MSc Thesis

Counterparty risk and collateral calculation at the APX-ENDEX energy exchanges

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Executive summary

APX-ENDEX is an energy exchange that provides a platform to trade power and gas in the Netherlands, Belgium and the United Kingdom. The company acts as central counterparty for its spot markets, which exposes it to counterparty risks such as market and credit risk. This research evaluates the risks involved, the exposure APX-ENDEX has to these risks and the ways to cover for this exposure.

The research consists of two parts. In the first part the counterparty risks involved were identified, the ways to cover for these risks were investigated and an assessment was done whether the current risk capital structure is adequate given the risks found.

The counterparty risks faced by APX-ENDEX are linked to the contractual obligations it takes on to handle clearing and settlement of transactions. This entails delivery risk towards sellers and credit risk towards buyers, with the exposure depending on the commodity and the market.

Several ways to cover for these risks where found. The ways to cover for counterparty risk under normal market conditions are to set participant requirements, enforce position and trade limits and to set a collateral requirement. The ways to cover for counterparty risks under extreme market conditions are to set up a default fund, take out insurance or lay down a claim on members to cover residual losses.

The current risk capital structure employs the viable coverage ways from the ones named earlier, excluding insurance and a residual claim. A confrontation of the risk capital structure with the different counterparty risks that APX-ENDEX faces did not lead to suggestions for amendments. Therefore it can be concluded that the current structure is in line with what literature and the recommendations for central counterparties suggest and is well suited to cover the exposure to the counterparty risks faced by APX-ENDEX

After the conclusion of this first part of the research, the second part of the research focused on the main element of coverage; the amount of financial security requested from the members.

Based on an analysis of the current methodology and the characteristics of the data available, and input gathered from a literature review, a benchmark of methods in use by other energy exchanges and interviews with stakeholders, several alternative calculation methods were formulated.

The last step of the research dealt with setting up criteria, and comparing the performance of the alternative methods on these criteria. The criteria used are measures of prudentiality (how well does the method cover the exposure, and what is the magnitude of the shortfall that is to be expected) as well as measures of opportunity costs imposed by financial security demands. Furthermore the issue of combined collateral across different markets for the same member is addressed as well as the contribution to the default fund.

The outcomes are outlined in the following two sections for the collateral requirement (for the auction) and margin level (for continuous trade).

Auction collateral

Currently a member taking part in the auction in Belgium as well as in the Netherlands faces separate collateral charges, even though it could have positions in these markets that would offset each other. The consolidation of the clearing operations into one legal entity opened up the possibility to introduce a single combined collateral requirement for these two markets. The suggested approach comes up with a netted exposure figure for each day, taking into account the difference in delivery risk between these markets. This allows for a simplification in the formulas needed which also makes the approach easier to understand. When applying this netting approach while keeping the rest of the calculation methods the same, a drop in collateral level of 5% to 20% could be expected, depending on the member and its trading behaviour.

The analysis of alternative methods identifies the 'Exponentially Weighted Moving Average' (EWMA) as a viable alternative method for the calculation of the collateral requirement. This method has some attractive characteristics, such as letting the collateral requirement decline gradually, with a certain persistence, after a peak has occurred and has a rationale in the choice of parameter setting.

In the tests for performance EWMA outperformed the current 'Simple Moving Average' (SMA) method on the measures of prudentiality as well as the measure of opportunity costs; for moderate to high persistence choices of the EWMA parameter.

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Continuous margining

The performance tests done on the alternative margin setting methods for continuously traded instruments gave the impression that the more reactive methods outperformed the current fixed margin method. However, from the results of a stress-test it can be concluded that a fixed collateral level is more prudent and clearly provides a better cover than the reactive margining methods. The reason is that while the reactive methods let the margin decline when volatility allows for it, this in turn increases the magnitude of the shortfall when the next peak occurs. Given that the total shortfall scales with the position of a member, the resulting total uncovered exposure is higher than with a (non-declining) fixed margin.

It is therefore recommendable to keep the fixed margin method and regularly review the adequacy of the chosen levels for the different instruments and adjust these where needed.

Since the markets are relatively illiquid the choice of the somewhat 'high' amount of 50% of initial margin in the current system being available for mutualisation of losses can be considered prudent.

Contents

1 Research Approach

1.1 Introduction

APX-ENDEX is an exchange that provides a platform to trade power and gas in the Netherlands, Belgium and the United Kingdom. The company acts as central counterparty for its spot markets, providing clearing services that make the market more efficient, allow for anonymous trading and lower the counterparty risk exposure for trading members.

