. Rather they assume that the other bidders' valuations will be random within a predictable distribution. Moreover, all valuations are considered independent. This means that the knowledge of one valuation does not impact the estimation of the other valuations.

In the context of emission permit auctions, the IPV model applies if all companies know how much an emission permit is worth to them. This implies that they know exactly their abatement costs, being the costs they have to bear in order to reduce their emissions. If the IPV holds, the companies would also need to know the future demand for their products, which determines their output and consequently their need for emissions permits.

The IPV model allows that the abatement costs of all auction participants may be different. This reflects the fact that different companies may produce different goods or apply different technologies or have a different investment cycle. Emission abatement will incur different costs for different companies.

3.3.2 The common value model

If buyers have a **common value** for the item, the emission permit is worth the same to every bidder but no-one knows that value with certainty. Rather, they only have estimates of this value.

For example the common value model may hold if all participants in an emissions permit auction were similar power generators that all have the same abatement costs. In such a case, the valuations for permits would be equal among all bidders. Uncertainty regarding the value would arise if the abatement costs were unknown. This could be the case, for instance, if the cost of measures to increase efficiency, or the future price of an alternative fuel, or simply the future demand for electricity were unknown.

A permits auction also has a common value character if bidders participate only for speculation, i.e. for reselling the permits later, but not for the purpose of using them themselves. The value of a permit is then its future market price which is unknown at the time of the auction, but identical for all bidders.

3.3.3 Modelling information structures in the Australian ETS

The examples in Sections 3.3.1 and 3.3.2 indicate that features of both, the private values and the common value model, apply in an ETS. Thus, a hybrid approach which combines aspects of both models is most appropriate to model decision analysis in an ETS context. A hybrid approach also allows for correlated abatement costs.

For the auctioning of a permit of a particular vintage, the earlier the vintage is auctioned compared to its first permissible use date, the more relevant is the common value model. In an early advance auction, for example, the common value component of a permit is high as traders have many outside options to either acquire or sell the permit later in another auction or the secondary market. As a consequence, the proposal for an auction design should take into account issues related to auctioning common value items.

The common value component diminishes as the reconciliation period of a vintage draws closer. In the secondary market it is the private value component of the permit that provides the incentive for participants to trade. If, in a secondary market, the permits had a purely common value, then the so called no-trade theorem (Milgrom and Stokey, 1982) would apply and no trade would be observed.

3.4 Selected auction phenomena

3.4.1 Revenue equivalence

The Revenue Equivalence Theorem states that if the independent private values model applies, and if all bidders are symmetric and risk neutral, then all efficient single-item auctions generate the same expected revenues (e.g. Myerson, 1981). As noted in Section 3.2.3, this particularly holds for first and second-price sealed-bid auctions as well as for English auctions.

However if the assumptions (IPV model, symmetrical, risk neutral bidders) do not hold then the revenue equivalence theorem also no longer holds and any ranking of auction formats with respect to revenue is not possible. With risk averse bidders, for example, a first-price auction yields higher expected revenues than a second-price auction (Krishna, 2002, 38), but the reverse is true when valuations are interdependent (Krishna, 2002, 97).

In theory, the revenue equivalence theorem extends to multi-unit auctions. Any two multi-unit auction formats that result in the same allocation raise the same expected revenue (Krishna, 2002, pp. 199f). For example if both uniform and the pay-as-bid auctions result in an efficient (and thus identical) allocation, expected revenues under each auction format will also be identical.

In practice the assumptions of the revenue equivalence theorem (risk neutral and symmetric bidders with independent private valuations) generally do not hold. In addition the allocations resulting from the various multi-unit auction formats are typically not the same. As a consequence identical revenues cannot be expected. It is not even possible to rank auction formats by expected revenues. Both the efficiency of the resulting allocation and the revenues depend on the distribution of valuations and the characteristics of the bidders. Examples can be constructed such that any ranking of revenue is possible (Ausubel and Cramton, 1998, 2002).

3.4.2 The linkage principle

Whereas the Revenue Equivalence Theorem applies to auctions with independent private values, the linkage principle deals with auctions in which the auctioned item has some common value component. In this case, it is natural to assume that if one bidder has a high signal (information or estimate) regarding the true value of the item, it is likely that the other bidders' signals are high as well and that the item's true value is also high.

Analysing single-item auctions, Milgrom and Weber (1982) show in general that for such situations revenues are increased by the publication of information which is linked to the (unknown) value of an auctioned item. Thus for example, according to theory, a single-item English auction raises higher revenues than a second-price auction if valuations are interdependent.

In an ETS environment it is likely that if the abatement costs of one company are high, then the abatement costs of other companies will also be high. In such an environment the linkage principle is relevant. Even though care should be exercised when drawing analogies between single-unit and multi-unit auctions, the linkage principle suggests that an open auction format which reveals as much information as possible during the course of the auction raises more revenue. From the perspective of the auctioneer it is thus preferable to a sealed bid approach.[10]

For example compare a static uniform price auction introduced in Section 3.2 against an ascending clock auction. Ignoring bid increments and assuming that after each round the auctioneer only indicates whether total demand exceeds supply or not, the ascending clock is simply a dynamic implementation of the uniform price auction in the sense that it allows for iterative bidding. The strategic situation of a bidder, however, is similar in both auction formats and a bidder's strategies in the two formats can be characterized by the same bidding or demand schedule. In game-theoretical wording, the two formats have the same normal-form representation and lead to the same resulting allocation and revenues.

Clearly, the policy of publishing the total reported demand at the end of each round reveals more information than the policy of advising only whether demand exceeds supply. Thus, one can conclude that with common value components the former format raises higher revenues than the latter and consequently an ascending clock auction is likely to raise higher revenues than a static uniform price auction.

3.4.3 Winner's curse

The winner's curse may occur in auctions if bidders have incomplete information regarding the actual value of the auctioned item, as it is the case e.g. if the common value model applies. Examples comprise auctions for drilling rights (the amount of oil in that particular tract of land, the cost of extraction or the future market price of the oil may not be known), mobile communication licenses (unknown success of future services), or – for illustration purposes – the auction of a jar filled with coins. This may also apply for auctions of CO_2 emission permits. In such a situation, bidders have to *estimate* the actual value. If estimates are roughly approximate on average, some bidders will under- and some bidders will overestimate the true value of the item.

Consider the auction of the coin jar. Assume that all bidders can look at the jar, shake it or weight it in their hands, but may not open it and count the coins. Bidders will then submit bids based on their estimate of the total value of the coins. Obviously, a bidder's bid will depend on this estimate and, as a general tendency, the higher the value estimate of the bidder is, the higher the bid will be. By awarding the item to the bidder with the highest bid, the auction mechanism effectively selects the bidder who has the highest estimate (or one of the highest estimates) of the true value. This bidder is likely to have *over* estimated the true value. If the bidder fails to sufficiently shade her bid, she might not only have overestimated the value but even find herself paying more for the jar than the coins are actually worth. This is called the winner's curse.

[10] In fact, the linkage principle does not hold without restrictions for multi-unit auctions. Some negative results are summarised by Wolfstetter (1999, p. 235).

Despite its empirical existence, the winner's curse is a strategic mistake by the bidders. It arises only if bidders fail to take into account that winning the auction will also reveal that the winning bidder had (one of) the highest estimates of the true value of the item.

According to theory, the winner's curse should not occur. Bidders know in advance that if they are awarded the item, they have the highest value estimate. Thus, they would not determine their bid based on their simple, individual estimate of the true value, but on a corrected estimate which takes into account that, if the bidder wins the auction, the estimates of all other bidders are lower.

A rational bidder avoids the winner's curse in an auction by accordingly adjusting her bid downwards (Wilson 1969). Before submitting her bid, the bidder must ask herself: "How would I change my estimate if I knew that my estimate was the highest among all bidders?". The actual bid will then be based on the adjusted value estimate.

If bidders are aware of the winner's curse and are risk averse, an additional issue might arise: in order to avoid the winner's curse they may bid even more defensively than described above. Since the actual value of the auctioned item is unknown, a risk averse bidder deducts an additional risk premium when deciding on her bidding strategy. Thus, rather than enjoying high revenues, the auctioneer may even suffer from low revenues due to the existing risk of the winner's curse. In order to avoid defensive bidding strategies and such low revenues, it is in the interest of the auctioneer to reveal both prior and during the auction process as much information as possible regarding the true value of the item.

3.4.4 Strategic demand reduction

In environments in which multiple units are being auctioned, large bidders may have an incentive to shade their demand by reporting demand schedules below their true valuations. The bidder then risks getting fewer units compared to reporting her true demand. At the same time, however, the bidder also reduces the market clearing price and thus pays less for all the units she still wins (Ausubel and Cramton, 2002).

Uniform price auctions are particularly vulnerable to demand reduction if few, large bidders dominate the auction. In such a case, the resulting allocation is inefficient.

3.4.5 Reserve prices

Reserve prices define the minimum price that has to be paid in order to obtain an item. Bids below the reserve price are not accepted.

Reserve prices are appropriate means for the auctioneer to raise expected revenues, to speed up the process of an open auction and to protect against collusion.

A possible downside of implementing high reserve prices is a loss in efficiency in the event that permits are not allocated because the reserve price exceeds bidders' valuations.

3.4.6 Collusion

Collusion refers to an implicit or explicit agreement by bidders to coordinate their strategies and to bid defensively in order to keep the auction price low. Technically, bidders collusively shade their bids below equilibrium bidding strategies and thereby reduce the level of competition. Successful collusion by bidders may not only result in low revenues, but potentially also in inefficient outcomes.

Different auction formats vary in their vulnerability to collusion. Generally, sealed-bid formats are a more robust defence against collusion than open bidding procedures. The reason for this is that in a sealed-bid auction, the bidding behaviour of the other bidders cannot be observed and coordinated strategies cannot be enforced within the auction. However in repeated settings this distinction is less important.

3.4.7 Revelation of information

Auctions are often used when the auctioneer lacks precise information on the value or cost of an item. The auction process, if appropriately designed, can elicit the true market value of the item. In the embryonic stages of a carbon market, the early revelation of the marginal cost of carbon abatement, as represented by the marginal cost of an emission permit, is highly valuable for shaping company behaviour and investment.

4 CONTEMPORARY EXPERIENCES IN DESIGN AND IMPLEMENTATION OF AUCTIONS

This Chapter 4 assesses experiences with auctions of environmental goods such as emission permits or emission reductions. The focus is on environmental auctions in similar contexts since emission permits have very specific characteristics (e.g. vintages, banking, compliance periods) compared to other goods (electricity, bonds, spectrum licenses etc.) which need special provisions. Lessons learnt in auctions of other commodities are difficult to reliably transfer and sufficient is written and readily available elsewhere. Experience with other auctions has been taken into account where appropriate in the recommendations although they are not evaluated in detail in this report. Only environmental auctions are reviewed in detail: the main lessons learnt are extracted and general conclusions drawn. These lessons form the basis of review in subsequent chapters of the ETS in the Australian context.

4.1 Emissions

4.1.1 Auctioning of SO_2 permits in the Acid Rain Programme

The Acid Rain programme (ARP) is a two phase programme implemented in the United States of America, and aims to achieve reductions in annual emissions of SO_2 and NO_x from energy generating activities. Phase I (1995-1999) included coal-fired energy generators with a capacity greater than 100 MW. Phase II (since 2000) included all coal, oil and gas generators with capacity greater than 25 MW (EPA, 2006)[11]. Each participant was allocated 97.2% of its emissions in permits. The remaining 2.8% was withheld and auctioned to activate trading and ensure accessibility for new entrants.[12] The auction revenue was redistributed among the participants from whom the permits were withheld. The auction forces participants to sell a minimum of their permits, but does not generate revenue for the government. The first auction was conducted in 1993 by the Chicago Board of Trade[13] and comprised a spot auction (permits for compliance in the same year) and two advance future vintage auctions (permits effective in six or seven years). Since that time, spot and 7-year advance auctions have been held every March.

The enabling legislation included some details on the auction specifics, which interpretation lead to a unique auction design: a two-sided sealed-bid pay-as-you-bid call auction[14]. Potential sellers submitted sealed offers indicating the minimum price they were willing to accept for the permits. The reserve asking price for the withheld allowances was set to zero by EPA. Potential buyers submitted a sealed bid indicating the maximum price

11 www.epa.gov/airmarkets/trading/factsheet-auction.html

12 Under the US Acid Rain programme permits are issued 30 years in advance (Cramton and Kerr 2002).

13 The Chicago Board of Trade (CBOT) administered auctions up to 2006 without being compensated by US Environmental Protection Agency (EPA) for its services or allowed to charge fees. In 2006 the administration of this auction passed from the CBOT to the EPA.

14 This is a call auction, since the market is "called" and trades are executed for all units with bids exceeding asks at a specific, pre-announced time.

they were willing to pay-for the permits. The auction was open to the public, as both buyers and sellers, with no limits on volume. Participation was conditional on bids being submitted no later than three business days prior to the auction and inclusion of either a wire transfer, certified cheque, or letter of credit for the total bid cost (EPA, 2007).

For each vintage year, all of the selling offers were ranked in descending order. For the same year, bid prices for the permits were ranked in ascending order. Permits were then allocated by matching the lowest selling offers with the highest bid prices. The price is determined by the buyers bid. The clearing prices quoted in the following are the lowest prices at which a successful bid was made.

Carson and Plott (1996) assessed the EPA auction experimentally and concluded that the auction design provided buyers and sellers with an incentive to under-report their valuation of the permits. As a result market prices were biased downwards; the auction was inefficient and generated low revenue. This was a consequence of the EPA rules under which the seller with the lowest asking price is matched to the highest bid. Under those rules sellers have an incentive to ask according to a "jump model" and buyers to bid according to an "elbow model", as seen in Figure 4.1.

Where lowest selling prices are matched with highest bids, a strategy of asking a low price maximises the potential for the largest profit. Sellers will offer permits at the lowest possible price until the expected clearing price is reached. In the example in Figure 4.1 the clearing price is 220. Sellers which value the permits, perhaps because they have marginal abatement costs equal to or lower than 220, will ask 1¢ (being the smallest possible increment) in order to be matched with the highest buyers. Only sellers with a valuation higher than 220 will ask any price above 220+1¢, thus the price jumps from 1¢ to over 220+1¢ (jump model).

On the other hand buyers with abatement costs higher than the clearing price will attempt to bid as close as possible to the expected clearing price to avoid paying a higher price for the permits. In the example in Figure 4.1 the buyer with a valuation based for example on marginal abatement costs above 220 has an incentive to bid exactly 220+1¢. With a valuation equal to 220 they will be indifferent and might bid 220. With a valuation below 220 they can bid any price below 220, since they can be sure the bid won't be matched: the shape of the curve has similarities to an elbow.

The experimental results which compare the unique EPA auction design with a more common uniform price auction indicate that under a uniform price auction, traders would have an incentive to bid closer to their true values as it is the bid of the marginal trader that determines the price[15]. This comparison also revealed that under the specific EPA design, efficiency does not increase over time as it does under the uniform price auction.

Finally, the chosen design is also less responsive to, and slow to recover if affected by, changes in underlying market conditions (Carson and Plott 1996).

[15] Neither uniform nor pay-as-bid auctions prevent bid shading.

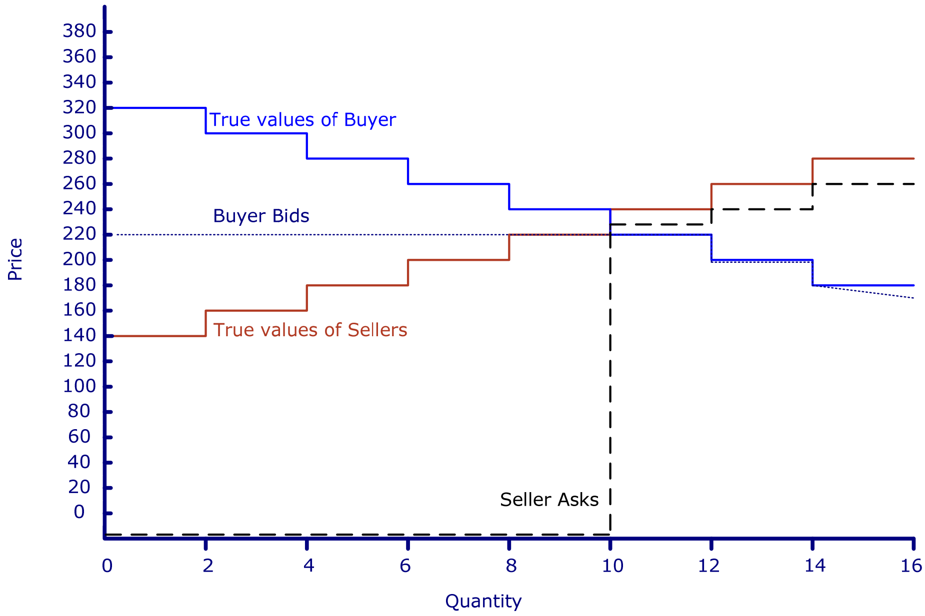

Figure 4.1: Elbow and jump strategies for EPA auction (periods 1-16)

Source: Evans & Peck after Carson and Plott, 1996

4.1.1.1 Efficiency of scheme

A more recent analysis indicates that the inefficiencies arising from the EPA auction design did not have a major impact on the efficiency of the SO_2 scheme as such (Ellerman et al., 2000). The authors attribute this to the minor role the auction played in the system: the auction was not used as a major trading platform.

Table 4-1: Number or permits auctioned and secondary market liquidity in ARP

1	2	3	4	5	6	7	8	9
Year	EPA's supply (withheld permits) at spot auction	Private supply at spot auction	EPA's supply at 7 yr. Advance auction	Private supply at advance auction	Internal trade secondary market	External trade secondary market	Total trading volume at secondary market	Auction from total volume traded
1993/95	50,010							
1994	50,000	58,001	100,000	47,000	8,300,000	900,000	9,200,000	3%
1995	50,000	600	100,000	400	14,800,000	1,900,000	16,700,000	1%
1996	150,000		100,000		3,800,000	4,400,000	8,200,000	3%
1997	150,000		125,000		7,300,000	7,900,000	15,200,000	2%
1998	150,000		125,000		4,000,000	9,500,000	13,500,000	2%
1999	150,000		125,000		12,500,000	6,200,000	18,700,000	1%
2000	125,000	-	125,000		12,300,000	12,700,000	25,000,000	1%
2001	125,000	2,788	125,000	2,388	9,900,000	12,600,000	22,500,000	1%
2002	125,000	2,388	125,000	2,388	9,800,000	11,600,000	21,400,000	1%
2003	125,000	10	125,000		8,400,000	8,100,000	16,500,000	2%
2004	125,000	11	125,000		Not available	Not available	-	-
2005	125,000		125,000		Not available	Not available	-	-
2006	125,000		125,000		Not available	Not available	-	-.
2007	125,000		125,000		Not available	Not available	-	-

Comment: Volume of auctioned permits is assumed to be included in external transfers

Table 4-1 can be used to interpret the actions of market participants.

Column 3: Private sellers mainly used the auction as a trading platform in the early years before a secondary market had evolved.

Column 6: The trading activity on the secondary market indicates that substantial transfers took place between economically related organisations.

Column 7: Trading between economically unrelated organisations became more relevant over time.

Column 9: Subsequently, permit trading occurred predominately in the secondary market, with only 1-3% of being auctioned.

4.1.1.2 Effectiveness of price prediction

The clearing price for permits in the first auction (1993) was equal to $US131/tonne. This was much lower than that predicted by previous studies of compliance cost, by earlier bilateral trades or by estimates of experts, which approximated $US300/tonne. Thus, the auction was important in setting a more accurate early price signal than the signals received from revealed information of early bilateral trades, which were based on expert studies which overestimated the marginal abatement costs (Montero and Ellermann, 1998).

As seen in Figure 4.2, as time progresses, the spot auction clearing price closely approximates the prevailing price in the secondary market. The permit price in the EPA auction was influenced by the secondary market rather than the other way round. The downward price bias resulting from the low seller's offers did not influence the operation of the EPA auction as prices were in fact set by the buyer bids at current secondary market prices (Ellerman et al., 2000). Although prices fluctuated in the first few years reflecting price uncertainty, prices seldom exceeded $US200/tonne in the first 10 years of the programme.

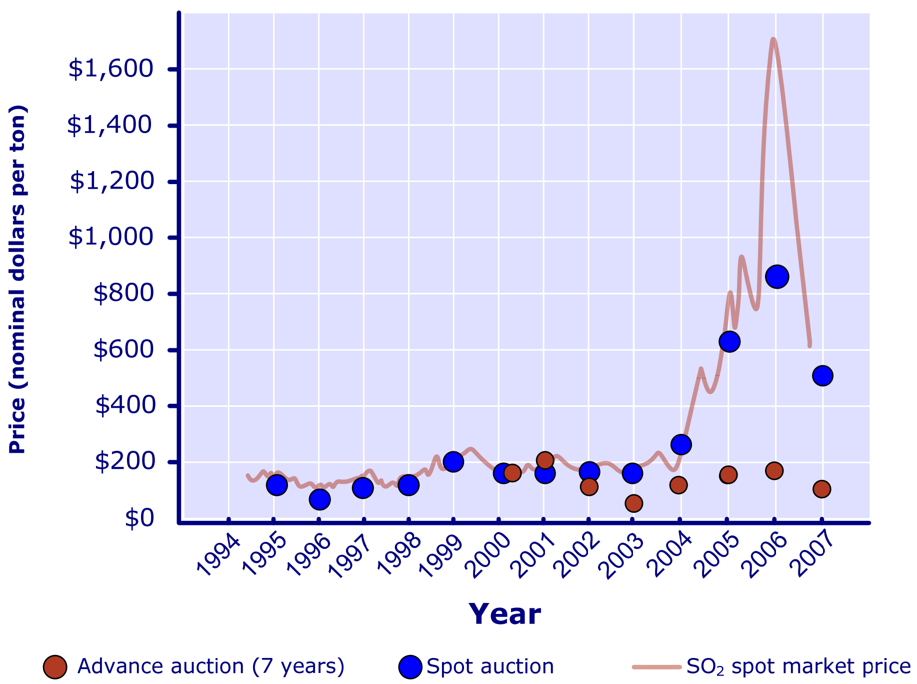

Figure 4.2: Spot and 7 year advanced SO_2 permit prices from 1994 – 2006

Source: Evans & Peck after www.epa.gov/airmarkets/progress/docs/2005report.pdf

4.1.1.3 Regulatory uncertainty

From 2004 to 2006, secondary market prices increased rapidly, reaching a peak of $US 1,600/tonne in 2006. This price increase resulted from the Clean Air Interstate Rule (CAIR) which increases the stringency of the scheme caps[16].

It can be seen that the advance auction was reasonably effective in predicting the future trend of prices until the CAIR came into force. From that point on the future vintage prices, established prior to the regulatory change, were meaningless as predictors of future secondary market prices. A stable regulatory framework is important to create efficient price discovery.

The following conclusions, relevant to the Australian NETS, can be drawn from the Acid Rain Program:

- Although auctions are able to create early price signals, the quality of a price signal from an advance auction depends on the stability of the future framework in which the scheme operates.
- Small annual auctions seem to loose importance over time and are quickly dominated by the secondary market.
- It is feasible to allow companies allocated free permits to sell these permits at an auction in order to increase and facilitate generation of price signals.
- Enabling legislation needs to be carefully worded to ensure that the design of the auction is left to experts and only the objectives of the auction are determined.
- It is important to test an auction design by experiments before implementing it, to ensure that the specific design meets the declared objectives.

4.1.2 Auctioning NO_X Allowances in Virginia

In October 1998, the EPA finalised the "Finding of Significant Contribution and Rule-making for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone"—commonly called the "NO_x SIP Call". The NO_x SIP Call was designed to mitigate the effect of significant transport of NO_x, one of the precursors of ozone depletion. In order to raise revenue, the state of Virginia decided to auction 5% of the state's total permits, a total of 1,855 permits. The auctioned permits were not homogenous since they compromised different vintages (2004 and 2005). In addition, the two vintages were asymmetric (non-homogeneous) substitutes since banking from one year to the other carried the risk of depreciation. As a result of these characteristics, combinatorial auctions appeared to be appropriate. Three auction types were assessed in the planning stage of the auction:

[16] The CAIR permanently caps SO_2 and NO_x emissions in the Eastern part of the USA, and aims at reducing SO_2 emissions by over 70 % and NO_x emissions by over 60 % from 2003 levels.

- Combinatorial[17] Sealed Bid Auction (CSB).
- Combinatorial English Clock Auction[18] (CEC) in which 'combinatorial' has a specific meaning under which activity rules would be imposed controlling bid switching combining different vintages; and.
- Sequential English Clock Auction (SEC)

Two factors were identified as critically affecting auction performance, namely, the elasticity of the demand curve and the difference in clearing prices of different allowance vintages[19]. Both of these factors have been tested experimentally, an example of which is presented in (Porter et al., 2003). In this study, the authors found that the combinatorial clock auction performed best, as measured by revenue maximisation and allocational efficiency. However, due to time pressure and difficulty of implementation, the sequential clock auction was selected as the preferred auction design. Notwithstanding this, a higher price for the allowances was yielded by the sequential auction when compared with the morning spot market price. As such, the objective to use an auction to raise revenues ($US10.5 million.) was successful. In addition, auction implementation was rapid and operationally inexpensive ($US200,000)[20].

From the Virginia's NO_x auction it can be concluded that:

- Sequential clock auctions are feasible for auctioning emission permits and might generate substantial revenue;
- Testing of different auction designs experimentally was important to inform policy makers about trade-offs of the different options; and
- English clock auctions (both SEC and CEC) yield higher revenues than the combinatorial sealed bid (CSB) auction design if demand is elastic (Porter et al., 2003, Result 1).
- The CEC auction format which is referred to as "combinatorial English clock auction" by Porter et al. (2003) and which in this report is called "simultaneous ascending clock auction" outperforms the combinatorial sealed bid (CSB) and the sequential English clock auction (SEC) in terms of efficiency (Porter et al, 2003, Result 6).

[17] In a 'combinatorial' auction bidders can place bids on combinations or packages of items rather than just for individual items.

[18] In the context of the NO_x auction in Virginia, the term combinatorial clock auction has been used (e.g. Porter et al). In this report the auction format is referred to as a "simultaneous clock auction".

[19] Due to the limited possibility of substitution of vintages, the clearing prices of these vintages might be different. Therefore bidding strategies of the participants should reflect differences in clearing prices. Under a combinatorial auction design combined bidding is made easier and therefore such a design might lead to higher efficiency compared to sequential auctions.

[20] Presentation by Charles Holt at the RGGI Workshop on Implementing the Minimum 25% Public Benefit Allocation, organised by RFF, held on 20th of July 2006 in New York.

4.2 Greenhouse Gases (GHG)

4.2.1 UK ETS Auction

The EU emissions trading scheme (EU ETS) was formally launched in 2005. Member States of the EU were required to submit a National Allocation Plan (NAP) outlining the number of allowances they proposed to be allocated under the first phase of the EU ETS.

In advance of that process, in 2002 the UK established the first economy-wide scheme to limit GHG emissions using emissions trading. The scheme ran until December 2006. It included both baseline-and-credit as well as cap-and-trade approaches, leading to a high degree of complexity (Sorell 2003). In order to give incentives to participate, an auction was run in March 2002 to allocate money against voluntary GHG emissions reductions[21]. The aim of the auction was to allocate money (subsidies) for efforts to reduce GHG compared with company specific baselines.

The objectives of the auction were:

- to identify those companies willing to reduce emissions for the smallest incentive payment per tonne CO_2-e;
- to conduct the auction of subsidies for voluntary emission reduction in a simple manner, with regard to operation and participation; and
- to treat different firms fairly.

A descending clock auction was chosen as the preferred auction type, with a permit price starting at 100 £/t CO_2-e. The auction proceeded in a series of rounds. During each round the auctioneer announced a start price and an end price per tCO_2-e. An important innovation in the UK's implementation of the clock auction was the use of intra-round bids. Intra-round bidding means that in each round each bidder is asked to express her desired quantity at five price points between the round start and end prices. At the end of each round the auctioneer determines whether there is an excess supply of emission reductions at the price point. If so, another round is conducted until a clearing price is reached where there is no excess supply of emission reductions.

Bids could not be withdrawn or changed after the close of a round. A bid of zero quantity at a specified price indicates a choice to exit the auction at any price below that level without a binding commitment.