By providing these services the company is exposed to counterparty risks such as market and credit risk. The company currently covers the exposure to these risks with a collateral setup that is based on historical 97% VaR calculations. Recent developments however, such as a legal consolidation of the company's clearing activities, lead to possibilities to net exposures across markets which potentially should allow for a lower collateral requirement. Combined with the fact that collateral requirements were up until now determined from a commercially pragmatic point of view, this leads to the wish for academic research on the elements and boundaries of the risk capital structure and the way the collateral requirement is calculated.

1.2 Project goal

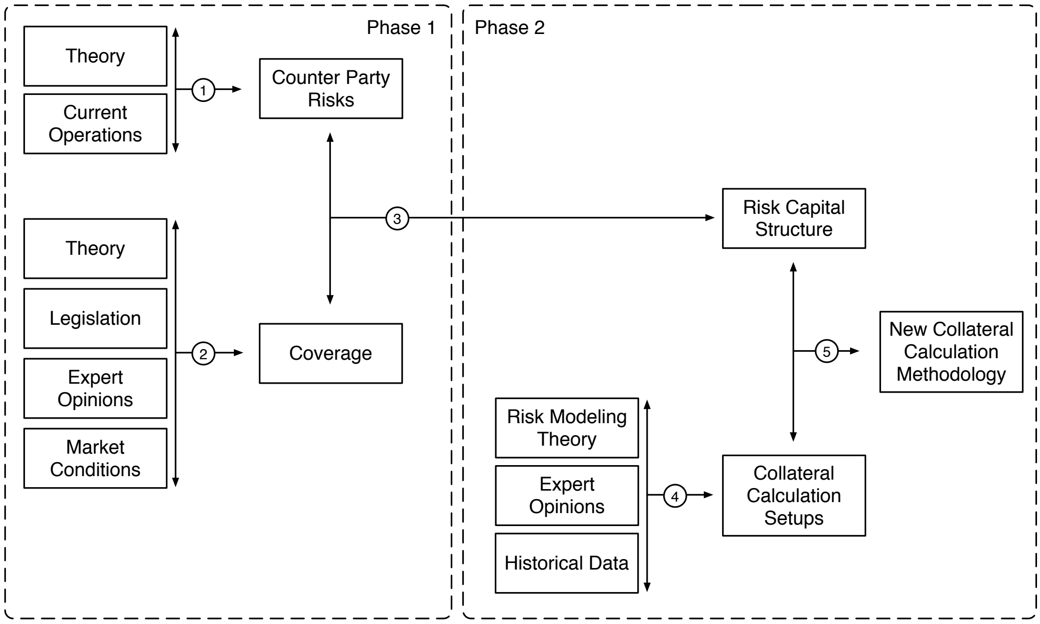
The goal of this research is to revise the risk capital structure of APX-ENDEX based on an assessment of the counterparty risks it faces, to generate alternative collateral calculation methodologies that fit in with this structure and subsequently to test the performance of these methodologies against the current method.

The scope of the research are the counterparty risks faced by APX-ENDEX in its clearing function for Power and Gas, Day-Ahead and Intra-Day spot markets, for the Netherlands, Belgium and the United Kingdom.

1.3 Research model

Following the methodology for setting up a research of Verschuren and Doorewaard (2005) and the tips from the Thesis Toolbox (Universiteit Twente, 2010) the following research model (depicted in figure 1) and research questions are formulated.

The research is split in two parts, first getting an overview of the exposure to counterparty risks and assessing whether the current risk capital structure needs to be amended, followed by developing ways to model the risk and calculate collateral within the boundaries set by the risk capital structure.



Numbers reflect the corresponding research question

Figure 1: Research Model

1.4 Research questions

1. What kind of exposure does APX-ENDEX have to counterparty risks in its function as central counterparty in its gas and power spot markets?
   (a) What are the operations of APX-ENDEX?
   (b) What kind of counterparty risks does APX-ENDEX face in its operations?
   (c) What happens in case of a default by a counterparty?
   (d) How is APX-ENDEX exposed in case of a default by a counterparty?
2. What methods are there for a clearing house to cover the exposure to counterparty risks?
   (a) What are the possible elements of a risk capital structure?
   (b) What is the required coverage level?
   (c) How do trading members handle counterparty risk?
3. Does the current risk structure need to be amended?
   (a) What is the current risk capital structure?
   (b) What are the expectations of the stakeholders about the risk capital structure?
   (c) Given the risks and coverage methods, is there a a need to amend the current elements or boundaries of the risk capital structure?
4. What alternative methods are there to calculate the collateral requirement for the exposure to counterparty risk?
   (a) What is the current calculation methodology?
   (b) What is the opinion of the stakeholders on the current calculation methodology?
   (c) Which ways are there to model the exposure and calculate collateral from literature?
   (d) In which ways do other clearing houses calculate the level of the collateral requirement?
   (e) Based on the methods and models, formulate alternative collateral calculation methods.