In each bidding round, this design allowed participants to cover a range of prices, rather than a single price, thus allowing the auction to progress more quickly. In addition, the clearing process was simplified as it was more likely that the clearing price would be determined by the quantity reduction of a single company. To make participation easier for companies, the auction was conducted in two days. On the first day, a single bidding round was conducted. Prior to the start of the second day bidders had time to adjust their bidding strategy after the information of the first round was revealed. The time separation

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[21] www.defra.gov.uk/environment/climatechange/trading/uk/bidding/index.htm

also allowed technical problems in the bidding process to be addressed. Finally, information from the first bidding round could be used to evaluate the budget[22].

The UK government had been warned by the EU Commission that an excessively concentrated allocation of the incentive funds could breach State Aid rules. Consequently it was important that the auction design lead to an allocation of permits to a reasonable number of participants. In order to attract more bidders, to include smaller firms and to ensure that the subsidy budget was not benefiting only a small number of participants, no bidder could be allocated more than 20% of the total quantity of reduction permits[23].

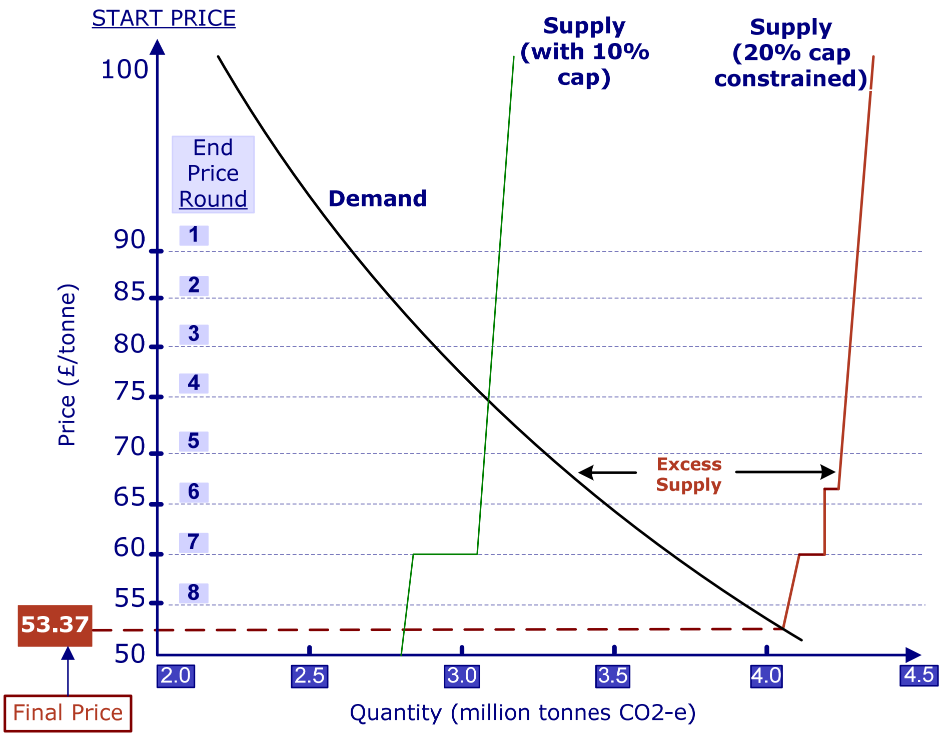

Figure 4.3: UK ETS Auction, Supply and Demand

Figure 4.3 depicts the bidding process based on the demand (available funds) and supply curves (accumulated GHG reductions). The red supply line on the right shows the supply constrained in such a way that no bidder was allowed to win more than 20% of the total quantity. The green line to the left shows the aggregate supply curve under a tighter 10% constraint.

[22] If bidding had been weaker, budget would have been reduced. Initial budget was set at £215m by the UK government.

[23] The results of the auction indicate that only one participant was restricted by this cap.

Figure 4.3 shows that the supply curve is relatively inelastic, with a noticeable reduction in supply only occurring when the price dropped below 60 £/ tonne CO_2-e. Nine bidding rounds were conducted until the clearing price of £53.37/tonne CO_2-e was reached. This implied a 13% reduction in 2006 against the aggregate baseline emissions.

The auction had a number of successes. It achieved broad participation and success in achieving quantity with 32 winners from 38 bidders with only one constrained by the 20% cap. The tighter 10% cap was discussed in the early stage of the planning. This would have shifted the supply curve to the left by over a million tonnes, reducing abatement by individual bidders and raising the clearing price. A 20% cap was finally implemented, which was thought to be the right balance since it provided higher reductions overall. The looser cap enticed more large bidders since the increased quantity available to each allowed them to recover fixed costs of abatement technology. Maintaining participation by the largest bidders was more important than increasing participation by smaller bidders. The auction achieved higher reductions than forecasted. Market power was not exercised by any of the participants.

However the auction performed poorly with regard to price discovery. The government estimated that the clearing price of £53.37 corresponded to a trading price in the range £12.45 to £17.79/tonne CO_2-e[24]. However, permits were traded at 2-4 £/t CO_2-e on the secondary market later on (Radov and Klevnäs, 2004). The price forecasting failure of the auction was the result of low baseline settings which finally resulted in a surplus in the supply on the secondary market. The problem lies within the baseline and credit approach which was used to determine the emission reductions. The voluntary scheme attracted those who were expecting to gain most from it (an adverse selection problem) rather than the cheapest abatement. Two years after the auction, actual emission reductions exceeded the target four-times. Baseline-and-credit approaches also suffer from information asymmetry: some of the reductions may have occurred even without the incentive payment. According to the National Audit Office, one third of emission reductions achieved by the four participants who over-achieved were non-additional (UK House of Commons, 2003). The House of Commons report concluded that "baselines need to be set according to a thorough understanding of participants' current performance and activity". It is likely, in respect of this initial auction process, that this was not the case.

From analysis of the UK ETS auction, it can be concluded that:

- Except for getting an early price signal, most auction objectives were achieved.
- The design of the ETS itself might have resulted in inefficiencies by allocating incentive money for non-additional reductions. Detailed assessment on reduction potential is important to ensure that the scheme is effective in reducing GHGs.
- A clock auction including intra round bidding is feasible.

[24] Since the auctioned money is paid out over a five year period and is subject to corporation tax, it is difficult to compare auction and trading prices which are charged at different rates to different organizations.

4.2.2 EU ETS

Building on the innovative mechanisms set up under the Kyoto Protocol the EU established what is considered to be the largest company-level scheme for trading in GHG. The emissions trading in the European Union (EU ETS) started in January 2005; it covers the CO_2 emissions of more than 11,000 installations and 6,546 entities from the energy and most other carbon-intensive industries. Approximately half of the total EU CO_2 emissions are covered by the scheme. In addition, the EU ETS allows the use of the flexible mechanisms of the Kyoto Protocol namely the Clean Development Mechanism (CDM) and Joint Implementation (JI).

The scheme has two phases: the first phase comprises the three years from 2005 to 2007, the second phase spans the five years from 2008 to 2012. The EU Member States are committed to reducing their combined emissions of greenhouse gases by 8% from 1990 levels by the end of the Protocol's first commitment period between 2008 and 2012. This overall target has been translated into differentiated emission reduction targets for each Member State under a 'burden sharing' agreement.

For each phase, each Member State is required to prepare a National Allocation Plan (NAP) which determines the total available permit volume (Emissions Trading budget) and specifies the allocation method across installations and entities. Only four EU members (Denmark, Hungary, Ireland and Lithuania) decided to auction off parts of their ET budget – a total of only 4.4 Mt of CO_2–e per year, or 0.2% of the entire ET budget in the first phase. The aim of those auctions was not to reveal prices but to raise revenue to finance administration costs or to finance emission reduction in other sectors. Of those four countries, only two have actually conducted auctions: Ireland and Hungary. Other Member States have also committed to auctioning the remainder of their New Entrant Reserves. Emission permits are currently (June 2007) trading at less than 1€/t CO_2-e and are expected to trend lower for the remainder of the first phase. As a consequence it is not expected that either Denmark nor Lithuania will go through with auctioning permits, nor will any auction of New Entrant Reserves actually take place because the cost of conducting the auction would probably exceed the revenue.

It is predicted that more countries will auction permits in the second phase however few details exist of the manner in which these auctions will be conducted. Again it seems that the auction will acte more as a revenue raiser than a revealer of price signals. The Polish Phase II NAP outlines an auction which contemplates limiting participation to Polish companies with the intention of achieving lower prices thus giving an advantage to national companies. However, this is not in line with EC state aid rules and therefore it is questionable if such an approach would be approved by the EU commission.

Table 4-2 shows the proposed auction quantities as a proportion of ET-budget (total of issued permits).

Table 4-2: Auction Share of ET-budget including new entrant reserve in Member States of the EU in Phase II

	Auction Share of ET-budget including new entrant reserve	
	Phase I	**Phase II**
Austria		1.22%
Belgium		0.5%
Denmark	5%	0%
Germany		8.8%
Hungary	2.5%	4.3 %
Ireland	0.75%	0.5%
Italy		0 % but 5.7% or 12Mt/a will be sold at fixed price
Lithuania	1.5%	2.7%
Luxembourg		5%
Netherlands		4%
Poland		1%
UK		7%

Source: Schleich et al. (2006)

4.2.2.1 Irish auction[25]

The objective of the Irish auction was to cover the administrative costs of the scheme. Approximately 1.2 million permits were auctioned in two auctions, both conducted in 2006. The first auction comprised 250,000 permits and the second 963,000 permits. A sealed-bid auction was chosen as the preferred auction type, being easier to implement than an ascending clock auction which requires more sophisticated software. A uniform pricing auction was selected as it was considered more efficient in the absence of market power and more equitable since all participants pay the same price.

[25] All information was derived from the presentation by Ken Macken at the Auction workshop held in Cambridge on the 15th of January 2007.

In this auction, the bidders were required to submit demand schedules with up to five mutually exclusive bids. A non-disclosed reserve price was set, as there was the risk of a lack in demand, based on information failures (e.g. not enough publicity and knowledge). A lot size of 500 EUAs[26] was used in order to accommodate small emitters, with this size substantially smaller than the lot sizes traded on the secondary market (5,000 - 10,000 EUAs). However, the lot size was increased to 1,000 EUAs in the second auction since a lot size of 500 EUAs was found to be too low, and was not traded. Participants were required to have a valid account in the registry, to which EUAs would be transferred. The risk associated with speculative bidding and bid validation was limited by conducting a qualification process prior to the auction, in which a €3,000 deposit was required. One hundred and fifty valid bids were received and the reserve price was met. Five individual bids were successful and were offered at a uniform settlement price of €26.30.

The Irish auction yields lesson in terms of practical implementation of auctions. The settlement period of five days was considered to be too long, especially in conjunction with the low deposit of €3,000. The concern was linked to the risk of the EUA price collapsing in the five day settlement period: €3,000 would not have been sufficient disincentive to bidders withdrawing or failing to honour their bids. In the second auction a two day settlement period and a deposit of €15,000 were adopted. Credit risk sits with the government for defaulting auction participants. Implementation (pre-qualification and bidding) was performed manually for the first auction but automated online for the second auction. Implementation costs for the government were low and can be driven down using light weight web applications equipped with banking standard security.

Lessons learnt from the Irish auction are that:

- A sealed-bid uniform price auction is feasible to auction small amounts of permits; and
- A linkage exists between security of payment provisions and settlement period.

[26] European Union Allowances (EUA). EU Allowances are the tradable unit under the EU ETS, equals 1 tonne of CO_2-e.

4.2.2.2 Hungarian auction

In Hungary, two auctions were conducted in order to finance the administrative costs of the emissions trading scheme[27]. The total volume to be auctioned was 2.37 Million EUAs, twice as many EUAs as in Ireland. The first auction was operated at short notice in late 2006 using an electronic platform. The second auction was conducted recently on 26th March 2007. The first auction was a uniform price auction with an unsealed reserve price and a lot size of 1,000 EUA. Deposits had to be handed in two working days before the auction. A reserve price was set, linked to the closing forward price quoted by Point Carbon for the day before the auction, less €0.90.

At the first auction 1.2 Million EUAs were sold at a clearing price of €7.42, which was €0.42 to €0.57 above the price on the secondary market at that time (the secondary price moved during the bid period). At the second auction Point Carbon reports that a total of 1,177,500 emission permits were sold at €0.88 per tonne.[28] It is questionable why the Hungarian government decided to auction the remaining permits since the prices were expected to be low. One explanation might have been that the contract with the private company which undertook the auction did not include a provision to cancel it. The auction has been criticised for lack of transparency as no information was revealed at its conclusion.

The volume auctioned was small in comparison to general daily trades (approximately 1.5 times the daily volume) and it is likely that it would have been more efficient to sell them twice a week on a spot exchange instead of auctioning them. The transaction costs of conducting a special auction are higher than spot trades and there is a risk of lower revenue since the time is less diversified. However, the government would need to decide over which trading platform they would sell their allowances, which might raise questions of fairness.

This experience from the Hungarian auction leads to the following conclusions:

- A short bidding time (e.g. 1h) is preferable to limit exposure to shifts on the secondary market;
- Low transaction costs increase participation; and
- Transparency should be increased as much as possible.

[27] All information is based on a presentation of by Peter Kaderjak at the Auction workshop held in Cambridge on the 15th of January.

[28] See www.pointcarbon.com. The auction was postponed and originally planned to be held in 2006.

4.2.2.3 German auction for Phase II

In late June 2007, the German parliament announced a decision to sell or auction 40 million CO_2 allowances per year during the 2008-2012 period of the EU emissions trading scheme.

This represents around 8.8% of the annual 453.1 million allowances the German government can hand out to its companies. The quantity may vary as it must stay below the 10% threshold by EU direction. All 40 million allowances will be taken from the amount of emissions permits originally intended to be handed out for free to the power sector. The announced intention is to carry out the first auction as soon as possible and at the latest by 2010.

The government's stated preference is to sell through government auctions rather than using third party intermediaries. Some in the private sector argue that there is no real need for an auction and that the existing market already provides a reliable price signal. The argument also goes that auctioning would require more infrastructure and would increase transaction costs. Supporters of secondary market disposal argue that the 40 million allowances should be sold in equal portions every day, meaning just below 200,000 allowances per day. Implemented that way, it wouldn't interfere with the market.

Special regulation is expected to control the auction process. Equal shares will be auctioned through the year, each announced at latest two months in advance. The dates for auctions will be set so as not to overlap with auctioning in other member states. The announced intention is that auction rules should be objective, comprehensive, non-discriminatory and avoid any market power or collusion.

The intention is that the provision comes into force before 1 August 2007.

The declared objectives are consistent with the declared objectives for an Australian auction.

4.3 Interim conclusions

Table 4-3 provides a summary of the conclusions presented in this Chapter 4.

Table 4-3: Summary of Experiences in Design and Implementation of Auctions

	SO_2	NO_X	UK ETS	Irish CO_2	Hungarian CO_2
Auction objectives					
Efficient allocation / Price signal	X				
Liquidity for new market entrants	X				
Revenue raising		X	X	X	X
Auction Type					
Uniform (U) / Discriminatory(Pay-as-bid) (D)	D	U	U	U	U
Static (S) / Dynamic (ascending (A) / descending (D) clock auction)	S	A	D	S	S
Sealed (S) / Open (O)	S	O	O	S	S
Reserve price (open (O) / sealed (S))	-		-	S	O
Spot (S) / advance (A)	S+ A	S+ A	A	S	S
Sequential (Se) / Combinatorial (C)/ Simultaneous (Si)	Se	Se	-	-	-

On the basis of previous auctions some general lessons can be learned which might be relevant for the Australian NETS:

- There is no experience of auctioning more than 5% of the total emission permits available for allocation. Therefore most of the auctions played a minor role as a trading platform and were dominated by secondary markets.
- The US Acid Rain program is the only scheme which has similar auctioning objectives to improve the efficiency of the scheme and ensure liquidity for new entrants. The focus of the other schemes was more on revenue generation rather than allocational efficiency therefore auctioning as a means of setting early price signals was less important.
- The only scheme which included auctions before the start of the scheme and annual advance auctions was the US Acid Rain Program. The experience has shown that early auctions are important to reveal marginal reduction costs as this may be materially different from that suggested by previous expert studies.
- It is important to avoid changes in the regulatory framework if advance auctions to have a substantive role in predicting long term prices.

- The NO_x auction shows that an ascending clock auction is feasible for auctioning emissions permits and experiments showed that simultaneous[29] clock auctions instead of sequential auctions could have achieved a higher efficiency.
- The UK auction demonstrates that intra-round bidding is feasible, is a mechanism which saves time, allows adjustment of bidding strategy to early price signals and makes clearance easier.
- Some technical design elements have been learned: e.g. security provided by payment bonds and deposits need to be carefully set in order to ensure that bidders don't use the auction trading of options. This is especially important if settlement periods are longer and secondary market prices are volatile.
- Transparency of the auction process is important to ensure credibility.

[29] Refer Footnote 18 on page 26.

5 INTERDEPENDENCIES OF ETS DESIGN AND AUCTION IN THE AUSTRALIAN CONTEXT

This Chapter 5 investigates the interdependency between an Australian emission trading scheme and the design of an auction of permits in such a scheme. Figure 5.1 illustrates the interdependence of the trading scheme and the auction design with regard to elements such as coverage, cap, allocation method, timing, international linkage, offset and sanction mechanisms.

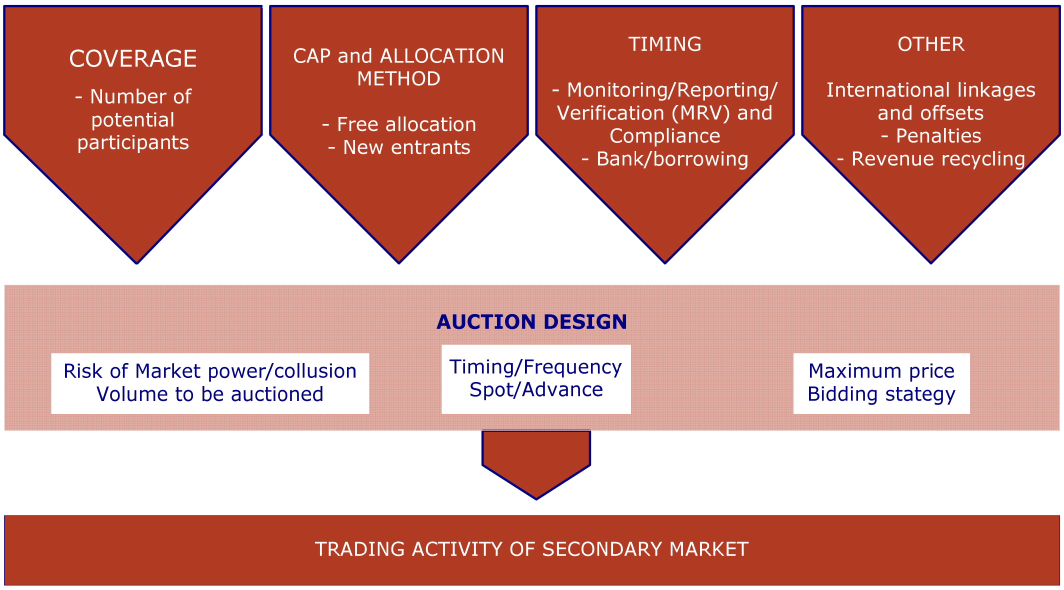

Figure 5.1: Interdependency: Emissions trading scheme and auction design

The emissions trading scheme design elements that will affect auction design are:

- coverage, which could influence the likelihood of collusion or could result in market power being exercised by one or a small number of auction participants,
- the cap and the number of permits allocated by alternative methods will influence the number of permits available for auction,
- monitoring, reporting, verification and compliance could influence decisions regarding timing and frequency of the auctions,
- international linkages might tie the permit price structure in Australia to the international cost of abatement. This will have implications for the risk of market power and also the value of the auction in increasing market liquidity,
- penalties imposed for non-compliance might establish upper price limits both in the secondary market and the auction, and
- mechanisms for revenue recycling could influence the bidding strategy of auction participants,

The auction variations (e.g. volume and frequency) might have an impact on the trading activity on the secondary market.

In this chapter, each of these emission trading specific design elements and its impact on the auction will be analysed.

5.1 Coverage

"Coverage" in an emissions trading scheme refers to the range of installations and/or operators that are liable for emissions and are thus required to surrender emission permits according to their emissions in a given trading year. Thus, coverage defines:

- the number and size of companies which are potential participants at a permit auction. Note this is only relevant if companies have to be covered by the programme in order to be eligible to participate at the auction, and
- the potential volume of permits to be auctioned. This will depend on the cap ('Emissions Trading Budget' or ET budget) and the number of permits allocated by alternative methods. The auction volume will also depend on the voluntary contributions to the auction (see double auction format described in Section 6.7. In the following we use the term "auction volume" to denote the volume without voluntary contributions.

5.1.1 How does the number and size of companies affect the auction?

The number and size of companies and their sectoral distribution is important to the design of a permit auction as it allows assessment of the likelihood of abuse of market power and the risk of collusion. Abuse of market power is more likely to occur if only a small number of highly heterogeneous (different sizes) rather than a high number of homogeneous (similar sized) bidders participates in the auction. Similarly, collusion between participants is more likely if there are relatively few bidders who are all from the same or similar sectors. The reason for this is that they can potentially identify one another more easily and punish defection accordingly. In addition, collusion might be tacit because participants would all realise that similar behaviour was the way to maximise their individual rents.

The size of potential participants is an important consideration when deciding on the complexity of the auction design. If participation by small companies/emitters is desired, a simple auction design should be selected since complex auction designs could increase the cost of participation (e.g. training, consulting, etc.). This would either deter small companies from entering the auction or would encourage them to outsource bidding to intermediaries (e.g. banks or brokers). The Bulow-Klemperer theorem shows that an auction design should be kept simple so as to lower the cost of entry and attract a high number of bidders by stating (Bulow and Klemperer 1996): "*Every additional bidder is more effective in increasing competition than any complex auction design could be.*"

5.1.2 How does the volume of permits to be auctioned affect the auction design?

In a similar way as for auction complexity, the volume of permits to be auctioned influences the potential number of participants.

If the auction share of the total volume of permits (ET budget) is relatively small then fewer companies might enter the auction since they are unlikely to acquire a sufficient number of permits for compliance solely through the auction. Under such circumstances the transaction costs for small companies entering the auction would exceed their likely benefits and they would buy permits on the secondary market. A low auction volume acts as a deterrent to participation.

The volume of permits available to be auctioned will depend on both the coverage status in that year and the amount freely allocated to generators and trade exposed energy intensive industries (TEEII). The demand from generators is usually determined by the difference between the number of allocated permits and actual emissions after own cost-effective abatement measures. The higher the amount allocated to generators, the lower will be their demand on the permit market. Thus, the available volume of permits at the auction for others is higher and the effect of a lower overall available volume is softened.

5.1.3 What is the planned coverage (number of facilities and emissions) for the NETS?

The number and size of potential auction participants were outlined in the Background Paper supplied (NETT, 2007) and estimates have been made of the number of facilities covered, the emission volumes and the potential auction volumes.

The stationary energy sector dominates the national GHG emissions comprising some 50% in 2004. The electricity generation segment represents approximately 35% of all GHG emissions. (NETT, 2006).

Free allocation to existing TEEIIs is reduced from 2020 onwards, due to the assumption that more stringent benchmarks - based on Best Available Technology (BAT) - will be applied. In addition, as the justification for TEEII allocations is international leakage, if future international agreement achieves broader coverage these should be reduced or eliminated. The number of permits to be auctioned could be substantially increased if other permit holders including generators and TEEIIs are permitted to sell their permits at the auction.

5.1.4 What is the likelihood of an abuse of market power in the auction?

Four different possibilities to exercise market power can be distinguished which might negatively impact on the efficiency of the scheme:

- In order to generate profits by **understating demand and lowering the permit price** at the auction (strategic demand reduction, see Section 3.4.4), the market share and elasticity of demand of one or a small group of buyers must be high and for the other buyers permit demand needs to be relatively inelastic (Cramton and Kerr, 2002).

- In order to generate profits from **overstating demand and increasing the price** at the auction, the share of the free allocation has to be high so that windfall profits are high; or in the case of 'exclusionary manipulation', the monopolist has to be able to increase the profits in the product market. Higher prices for permits will have negative effects for new entrants if they need to buy permits and act as a market entry barrier.

  In the first case (windfall profits) it might not only be the case of market power but tacit collusion might also occur in emissions trading schemes which allocate high proportions of permits for free to electricity generators and only a very small part is auctioned. If generators receive permits for free, then passing the opportunity costs of not selling the permits on to the consumers results in extra profits. Empirical estimates and model findings for Germany and the Netherlands show pass-through rates varying between 60% and 100% for the wholesale electricity market (Sijm et al., 2006). The extent by which permit prices are passed on to the customer depends on factors such as time (peak and off-peak hours), the competitive environment, changes in merit order of the supply curve (depending on gas-coal price spread), scarcity of generation capacity, and demand elasticities for electricity consumption. This pass-through of opportunity costs affects the profits of power stations which depend on the marginal unit and the permit price. The higher the permit price and the higher the proportion of permits allocated for free, the higher the profits. Given these interdependencies it seems likely that electricity companies (since electricity demand is inelastic at least in the short run) have an incentive to keep permit prices high in order to keep profits up if a substantial share of permits was allocated for free. This means that free allocation might have a negative impact on efficiency since it gives most electricity generators an incentive to overstate prices.

- In the case of **exclusionary manipulation**, a company increases the permit price at the auction to increase the costs for competing companies on the product market which could lead to a situation in which all or part of that company's production capacity is excluded from the product market. Thus the company maximises its overall profits (losses on the permit market are overcompensated by profits on the product market).[30] In order for exclusionary manipulation to occur, the scheme would need to be primarily limited to one sector (generation) and one or a small group of players would need to be able to push prices up enough to exclude their competitors without too large a loss of profit – i.e. their demand elasticity must be high while their competitors' elasticities must be low.

- The last possibility to exercise and profit from market power is for a company to buy many permits at the auction and **corner the secondary market**, thus essentially acting as a monopolistic supplier of permits (short-squeezing) which would allow them to set the price on the secondary permit market. This is another

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[30] For exclusionary manipulation see Misiolek and Elder (1989) or Carlén (2002).

form of market power which is independent from effect on the product market and only focuses on the permit market.

Cornering the market would be very unlikely if offset credits are allowed through abatement in other sectors or abatement in developing countries (viz: Clean Development Mechanism). Both would provide additional supply and cap the price on the secondary market and reduce the potential for short-squeezing. In addition, if the penalty sets a maximum price, the price of domestic emission permits would be effectively capped.

Additional work needs to be carried out in order to assess the likelihood of market power proving profitable using one of the above mechanisms. Information on free allocation, elasticities and the net demand situation of each company would be required and would need to be assessed. This information is not available and therefore we focus more on the likelihood of a company actually influencing the permit price through its purchases at the auction. The latter will depend on the size – meaning in this context the emissions - of the company. As a proxy for the emissions shares in the permit market, the market structure of the electricity market is analysed more generally.

Abuse of market power is unlikely. The stationary energy sector, particularly the electricity generation sector, is by a significant amount the dominant effect in Australian emissions. Figure 5.2 presents an analysis of market power in which ownership structure of the electricity sector is relevant, rather than the number of facilities. Figure 5.2 shows the relative market share of the electricity generation companies. [31]

[31] The GHG emissions of each facility were determined by making assumptions with regard to operating times, emissions and capacity factors. The operating time was assumed to be a function of the status of the plant (peak, baseload, intermediate, etc). The emission factor was determined as a function of resource type, with brown coal having the highest emissions factor followed by black coal, gas, etc. The capacity factor of each facility was determined by expressing actual electricity output (MWh) as a function of the theoretical energy output (determined by the installed capacity). The electricity output of each of the plants was sourced jointly from Minter Ellison (2007) and from data produced by the Australian Greenhouse Office (www.ga.gov.au/fossil_fuel/).

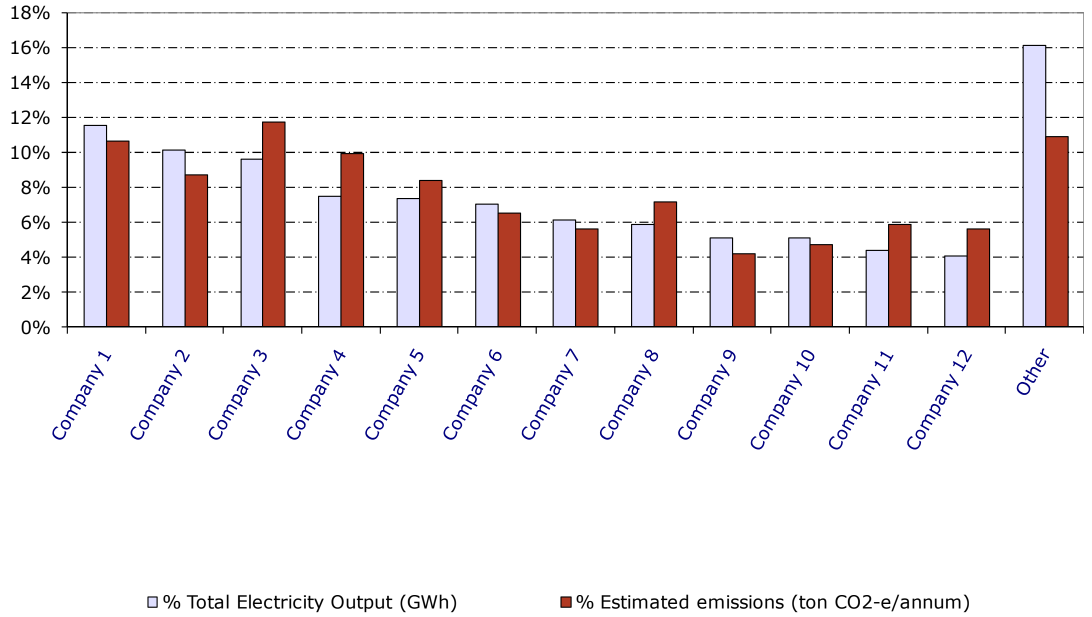

Figure 5.2 Market share of electricity generation and GHG emissions in Australia (2006)

From Figure 5.2 it can be seen that for the top 12 electricity generating companies the market shares based on electricity output range from 4.1% to 11.5%. The market share based on estimated emissions falls in a similar range, namely 3.8% to 10.8%. Of the 57 electricity generating companies in Australia, the five highest emitting companies account for approximately 50% of emissions and the ten largest for 79%.

In order to give an indication of the structure and concentration of the electricity market, the Herfindahl-Hirschmann-Index[32] (HHI) was calculated. This index is calculated from the following equation:

$$HHI = \sum_{i=1}^{n} s_i^{\ 2}$$ **Equation 5-1**

In which s_i represents the percentage market share of company *i*, and *n* is the number of companies.

Based upon the estimated emissions, the HHI of the electricity generating market was found to be 0.075. A HHI index of 0.075 is considered to be low, and thus indicative of an un-concentrated market. [33]

Based on the HHI it is concluded that these generators cannot exercise market power to significantly affect the market price of permits and, even if they could, it would not be

[32] The Herfindahl-Hirschman Index (HHI) is a common measure of market concentration which is particularly sensitive to the number of actors in the market.

[33] The U.S. Department of Justice considers markets with an HHI between 0.0 and 0.1 not to be concentrated, between 0.1 and 0.18 to be moderately concentrated, and above 0.18 to be highly concentrated (www.usdoj.gov/atr/public/testimony/hhi.htm)

profitable in most cases. Only in the case of a high proportion of free allocation tacit collusion might be profitable. Allocating only a small share of permits for free to generators would be the best way to reduce this risk.

5.1.5 What is the likelihood of collusion?

Similar to the abuse of market power, the likelihood of collusion appears low and will be further reduced by any proposed broadening in coverage for the scheme – currently under investigation as part of the NETT's revised terms of reference. Moreover, the risk of collusion is very low if the permit auctions are open to companies that are not themselves being covered by the ETS.[34] Auctions should be open to everybody fulfilling the necessary requirements.[35] This includes companies in the financial sector seeking to become involved as intermediaries. It would also include potential new entrants as well as companies preparing a stock of emission permits against future requirements. The wider the pool of potential auction participants, the less likely an effective agreement could be struck between them and the less likely is collusive coordination of strategies. However, there might be the risk of tacit collusion as discussed in Section 5.1.4.

5.2 Cap and allocation method

The total emission cap (Emissions Trading budget) and the permit allocation method together define the minimum volume of permits to be auctioned. However, since the auction is for the residual part of the total ET-budget after the free allocation to generators and TEEII has been determined, the precise volume is uncertain.

5.3 Timing, frequency and liquidity aspects

Timing aspects of an auction design included questions such as:

- When should the auction be announced and take place; and
- Whether future vintages should be auctioned in advance auctions?

In addition, with regard to frequency, the following questions should be answered:

- How often should auctions be run; and
- How permits will be distributed over the period that auctions take place.

Finally, the liquidity question that should be addressed is whether the auction design impacts on market liquidity and to what extent this occurs.

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[34] In some EU Countries it is proposed to limit participation to national companies in order to achieve a lower permit price (hidden subsidy). However, in the US SO_2 programme participation is open to the public.

[35] In order to be able to transfer the permits which were acquired in the auction the participant will need an account in the registry or has to cancel the permits by transferring them to the general cancellation account.

5.3.1 Timing

5.3.1.1 Timetable

The timing of an auction can be based on a transparent timetable, included in the legislation (e.g. Acid Rain Programme with the auction taking place every March) or left open to be determined by an administrative body (e.g. the EU ETS in Ireland and Hungary, see Chapter 4).

If early price signals are an objective, then pre-determined auction dates would be favoured since companies will need to prepare the necessary information (expected abatement costs in the future). If the auction date is only announced by an administrator shortly before it is to be held[36], it could potentially have a negative impact on efficiency since necessary information for bidding is missing.

5.3.1.2 First Auction

In order to generate an early price signal, the first auction needs to take place before the start of the scheme. However, in order to set an efficient and reliable price signal the auction should not take place before companies have started monitoring their emissions and are aware of potential abatement measures and costs.

Monitoring, reporting, verification (MRV) and surrendering of permits (the latter is known as 'compliance assessment') are design elements which need to be considered when determining the timing of auctions. The timing of MRV has not been finalised yet for the NETS as it will be linked to the streamlined reporting approach of the Council of Australian Governments (COAG) which is still under development (COAG GERG, 2006). In the latest report, the COAGs Greenhouse and Energy Reporting Group propose the 1st of July 2008 as the starting date for mandatory reporting under the national reporting system, with first reports to be submitted by the end of October 2009. Based on these dates (which have still to be confirmed) it is proposed that the first auction is conducted after October 2009 (e.g. November 2009).

5.3.1.3 Last auction

The last auction of a specific vintage might take place after compliance assessment, during a so-called reconciliation period. A reconciliation period is important if no borrowing is allowed and usually consists of a period of 1 month after the emissions of the previous trading year have been measured and verified.[37] This is done to ensure that

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[36] This will be done by administrators who wish to conduct the auction when prices are highest. An example of this is the UK Gilt (UK sovereign bonds) auctions. The Treasury was to determine the auction date, with the view of maximising revenue. However, market participants anticipated the Treasury's intervention in rising markets, and the overall price level decreased. This structure has been changed; auction dates are now pre-determined (Neuhoff et al. 2007).

[37] The EU ETS requires companies to submit their verified emissions report by the end of March for the previous calendar year and to surrender permits for compliance by the end of April. Thus, the directive gives companies a 1 month reconciliation period to make sure that their permits match their emissions of the previous year. (CEC ,2003)

companies with an unforeseen shortage have time to acquire the necessary permits in order to avoid paying a penalty. As previously discussed the residual of the TEEII reserve would only be known at the end of the trading year. Therefore auctioning at the end of the year or during the reconciliation period is the best way to ensure that all permits for a given year are released into the market before compliance is assessed.

The COAG report (COAG GERG, 2006) suggests that the reporting period will be in line with the financial year.[38] This would have the advantage that it is staggered relative to the EU ETS trading years[39], which could have positive impacts on market liquidity in case of linking, since small companies tend to trade more for compliance and this happens usually at the end of a trading year during reconciliation periods (EuPDResearch, 2005). The period from July to October seems to be suitable for reconciliation and might include the auction of the residual of the TEEII reserve (e.g. in August) if it is not possible to predict the surplus of the TEEII reserve already before the trading year ends (e.g. in May).

This leads to the question whether permits should be auctioned only for or within the trading year to come (spot auctions) or also for trading years in the future (future vintages auctioned in advanced auctions).

5.3.2 Spot vs advance auctions

Spot auctions are auctions of permits of the current vintage which can be used for compliance in this trading year. **Advance auctions** auction permits of future vintages.

The advantages of **spot auctions** are:

- they will generate regularly price signals for the secondary market and thus lower its uncertainty, and
- they guarantee permit supply for buyers and new entrants.

The advantages of **advance auctions** are:

- They set early price signals for the future.
- They ensure that permits are in circulation before the compliance year for which they are valid. This gives a greater certainty to investors interested in investing in infrastructure with longer lead times and long life times. It is especially relevant if market participants are risk averse. However, since permits can be banked investors might buy current vintages to secure future investment. The disadvantage will be that they will have to pay higher prices.
- Trading permits of future vintages compared to trading futures or forwards has the advantage that those permits can be traded spot without any risk premium.

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[38] There might be some benefits from a more frequent surrendering of permits such as providing additional information during the trading year, or less cash flow implications. Therefore it might be useful to surrender permits more frequently (e.g. quarterly) similar to the mechanism of a provisional tax. That means the permits to be surrendered are determined on the basis of the emissions in that quarter of the last year unless proven otherwise.

[39] The EU ETS compliance year is from 1st of January to 31st of December. (CEC, 2003)

Little experience is available on the merits of advance auctions. The only scheme so far which includes 7 year advance auctions is the Acid Rain Programme (see Section 4.1). As shown in Figure 4.2 prices at advance auctions were usually lower than of the spot auction reflecting the discounted value of the permits. Buying permits at the advance auction will cause holding costs since the capital is bound and can not be used to create interest elsewhere therefore the price at the auction is usually lower. In addition, the higher prices for current vintages at spot auctions indicate that those permits can be used more flexibly (they can be used for compliance in any year because of banking). In order for the advance auction to work the regulatory framework needs to be stable, otherwise the price signals will be meaningless (see Section 4.1.1.3).[40]

However, the extreme case of auctioning all vintages at an early stage, will have the disadvantage that all the necessary information might not be available, which would have the effect of yielding price signals that might not be as good as signals yielded by auctions held later on. Also having one auction only in an immature market is likely to preferentially benefit smart players at the expense of smaller or less experienced players (possibly including government) who do not appreciate the potential value of the permits. It may lead to political problems if some players are found to have profited unreasonably at others expense. Therefore we do not recommend auctioning all permits at a single advance auction.

Furthermore, it is important to note that new entrants to the scheme will be able to purchase permits only on the secondary market. Thus the auction would not function as a guarantee of liquidity for new entrants. Finally, pure advance auctioning would not work since the total amount to be auctioned is uncertain and depends on the TEEII allocation. For this case, the total auctioning volume is only known at the end of each trading year so an additional yearly auction would be required during each reconciliation period.

Based on the arguments above, we propose a mixture which would consist of probably four (perhaps two) spot auctions per year with some advance auctions of future vintages. To set a price signal for the future it is not necessary to auction permits for each future vintage, but it seems sufficient to auction only individual vintages as was practiced under the US Acid Rain programme (see Section 4.1.1). Free allocation will be granted for 20 years to generators so these will be available to provide some liquidity to the secondary market for future vintages.

5.3.3 Horizon for future vintages

What is the vintage of the furthest year into the future which could be auctioned? To answer this question the most important design element to consider is the gateway contemplated in the Discussion Paper. The suggestion is to establish firm annual caps set for the first ten years and gateways (an upper and lower bound) for the next ten years. On a rolling basis every year after the scheme commencement governments would

[40] The EU ETS is based on National Allocation Plans and therefore the permits are valid for one phase. Advance auctions beyond one phase would not be possible and within a phase they would not generate any additional information since they are homogenous.

announce within the bounds of the gateway an additional year's cap, so that there would always be ten years of firm caps. Every five years, gateways would be extended for a further five years. It follows that the total amount of available permits beyond a ten year period is uncertain, with only the minimum known. However, it would be possible to auction in 2009 some permits for 2020 (the volume will need to be substantially below the lower bound for the cap minus the allocation to generators in 2020).

It is questionable whether companies will be able to predict accurately what their abatement costs will be twenty years before actual abatement is set to occur, and even less likely that they will be able to predict the abatement costs of others to allow them to make an overall prediction on the supply and demand situation.[41] In addition, auctions which are far into the future beyond the ten years of firm caps might attract only few participants since there is a much higher price and quantity uncertainty. Therefore it is recommended that the advance auctions be oriented around the timing of investment decisions for abatement measures. Such measures generally have a lead time of up to three years before they become effective. Advance auctions should be run a maximum of three years in advance, to allow progressively more accurate information to become available from engineers: this will provide rolling robust price signals.

Such time frames are also common on the electricity market. Power generators typically forward contract for selling power on a time horizon out for five years. Forward contracts progressively diminish from a high contracted proportion for the immediate years to a high spot proportion five years out. A liquid secondary market is likely to be the most useful resource for electricity generators seeking to manage future needs for emission permit supply with auctions acting as the mechanism for getting supply onto the market in the first instance.

It is therefore recommended to only auction permits of up to 3 years in advance. Such auctions might support establishing a forward and future market of permits.

5.3.4 Combining vintages at auction

As mentioned before permits will be date stamped. If a permit is date stamped it stipulates the date from which it can be used for compliance. If such a permit is not used in the trading year for which it is valid it could then be used in later trading years. This is called **banking** and means that the vintage date only determines the first date in which permits can be used for compliance. After the vintage date of a permit has passed they all rank equally. **Borrowing** of permits is generally not allowed: NETT proposes that only 1% of a liable party's obligation could be met using next year's vintage permits. Apart from this, permits cannot be used before their vintage date for compliance. That means that permits which are of consecutive vintages are better substitutes because they will be interchangeable earlier than permits of further apart vintages.[42] For the auction design

[41] For a prediction on future overall demand and supply, information is needed on the supply and demand of international credits, national offset projects, weather, fuel prices etc. This makes such a prediction almost impossible.

[42] In 2013 a permit with 2011 and 2012 vintages could be used for compliance but not permits with a 2020 vintage. Those permits will only become substitutes with 2011 and 2012 in 2020 or after.

this means that either a combinatorial or a simultaneous auction might be more efficient if permits of consecutive or close vintages were to be auctioned. Such a design would allow speculators to switch between permits and invest their budget in permits which they assume to be most undervalued (see NO_x auction in Section 4.1.2 and Porter et al., 2003). If permits at the auction have a difference of vintage of either one or three years they are reasonably homogenous. Therefore it is likely there would be benefit in running simultaneous auctions for multiple vintages, although not in a combinatorial fashion.

5.3.5 Auction frequency

Together with the decisions regarding timing and auctioning of vintages, the frequency of auctions should also be assessed. In the event that more than one auction is run for a particular vintage it is necessary to determine how permits are distributed across the different auctions. The advantages and disadvantages associated with frequent auctioning are as follows:

Advantages of frequent auctions[43]

- Frequent auctions reduce the risk of abuse of market power by short-squeezing the market (bidders will be able to react in the subsequent auctions by increasing their bids).
- If the auction timing is in line with product sales, with the frequency matching the demand profile, both corporate cash flow implications and price risk will be reduced. This is important as risk premiums can be substantial.
- More frequent auctioning (ensuring a minimum auctioning volume) might increase participation rates for organisations not used to trading platforms and ensures liquidity for new entrants. It will also allow participants to learn by doing.
- More frequent auctions could increase flexibility, if caps have to be adjusted or the volume to be auctioned is not known at the beginning of the trading year.
- More frequent auctions might have less impact on the secondary market. The reason for this is that several auctions of small volumes compared with one auction of a large volume is likely to have a smaller impact on the secondary market.
- More than one auction at the beginning might lower the political risk of being criticised: e.g. if the first auctions fail to deliver against objectives, changes can be made. Furthermore, "bad-timing" which leads to low revenues is less of an issue since time of the auctions is diversified.

[43] For a detailed discussion of the advantages and disadvantages see Neuhoff et al 2007.

Disadvantages of frequent auctioning

- More frequent auctions would decrease the auctioning volume at the beginning of the scheme, thus decreasing the possibility of a reliable price signal (due to lower participation rates).
- More frequent auctioning might reduce the activity level of the secondary market if they are two-sided, unless it is used to hedge against uncertainties of auctions.
- More frequent auctions may increase the risk of collusion if auctions are transparent and if there are relatively few participants. The reason for this is that participants could interact more frequently and thus have the potential to agree upfront about bid prices.
- More frequent auctioning will result in higher transaction costs for the administrative body and companies. However, on-line auctions are relatively cheap to run as the experiences cited in Section 4.1.2 have shown.[44]

On balance, frequent auctions have more advantages so quarterly spot auctions are preferred. For the actual dates of the auctions, synchronisation with auctions in related markets would be beneficial. For example, auctions for settlement residues in Australia are auctioned quarterly in November, February, May and August.[45]

However, since the auction volume at the beginning is relatively low, bi-annual auctions might be sufficient. For a final decision between bi-annual and quarterly auctions industry consultation might be useful.

5.3.6 Progressive auctioning of a vintage

With regard to the distribution of permits across spot and advance auctions, two alternatives seem to be feasible, namely: equal distribution of permits or a front-loaded allocation of permits. Front loading means that a higher percentage of permits of one particular vintage is made available in earlier auctions and a lower percentage at subsequent auctions (e.g. 50%, 30%, 20%, and 10%). Back loaded allocation is not recommended since it would increase the risk to participants by postponing the availability of a higher share of permits to the end, thus reducing the time for trading on the secondary market. Front-loaded auctioning has the advantage that companies have an option to purchase more permits earlier on, thus giving more time to trade those permits for compliance - an important consideration for risk-averse companies.[46] In

[44] For companies the transaction costs associated with the auction will substitute for transaction costs on the secondary market.

[45] Settlement residues are the result of price differences across regions; this means the electricity price in the region where the electricity is generated may vary from the price paid in another region where the electricity is sold. There might be benefits of auctioning the emission permits simultaneous with the settlement residues of the electricity market since generators might optimize their generation according to both prices. For the actual settlement residue auction dates see www.nemmco.com.au/settlements/results.htm.

[46] A risk averse company would like to be sure early on that they will be in compliance, with permits matching emissions. If there is the risk of not being able to buy enough permits at the market such companies might implement early on their own

addition, permits will be available at an earlier stage to be traded on the spot market, without a risk premium, compared to future or forward trades. The disadvantage of "front-loaded allocation" is that participants will be required to purchase permits earlier, and might have less information on their actual emissions.

To date there is a limited amount of experience available on the implications of permit distribution across auctions. The only information available is based on the SO_2 trading scheme, where permits are equally distributed across advance and spot auctions. However, there are merits in the front-loaded distribution therefore we recommend a slightly front-loaded approach (20% at each advance auction and 15% at each quarterly spot auction). Since only little information on the implications of the distribution of permits across auctions is available further analysis by both industry consultation and experimental investigation might be beneficial to improve understanding.

For the early years, there will need to be greater front loading so that all permits available for auction are released onto the market as soon as possible.

5.4 Interaction between auction design and market liquidity

Liquidity of a market is defined in two ways. First, in a liquid market participants are able to acquire and sell permits when they desire to do so. Second, in a liquid market participants can undertake large transactions without significantly changing the market price. Therefore liquidity is not the same as trading activity: trading might be low if allocation was efficient although the market would be liquid since if somebody wanted to trade there would be supply and demand. Market liquidity is difficult to assess since it is difficult to measure. Therefore often the number of trades is assessed instead. Experience in US T-Bond auctions has shown that market activity increases when auctions are held (Neuhoff et al., 2007). This might be attributed to the fact that when an auction is held there is a clearer price signal that reduces uncertainty in the secondary market if there is a spread of prices. Also there are more permits available to trade. Finally, not all those who buy in the auction will use the permits themselves. Some will be buying in order to participate in the secondary market. Therefore it may not be true to assert that greater auction frequency reduces market activity of the secondary market since auctioning replaces trades of the secondary market.

The allocative and price signalling efficiency of a scheme depends on the total liquidity of the primary and secondary market together. The main question is whether the primary (auction) or secondary market is the superior institution for achieving the objective allocative efficiency in the short and long run.

Auctions are typically used in environments where prices are uncertain. Therefore the auction at the beginning of an ETS is very important where prices are uncertain, as experience has shown in the ARP (see Section 4.1.1.2). Apart from this role auctions have the advantage that they are generally more transparent than the secondary market – especially bi-lateral trading - since typically the number of participants (sellers, buyers),

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abatement options at a cost higher than the cost of a permit later: this is not cost efficient. Auctioning a higher share of permits earlier on would give those companies the possibility to ensure early on their compliance (Baldursen and von der Fehr 2004).

the maximum and minimum price and the clearing price are all revealed. The generated information might be important for the market participants and make the secondary market more efficient. With regard to costs there is no clear indication if auctions are cheaper for participants compared to transaction costs on the secondary market.[47] Another difference between auctions and the secondary market is the flexibility of contracts. Participants will be more flexible to design contracts to match individual needs on the secondary market compared to an auction. Special products might be developed on the secondary market. In addition, participants are more flexible in timing transactions on the secondary market that at an auction. Thus, trades on the secondary market will be able to be in line with product sales and react on price fluctuations in other markets or unpredicted weather conditions since trading can take place every day whereas auctions will be scheduled less frequently. Finally, there might be differences in prices at the secondary market and the auction as experience has shown in Chapter 4. Auctions are sometimes able to generate higher prices compared to the secondary market. It seems that the role of the different institutions in setting price signals might change over time. Auctions might generate valuable price information for the secondary market in the early years. Later on the secondary market will dominate over auctions and will generate price signals used by auction participants for their bidding strategy.

[47] Bi-lateral trading will involve costs to assess the creditworthiness of trading partners. Over the counter trading (OTC) will charge fees depending on the volume traded (e.g. €0.025 / EUAs (small amounts) for € 0.01 / t CO2e ≥50,000 EUAs). Costs for trading at exchanges depend on the exchange. Some exchanges have only exchange fees other have entrance fees (ECX 2,500€), annual fees (ECX 2,500€/a) and variable costs per transaction (€0.002 /EUA). The costs to buy permits at the auction will mainly depend on the complexity of the auction design and the frequency of auctions.

Table 5-1: Differences between Auctions and Secondary Markets

Characteristic	Auction	Secondary market
Transparency	High, depends on design	Bilateral: low OTC: middle Exchanges: higher
Flexibility	Low	Bilateral/OTC: High Exchanges: middle
Timing	Fixed	Flexible
Costs	Preparation for bidding strategy; establishing eligibility; time spent at auction	Varies see Footnote 47
Prices	Robustness of price signal depends on participation Beginning: might inform secondary market Later: Might be influenced by secondary market	Robustness of price signal depends on participation Beginning: might be informed by auction Later: Little difference between auction and secondary market otherwise arbitrage

Why should the government run an auction and not sell the permits on the secondary market in little shares? This question was raised in the Hungarian context since the auction volume was very little and price fluctuations have been very high in the EU ETS. A similar discussion is underway in Germany where the parliament is deciding on changing the National Allocation Plan for Phase II in order to reduce the amount of free allocation. Selling permits over the whole trading period might lead to higher revenues compared to auctioning them at the end, when price volatility is very high. However, in order to sell permits the government would have to decide which of the brokers or exchanges it will use, which might be a difficult decision. Secondly, some of the advantages of auctions compared to secondary market mentioned above might be lost (e.g. transparency), which might lead to criticism of the government.

Based on this analysis and the analysis earlier on (Section 2.1) it seems that auctions generate valuable information (e.g. transparency) and might increase liquidity on the secondary market leading to the conclusion that permits should be auctioned rather than sold on the secondary market. In order to ensure price transparency also from bi-lateral trades it could be required by government that the prices of bi-lateral trades be made available to the emission trading authority for regular but anonymous publication. This might be especially relevant in the case of trading between companies of TEEII and their electricity generators since they have already established trading relationships which might facilitate bi-lateral trading.

5.5 Other issues

In addition to the design elements mentioned above national offset credits, international linkages, penalty and revenue recycling may have an impact on the auction design.

The possibility of acquiring credits created by national offsets will reduce any potential of market power abuse. The reason for this is that, at least in the long term, regulated companies will be able to buy credits created in such projects if it proves cost-effective and thus short-squeezing the market and overstating prices will be less likely.

A similar effect is assumed from the link to the international market, through the potential use of Clean Development Mechanism (CDM) credits. Depending on supply of these credits and liquidity in the international market, it is predicted that the price at the auction will never surpass the price for issued Certified Emission Reductions (CERs) which again will reduce the risk of short squeezing as well as overstated prices.

A penalty is foreseen by the NETT which would:

> "*[…] cap the cost of the scheme at an acceptable level but also encourage compliance*" (National Emissions Trading Taskforce, 2006).

Thus, the penalty (adjusted for taxes) should function as a price ceiling and the auction price would be unlikely to go beyond the penalty rate. This would also reduce the risk for short-squeezing the market as well as for overstated prices.

Recycling auction revenue to NETS participants is inefficient because it distorts their incentives to abate with the result that marginal abatement costs are no longer equalised. In addition, it misses the opportunity to reduce distortionary taxes, an opportunity that can reduce the cost of the programme to Australia as a whole by up to 50% (Cramton and Kerr 2002). Furthermore, it might affect the bidding strategy of bidders and thus the efficiency of the auction. If the revenue is recycled based on a performance indicator (measured by emissions), it would be difficult for a bidder to assess its marginal incentive to abate, which depends on the auction price and also on the abatement strategies of all other participants. Therefore the recycling of the revenue should be independent and not include factors which would interact with the bidding strategy. Auction revenue would not flow to regulated emitting companies but would be used in other ways deemed appropriate by the government. Feasible options, which might require Commonwealth involvement, include reduction in personal income tax, reduction in corporate taxes, sector-specific reduction in corporate taxes, reduction in other taxes, subsidies for innovation and R&D[48].

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[48] Further details are discussed in the presentation of Angus Johnston at the Auction workshop held in Cambridge on the 15th of January 2007.

The Discussion paper states that:

> *"The auction revenue will be divided among the States and Territories on a basis yet to be determined, but in a manner that recognises the differing impacts of the scheme. This revenue could be used to fund assistance measure for other groups, such as households, regions or small business."*

Based on this statement, it is not envisaged that revenue recycling would impact the bidding strategy of the auction participants. In addition, companies which are likely to be negatively affected by the scheme are already compensated by free allocation of permits.

Review and commentary on options for revenue recycling are beyond the scope of this study.

5.6 Interim conclusions

5.6.1 Auction volume

The volume of permits to be auctioned will increase from 2020 when the TEEII allocations will be based on BAT benchmarks (2020) rather than individual benchmarks.

5.6.2 Market power and collusion

Any measure which promotes more participants increases allocative efficiency. Thus participation in the auction should not be restricted to those companies regulated under the ETS, since this would have the effect of reducing participation for example by intermediate companies. Raising the number of participants also reduces the risk of exercise of market power as well as collusion. Quantitative estimates on the structure of the electricity sector (Herfindahl-Hirschman Index) and qualitative analysis indicate that market power and collusion is unlikely to prove a concern. Allowing national offsets as well as international CDM credits and a price cap through the Penalty will lower the risk of market power further.

5.6.3 Timing, frequency and liquidity

The proposed auctioning timetable structure is shown graphically in Figure 5.3.

Figure 5.3: Timing, frequency and distribution of permits across auctions

Auction date Year	Qtr	10/11	11/12	12/13	13/14	15/16	16/17	17/18	18/19
		Financial Year of Emission Permit Vintage							
2009	Aug								
	Nov	20%							
2010	Feb								
	May	20%	20%		20%				
	Aug	15%							
	Nov	15%							
2011	Feb	15%							
	May	15%	20%	20%		20%	4 products available at auction		
	Aug	s_i	15%						
	Nov		15%						
2012	Feb		15%						
	May		15%	20%	20%		20%		
	Aug		s_i	15%					
	Nov			15%					
2013	Feb			15%					
	May			15%		20%		20%	
after review	Aug			s_i	15%				
	Nov				15%				
2014	Feb				15%				
	May				15%		20%		20%
after review	Aug				s_i	15%			
						etc			

Notes:

- % denotes proportion of a_i (permits of one vintage available for auctioning excluding the TEEII reserve).
- s_i is the surplus of the TEEII reserve, which will be available for auctioning at the end of the trading year.
- The light shading for some of the auctions held in 2013 and beyond indicates that the timing and quantum will be subject to a review some time after the start of the ETS.

Since early price signals and liquidity are both important in an immature market, it is recommended that auctions be held before the start of the scheme (e.g. November 2009, May 2010). Auction dates would be pre-determined and published in an auction calendar in order to give companies enough time to generate necessary information for their bidding strategy.

Spot auctions would take place quarterly to strike the right balance in minimising transaction costs and enabling both price and quantity risk management. It would also assist government to generate higher revenues if prices are volatile since auction dates are diversified. The timing of the quarterly auctions could be in line with the existing auctions for the settlement of residues of the electricity market (August/ November/ February/ May).

One and three year advance auctions would be held once a year simultaneous with the spot auction in May. Advance auctions would be held only once a year since there is not much difference regarding uncertainty and risk situation within a given year. In addition, it would reduce transaction costs and make a higher volume available at this one auction. This decision will make the auction date in May more important than the other auction dates. As shown in Figure 5.3, from May 2011 and onwards, initially four, then three, vintage products would be made available for simultaneous auction.

A slightly front-loaded distribution of permits of one vintage across the advance and spot auctions is proposed: 20% of all permits available for auction for a particular year (a_i) at each advance auction and 15 % of a_i at each spot auction date. The reminder of permits of the TEEII reserve (s_i) would be included in the last auction in May or, if this is not feasible, in August.

The interaction between the characteristics of participants and the way that vintages are offered (with respect to frequency of releases) creates some complex design issues. Since little experience with regard to auction timing, frequency and distribution of permits across auctions is available it is appropriate that experimental analysis be conducted to validate some elements prior to implementation. Further, it is appropriate that the design recommendations be reviewed after three years of implementation and changed if other options (e.g. longer term advance auctions) would appear to increase efficiency of the market.

The process would continue into the future as determined by the three year review.

6 RECOMMENDED AUCTION TYPE AND DESIGN FEATURES

This Chapter 6 describes the features of the system recommended for use in auctioning the emission permits in an Australian ETS as outlined in the Discussion Paper.

In this chapter:

- Sections 6.1 to 6.8 discuss the auction characteristics in more detail.
- Section 6.9 deals with some of the mechanics of conducting the auction electronically over the internet.
- Section 6.10 cross refers auction design elements to auction design objectives.
- Section 6.11 discusses how the proposed auction design relates to the Key Auction Design Issues identified in Section 3 of the Background Paper. This section also covers more general features that do not relate to the auction design itself such as the timing and frequency of auctions and the amount of permits being auctioned. To a large extent, it is based on the conclusions of Chapter 5. Where applicable, cross reference is made to other chapters.

The recommended auction system has the following characteristics:

- ascending clock auction with iterative sealed-bidding in multiple rounds;
- uniform pricing;
- aggregate demand revealed in each round;
- simultaneous auctions with different vintages auctioned at the same time;
- allow TEEIIs and other recipients of free permits to sell these permits in the auction (double auction extension);
- proxy bids to accommodate small participants; and
- internet auction platform.

In addition, augmenting the auction with intra-round bidding should be considered.

6.1 The ascending clock auction

The ascending clock auction has been introduced in Section 3.2.5.

While the motives for trading emission rights are differences in individual valuations and CO_2 abatement costs, emission permit auctions cannot be analysed under a pure independent private values model. Due to the existence of secondary markets and the possibility to trade emission rights after the closing of an auction, emission rights also have characteristics of common value items.

In fact, both the Independent Private Value (IPV) and the Common Value (CV) model (or hybrid approaches as the affiliated values model) are relevant to emissions trading. Section 3.3.3 discusses how the two models relate to an ETS. The earlier an auction (or a trade) takes place, the more relevant is the CV model. As an emission right matures close to the reconciliation period, the common value component diminishes and then only the IPV model applies.

Whereas according to the theory, in an IPV environment all (efficient) auction formats yield the same expected revenues, this is no longer true if the CV model applies, or if the auctioned items have at least a common value component. In this case an English auction generally performs better than a sealed bid approach. Thus, a multi-unit extension of the English auction, the ascending clock auction, is recommended for auctioning emission rights in Australia. The iterative bidding procedure has the advantage of revealing additional information to the bidders (cf. the linkage principle, Section 3.4.2), thereby reducing the bidders' uncertainty regarding the value of the emission permits and leveraging expected revenues of the auctioneer. In addition, an iterative format is more likely to result in an efficient allocation.

Furthermore the proposed format has the advantage of being a simple procedure that is easy to understand. It can easily be implemented as a web-based application and thus the government's costs of preparing and running the auction are low. The same holds for the bidders' transaction costs for participating in the auction. As internet access and a web browser are the only technical requirement for participating, technical preparation costs are low.

In order to limit potential abuse of market power, it is recommended that each bidder's initial bidding eligibility be limited to 20% for all permits available in the auction. Review of the background data relevant to an Australian ETS system indicates that this cap will not impose a severe restriction on any of the potential bidders.

In the context of emissions trading, clock auctions are common formats: it was adopted for the initial UK ETS auction and is proposed for use under RGGI.

6.2 Uniform pricing

The auction applies a uniform pricing scheme that provides a strong signal regarding the participants' aggregated estimates of the future value of a permit and thus the economy's marginal abatement costs. It should be noted, however, that the uniform pricing scheme also raises an incentive for bid shading and demand reduction. In particular, if a few large bidders dominate the market, the resulting price is likely to understate the true marginal costs. However, as demonstrated in Chapter 5, in the Australian context no participant has a market share greater than 15%. As a consequence demand reduction is expected to have only a minor impact.

6.3 Information Revelation

In principle conducting an ascending clock auction provides several options for information revelation. After the end of each round, the auctioneer could:

- indicate only whether total demand exceeds supply and whether an additional round of bidding will be conducted; or

- publish the total demand which has been submitted; or
- publish the number of active bidders; or
- reveal every individual bid.

Publishing the total demand at the end of each round improves transparency and increases the information available to participants. This information reflects the aggregated (reported) demand curve and relates to the economy's abatement cost curve. To the extent by which bidders shade their bids, the reported demand understates the abatement costs. However it still provides valuable information for planning purposes and re-evaluation of individual business assessments.

In addition to generating better planning data for bidders, publishing the total demand at the end of each round has another advantage: according to the linkage principle, revenues are increased by the publication of any information which is linked to the (unknown) value of an auctioned item (cf. Section 3.4.2). A contrary argument is that by revealing the total demand, participants are in a better position to estimate the final price of the auction before it actually closes. This guides bidders regarding optimal bid shading and may result in more heavily shaded bids and stronger demand reduction.

On balance, we believe that revealing total demand at the end of each round will result in better outcomes. This information will help bidders in refining their future bids. Moreover, it may increase expected revenues. We also consider that the recommended multiple round ascending clock design performs as well or better than a static uniform price auction in which bidders face greater uncertainty as to the future market price of a permit.

Similarly, one could argue that publishing all individual bids at the end of each auction round, might be even more beneficial for both the bidders and the auctioneer. This alternative, however, is not favoured for the following reasons:

- The potential value of this information revelation is rather weak;
- It adds unnecessary complexity to the mechanism; and
- Publishing all individual bids opens the door for collusive behaviour.

As to the first bullet point in the context of a single-unit English auction, theoretical academic analysis tends to consider not the English, but a particular variant also know as a Japanese auction. In this variant, all bidders stand visibly in the auction hall while a clock continuously raises the price. Once a bidder wishes to drop out, she sits down. The auction continues until only one bidder is still standing. The auctioned is modelled on the basis that at any time all bidders know precisely the number of bidders remaining and at what prices others dropped out. The identities of the bidders who have dropped out or who are still active, however, are not considered. This is because it does not need to be considered: if signals are symmetrically distributed, knowing the bidders' identities does not provide additional information which is linked to the value of the auctioned item in the sense of the linkage principle. Even though in a multi-unit emissions permit auction, the identities of the bidders may carry some information relevant to the later market price of the permit (e.g. a large bidder might have done more extensive studies prior to the auction), the value of this information is likely to be only marginal.

Regarding the second bullet point above, the number of bidders in the Australian GHG emissions permit auction is likely to be relatively large and the auction is likely to be conducted in a relatively short time frame – possibly less than 30 minutes per auction round. If all individual bids are revealed, the information flow is tremendous and it is unlikely that bidders will be able to extract valuable information from individual bids in such time intervals. Moreover, small bidders that cannot invest in excessive bidding support systems might be disadvantaged.

Finally, as to the third and final bullet point above, observing and reacting to individual bids allows for effective and collusive coordination of strategies. Consider, for example, simple tit-for-tat strategies by large bidders who reduce demand from round to round in a coordinated manner, but immediately stop doing so once the competitor does not follow at similar speed. Such bidding behaviour can establish highly effective collusion and might result in low revenues and poor efficiency. If individual bids are not published, however, such collusive strategies cannot be enforced. Moreover, bidders cannot exchange messages through the bidding mechanism (signalling) as neither the sender (bidder) nor the content (individual bid) of a message is revealed.

It is, however, recommended that all individual bids be published after the closing of an auction (cf. also Section 6.11.12). Publishing all individual bids after the auction has closed, has the additional advantage of providing even more information to the bidders and will allow a subsequent academic analysis of the auction. It is probable that the information will leak out to at least some bidders. Immediate wide publication removes potential asymmetries by making the data universally available. If all individual bids are published, the number of active bidders is automatically revealed as well.

6.4 Proxy bidding

Even though a clock auction can be conducted in a single day with just a handful of rounds, a small bidder may prefer to submit a single demand curve to be used throughout the auction, rather than participate explicitly in each round. Similarly, a bidder may not want to closely follow the auction at all times, but be allowed to be absent for some time without disadvantage. For this reason, it is recommended that the auction allows and supports tools for proxy bidding. (c.f. Section 3.2.7)

In the ascending clock auction a proxy bid is a demand curve specified by the bidder and submitted to the system. The system then automatically bids on behalf of the bidder according to her proxy bid. In so far, as the proxy bid governs the bidders' actions in the current or future rounds, it can be updated or deleted by the bidder at any time. Also, submitting proxy bids should be possible at any time during or before the auction. With the possibility of proxy bidding, a bidder has the option of simply entering her demands at the beginning of the auction, just as in the uniform-price auction, or submitting bids iteratively as the auction progresses. Indeed, with proxy bids allowed, the ascending clock auction provides additional flexibility to the bidders. They can treat the auction as a uniform-price auction or they can take advantage of price discovery if they find it valuable.

6.5 Intra-round bidding

A desirable option is to augment the recommended auction mechanism described above with intra-round bidding (Ausubel and Cramton, 2004).

In the Australian ETS, bidders are expected to face large uncertainties regarding the value of a permit. Against this background, bid increments in the range of about 5% are already finely grained. Therefore intra-round bidding may not be necessary. Nonetheless, intra-round bidding is still likely to smooth the clearing process. It has the advantage of minimising the importance of rationing (tie-breaking) and it enhances auction efficiency. As was shown in the example in Section 3.2.8, intra-round bids may also increase revenue. Moreover, with intra-round bids allowed, the auctioneer may choose to use larger bid increments and thereby speed up the auction process. The potential downside of the latter option is that larger bid increments reduce the number of auction rounds and thus reveals less information to the bidders.

Intra-round bidding is used in the majority of high-stake clock auctions. Bidders find the approach easy to understand, and its implementation is simple for the auctioneer. Moreover, while bidders can take advantage of intra-round bidding, they are not required to do so. We recommend intra-round bidding for the Australian GHG permits auctions, subject to further study as described in Chapter7.

6.6 Auctioning different vintages

Emission permit auctions will have to deal with permits of different vintages. According to the proposed timing of auction events set out in Section 5.6, in one of the quarterly auctions each year permits of different vintages will also be auctioned.

In the proposed ETS, banking of permits from one period to the next will be allowed. If not being use for compliance in a given year, a GHG permit can be transferred to and used in later years without restrictions. To this extent, emission permits can be considered as substitutes although not perfect substitutes. They will be heterogeneous in nature because only very limited borrowing will be allowed.

GHG emission permits might also have complementary features. A power generator, for example, might have the possibility to invest in an abatement measure that will reduce emissions over a five year period. If the generator does not invest in the measure, he will need additional emissions permits for this period. Emission permits for only the last year of this period will be relatively useless if the generator is not able to also obtain permits for the earlier years of this period. This constitutes the so-called exposure problem which in non-combinatorial auction formats may lead to rather defensive bidding as (particularly risk averse) participants would tend to avoid the risk of obtaining and paying for an incomplete, rather worthless bundle.

If the complementary characteristics of the auctioned items were strong, a combinatorial auction which allows bidding on packages of allowances might be worth consideration. We do not recommend a combinatorial approach because the complementariness is likely to be small. In addition the existence of a secondary market reduces and perhaps completely eliminates the exposure risk. In the above example, the generator would be able to either sell an incomplete package or top it up to a valuable combination of permits in the secondary market. Thus, conducting a combinatorial auction is not necessary. On the contrary, a combinatorial design would be more complex with the increased complexity more than offsetting potential advantages.[49]

Because emissions permits of close vintages are strongly substitutable, the auction system should be designed in a way to explicitly address this issue. A **sequential** auction does not ensure that similar items sell for similar prices: it is not a favourable design. However a **simultaneous** approach has distinct merit. By allowing bidders to shift their demand from one vintage to another, a simultaneous auction offers the necessary flexibility to deal with highly substitutable items. In fact, since the FCC spectrum auctions (cf., e.g., Cramton, 1997), simultaneous auction formats have become common for large scale auctions and have proven very successful.[50] Bidders find them intuitive and easy to understand.

Thus, a **simultaneous ascending clock auction** is recommended for auctioning several vintages simultaneously. In the context of the Australian ETS, it is recommended that all clocks apply the same incrementing rule (see Section 6.8 for details on bid increments). Moreover, in contrast to the general format a simplified ruling regarding bidding eligibilities is suggested. Rather than implementing bidding eligibilities on individual vintages, it would be sufficient to consider only an aggregated bidding eligibility over all vintages. This means that a bidder's eligibility only limits her total demand, being the sum of all demand bids submitted for the different vintages. It is recommended to also restrict a bidder's total eligibility to 20% of all permits offered in an auction if several vintages are auctioned in the same auction event.

6.7 Double auction extension

The Discussion Paper proposes to allocate most of the emissions permits for free and only a minor share by means of an auction. In addition many permits will be awarded to companies of the TEEII sector which have a private valuation of zero for them. Thus, if the free allocations are known before an auction starts, there could feasibly be both net buyers and net sellers. Net buyers are those companies that have a residual demand and wish to acquire additional permits in the auction; net sellers are those companies that

[49] Note that there are relatively simple combinatorial auctions formats which even allow for open and iterative bidding procedures (Ausubel and Cramton, 2004). Still, they are more complex than the simultaneous format recommended here.

[50] One indicator for a high efficiency of the resulting allocation for example is that in simultaneous auctions similar items generally sell for similar prices.

have more permits than they will actually use themselves. TEEII companies would probably be net sellers.

If only the government sells permits in an auction, only those companies which have relatively high abatement costs have an incentive to participate in the auction; net sellers like TEEII companies are not expected to participate. Thus the companies that will participate in the auction represent a biased sample of all companies involved in the ETS. If bidders do not take this issue appropriately into account, the auction will be more competitive than the later secondary market leading its closing price to overestimate the future development of the market price: the resulting allocation may be inefficient.

For this reason, it is appropriate to extend the auction format in a way that allows companies, which already possess emission permits, to sell these permits in the auction. The auction then takes on the characteristics of a double auction. This adds some complexity, but has the advantage that the double auction format is likely to result in a more efficient outcome. Transaction costs for net sellers will be low compared to the secondary market. As a consequence of a less biased sample of participants the auction will generate more reliable price signals than its one-sided counterpart. Finally, the non-vertical supply curve also reduces the incentives for demand reduction (cf. Sections 3.2.9 and 0).

As extending the auctions to a double or two-sided format is expected to increase efficiency, the government should create an incentive for participation by not charging the sellers transaction fees.

6.8 Bid increments

Bidding levels are determined by relative bid increments (percentage points) and rounded to 10-cents amount. The auction starts at relatively large increments which are reduced as the excess demand decreases. If the recommendation for intra-round bids is not adopted, auction increments as determined by the auctioneer should be relatively fine grained, more so than would be the case if intra-round bids were allowed.

6.9 Conducting the auction

For running the auction, an internet bidding platform is recommended. From the bidders' side internet access as well as a standard web browser should be the only technical requirements. State-of-the-art security is now fully supported by the standard web browsers.

The recommended auction format is easy to realise in a web application. In particular the discretionary clock allows a straightforward implementation. Some care should be devoted to designing the user interface. Several software vendors support ascending-clock auctions. The software has been used in high-stake auctions worldwide over many years.

6.10 Relationship between design features and auction objectives

Table 6-1 describes in summary form how each of the recommended auction design features contributes to achieving the various auction objectives.

Table 6-1: Effect of auction design features on auction objectives

	AUCTION OBJECTIVES											
AUCTION DESIGN ELEMENTS	Limit market power	Maximise bidder participation	Allow new entrants	Reduce entry barriers	Flexible to future change	Allocative efficiency	Early, transparent and accurate price signals	Reduce price volatility	Raise public revenue	Credibility of system	True and binding bids	Low transaction costs
Financial year vintages			x		x							
Six auctions for any one vintage					x	x	x			x		x
Ascending clock auction	x					x	x	x	x	x		
Multiple iterative rounds of sealed bids	x					x	x		x			
Uniform pricing						x	x	x				
Reveal aggregate demand after each round	x		x			x	x	x	x	x		
Simultaneous auction of different vintages		x				x	x	x				x
Double auction extension	x	x	x	x	x	x	x	x		x		x
Allow proxy bids		x										x
Internet platform		x	x	x	x							x
Possible intra-round bidding						x			x			
Fine grained lot size	x	x	x	x	x	x						x
Individual caps	x	x	x							x		
Bid deposits										x	x	

6.11 Discussion of 'Key Auction Design Issues'

A number of Key Auction Design Issues were raised by the NETT in the Background Paper. These have all been addressed in this report. For ease of reference, we provide below a ready cross reference to each of those issues.

6.11.1 Collusion (Background Paper, 3.1)

Refer Section 3.4.6.

Collusion is not expected to be a major issue, because the market is characterised by many small participants. In addition, the proposed auction design is quite robust against collusion.

It is recommended that individual bids not be published during the auction process. Rather an auction clock ticks in increments specified by the auctioneer. This makes collusive coordination of individual bidders' strategies very difficult. Moreover, for auctioning different vintages, simultaneous auctions are proposed as opposed to a sequence of individual auctions. This further impedes collusion.

6.11.2 Market structure and power (Background Paper, 3.2)

Refer Section 5.1.4.

Since there is neither a single nor a small set of companies which individually or combined dominates the market, the risk of abuse of market power is very low. Market power is further limited by establishing caps on individual bidding eligibility (cf. Section 6.11.8).

6.11.3 Bidder behaviour (Background Paper 3.3.1)

Refer Sections 5.4, 3.4.3, 6.7

The auction design addresses the risk of the winner's curse by its iterative format and by publishing the aggregate demand of all previous rounds.

Bidder participation can be maximised by auctioning as large a share of permits as possible. For example, adopting a double auction extension by inviting TEEII companies as sellers will increase the attractiveness of auctions. Small lot sizes will permit small bidders to access quantities that best meet their needs.

6.11.4 New entrants (Background Paper 3.3.2)

Refer Section 5.6

During the first 3 years quarterly auctions are recommended which will ensure that there will be some supply of permits available to new entrants on the market. After the first three years (from 2013 onwards) there will be at least yearly auctions. The review after 3 years could assess the importance of the auctions for new entrants and make recommendations on that basis if more than one auction per year were to be run.

6.11.5 Lot sizes and packages (Background Paper 3.3.3)

The proposed clock auction implicitly defines lot sizes of one t CO_2-e. The finely grained lot size maximises flexibility and minimises barriers to entry. The small lot size does not have any negative impact on transaction costs, as in the proposed auction format, transaction costs do not depend on the size of the smallest lot.

As emission permits are almost substitutes rather than complementary items, there are no major package problems. To some extend, the simultaneous auction format even facilitates composing bundles of high individual value, and the existence of secondary markets reduces the risk of exposure.

6.11.6 Timing and frequency of auctions (Background Paper 3.3.4)

Refer to the extensive discussion in Section 5.6.

6.11.7 Accommodating change in market characteristics (Background Paper 3.3.5)

The final design recommendations included at Section 5.6 provide for a review of the long term auctioning and a change for the TEEII after the first 3 years. This review can also be used to make other changes to accommodate change in the market characteristics.

6.11.8 Eligibility requirements (Background Paper 3.3.6)

The pool of potential bidders should not be limited. Eligibility to bid in the auction should include all companies covered by the ETS as well as third parties such as banks or intermediaries. All participants should be required to demonstrate seriousness of purpose by establishing registry accounts and providing the required deposits.

Before an auction starts, bidders will be required to qualify for the auction and to apply for individual eligibility. A bidder's eligibility defines the maximum number of permits she is entitled to bid for in the auction. Caps established on individual eligibility should be strict enough to effectively prevent exercise of market power, but liberal enough in order to allow for sufficient flexibility and not negatively impact efficiency.

Section 6.1 argues to implement a simple and flat cap on bidders' individual eligibility of 20% of all permits available in the auction. According to the data about the Australian ETS system, this cap will not impose a severe restriction on any of the bidders.

Before the auction starts, bidders should be required to deposit a cash amount as security equal to the individual eligibility the bidder has applied for times the reserve price of the auction. Depending on the number of permits a bidder finally acquires and the auction's closing price, the deposit will be either reimbursed or deducted from the bidders' payment for the permits she acquires.

In addition, each bidder should provide a bank certificate confirming financing for the transaction. The total amount a bidder spends in the auction is limited by that certificate.

6.11.9 Auction format (Background Paper 3.3.7)

The proposed auction format and its effectiveness in meeting the auction objectives is described in detail in this Chapter 6.

6.11.10 Reserve prices (Background Paper 3.4.1)

Refer Section 3.4.5.

The reserve price should be sufficiently high to ensure that the auction does not run too long. On the other hand, it should be low enough in order not to hamper efficiency.

A reserve price of 33% of the lowest estimate of a future permit prices or a comparable permit traded in another ETS (e.g. Europe) might be a good benchmark. If at this price, demand were smaller than supply, this would indicate that the overall cap was set too defensively, rather than that the resulting allocation is inefficient. There will be no need to sell the remaining quantity at a lower price.

Identical reserve prices should be set for each vintage in each auction event, for each auction in a given year and for the auction events of all coming years. However some adjustment over time might be necessary. For example, if in a particular year total demand were more than about four times total supply, it would be appropriate to increase the reserve price for the up-coming auctions. An indicative new reserve price could be the price in the most recent auction at which total demand was exactly twice as much as total supply.

On the other hand, in an auction event if the total demand in the first round (i.e. at the reserve price) is lower than the total supply, it is arguable that the cap is too defensive and it might be better to reduce the cap rather than reduce the reserve price.

6.11.11 Loopholes and gaming (Background Paper 3.4.2)

No loopholes are known for the proposed auction format. The experimental studies recommended in Section 7 should verify the suitability of the recommendations.

6.11.12 Credibility of auction rules (Background Paper 3.4.3)

Refer Section 6.3.

Compared to other auction format such as a second-price or a generalised Vickrey auction, there is nothing mysterious with respect to allocation and pricing in the proposed auction format. However, if the revealed total demand in early rounds was unexpectedly high and the auction price rose higher than initially expected, bidders might become suspicious whether the auctioneer published the total demand honestly.

Credibility would be ensured by adoption of the recommendation to publish all individual bids after the auction closes. In this case every bidder can easily verify how total demand and the final allocation were computed. Any inconsistency would be immediately spotted.

6.11.13 True and binding bids (Background Paper 3.4.4)

Refer Section 4.2.2.1.

Sufficient deposits and bank guarantees ensure true and binding bids.

6.11.14 Market impact of auction (Background Paper 3.4.5)

A highly efficient auction may reduce liquidity and the number of permits being traded on the secondary market. This, however, does not constitute a "negative impact" of the auction.

6.11.15 Impediments to efficiency (Background Paper 3.4.6)

The proposed format is expected to result in a highly efficient outcome. Major impediments to efficiency are unlikely.

6.11.16 Interaction between likely allocation methods (Background Paper 3.5.1)

Refer Section 6.7.

Not inviting potential net sellers to the auction may inflate the price due to the biased selection of participants. The proposed double auction eliminates this problem.

6.11.17 Practicality, administrative cost, and risk (Background Paper 3.5.2)

It has been argued in Section 6.9 that the costs of running the proposed auction are relatively low as are the costs for the bidding software.

Revealing relevant information during the auction process and providing the flexibility of the simultaneous format, one feature of the proposed auction design is that it exposes bidders to low risk. There is no reason why this auction design would expose the government or States and Territories to particular financial or other risks.

6.11.18 Other local features, and stakeholder feedback (Background Paper 3.5.3)

International experience, particularly in the USA, shows that the auction could equally effectively be run by an exchange/private institution or by a public institution such as the scheme regulator.

The review in Chapter 4 of auctions relating to other commodities including Treasury bonds and settlements of residues auctions leads to the conclusion that emission permits are different in many ways (e.g. vintages, banking, compliance periods) therefore it was decided that a permit specific auction design was most appropriate.

6.11.19 Trial/experiments (Background Paper 3.6)

Refer Chapter 7.

Laboratory experiments prior to running the auction might be beneficial both to test the software and to spot potential problematic issues of the design.

6.11.20 International models (Background Paper 3.7)

Refer to Chapter 4 for lessons learned from relevant international experience.

7 FUTURE ACTIONS

Auctioning emissions permits is a complex mechanism where little experience yet exists. Every environment is different and it is difficult to transfer lessons learnt from one situation to another.

Testing design choices in a laboratory before actually implementation has proved to be useful as can evidenced by the SO_2 auction, where experiments conducted after the actual auctions revealed fundamental inefficiencies in the design. In situations where little empirical evidence exists, but where choice exists in the design and where the actual result is dependent on human behaviour then laboratory tests are a way to make a more informed decision.

Conducting an experiment will also ease the implementation of the actual auction.

It is worth noting that the cost of running experiments is small compared to the potential losses from a poor design. In addition the experimental platform can be used to train companies which will tend to improve general acceptance by market participants.

Accordingly we recommend that some of the design elements proposed in this report be tested by experimentation in the laboratory before making final decisions.

The elements which seem to be the most important ones to be tested are:

- the intra-round bidding in the double sided clock auction compared to the situation without intra-round bidding,
- simultaneous vs. sequential double-sided multi-clock auctions, and
- issues relating to the timed release of permits of a vintage comparing relative shares in advance auctions against spot auctions

8 GLOSSARY

Auction efficiency – An auction is said to be efficient if the auctioned items are awarded to the bidders who value them most highly.

Clean Development Mechanism (CDM) – Allows Annex I parties (industrialised countries) to implement projects that reduce emissions in non-Annex I parties (developing countries), and in so doing obtain Certified Emission Reductions. A CER is equal to one tonne of CO_2 equivalent (CO_2-e). The purpose of the CDM is to assist parties not included in Annex I in achieving sustainable development and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments.

Joint implementation (JI) - Allows Annex I parties (industrialised countries) to implement projects that reduce emissions, or remove carbon from the atmosphere in other Annex I parties, in return for emission reduction units (ERUs).

Marginal value - The value a buyer places on acquiring one more unit of something.

Market clearing price – The price at which the quantity of a good demanded in a given time period equals the quantity supplied.

Market liquidity – A characteristic of a market where participants can trade when they desire and the market allows large transactions without a substantial change in market price.

Market power – A participant is said to exercise market power if she has the ability to influence the price or other outcomes in a market.

Price discovery – The process of determining the market clearing price for goods through the interactions of buyers and sellers.

Revenue – The gross proceeds that result from sales of goods or services.

Secondary market – A secondary market is a market in which previously issued financial assets are traded between buyers and sellers.

Trading year – The year for which a vintage is issued and surrendering of permits is foreseen.

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