5. How does the performance of the alternative collateral calculation methods compare to the performance of the current methodology?
    (a) What are the criteria on which to compare the collateral calculation methods?
    (b) How does the performance of the alternative methods compare to the performance of the current methodology?

1.5 Research design

The methodology to address these research questions are listed in table 1.

Research Question	1				2			3		
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(a)	(b)	(c)
Desk research	√	√	√	√	√			√	√	√
Literature review		√			√	√				
Interview in person							√		√	

Research Question	4					5	
	(a)	(b)	(c)	(d)	(e)	(a)	(b)
Desk research	√	√		√	√	√	√
Literature review			√			√	
Interview in person		√					

Table 1: Research methodologies

Sources:

- The necessary historical data is available for analysis from APX-ENDEX for the past 5 to 10 years, depending on the market.
- The personal interviews should happen with the stakeholders of the company when it comes to risk and collateral, namely the main shareholder (TenneT), the Finance and Commercial departments and preferably each of the four types of trading members; a bank, a producer, a distributor and a broker.

2 Research Question 1 - Risk overview

This chapter answers research question 1: What kind of exposure does APX-ENDEX have to to counterparty risks as central counterparty in its gas and power spot markets?

To answer this question first the subject of clearing and settlement in energy markets is introduced, followed by a definition of counterparty risk and how a default is handled. The chapter ends with an investigation into the exposure to the found counterparty risks.

2.1 What is the function of a central counterparty?

APX-ENDEX is performing clearing and settlement services as a central counterparty. Before looking at the specific operations, this section explains the concept of clearing and settlement.

2.1.1 What is clearing?

Clearing is defined as the matching, confirming and the settling of trades. A clearing house can carry this out by assuming an agency role or by becoming a principal to the transactions (Knott & Mills, 2002). When the clearing house becomes a principal to the transactions (the 'central counterparty' or CCP) the transaction is split into two separate contractual obligations by means of novation. Through novation, the original contract between the buyer and seller is replaced by two new contracts, one between the buyer and the CCP and the other between the CCP and the seller (ESCB-CESR, 2009). The process of novation is depicted in figure 2.

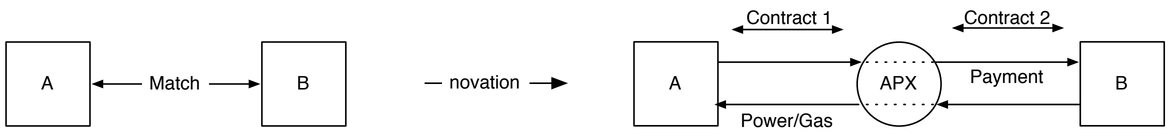


Figure 2: Process of novation

This means that normally a CCP has a 'balanced book'; meaning a net position of zero without exposure to market or credit risk. If however either of the counterparties defaults on an obligation the CCP ends up with an uncovered position, for which it requests collateral of its clearing members (Bernanke, 1990; Jackson & Manning, 2005).

2.1.2 Benefits

The benefits of using a central counterparty that handles clearing and settling are that it allows trading members to trade without concern for creditworthiness (Bernanke, 1990) and lowers overall risk by facilitating the netting of exposures (Knott & Mills, 2002). Furthermore it facilitates anonymity between trading parties

It is notable that a CCP in itself does not remove counterparty risk. If a party becomes insolvent, losses are still borne by its creditors in some way. However, a CCP redistributes these losses, replacing the exposure to several parties of variable creditworthiness with one high quality credit risk exposure (Hills, Rule, Parkinson, & Young, 1999; Knott & Mills, 2002).

2.1.3 Collateral

To secure the obligations of the different clearing members collateral is kept in the form of cash or a letter of credit from a financial institution. The collateral in cash is kept in a cash account; a bank account of the type 'in name of' or 'escrow' that is controlled by APX-ENDEX.

The collateral requirement follows from collateral calculation methodology. If the amount of collateral is too low, the trading member has to deposit extra cash into the cash account or arrange with its bank to extend the letter of credit.

The cash account is used furthermore to debit and credit payments resulting from the financial settlement (invoicing) of transactions (APX-ENDEX, 2010a).

2.2 What are the operations of APX-ENDEX?

The majority of trading in energy happens some time in advance on the futures and forward markets based on forecasts, which could make it necessary to buy extra energy or sell off excess amounts where needed. This happens on the spot markets, generally from 2 days up until delivery. This section will follow chronologically the timeline of a general transaction in the spot markets; taking the steps shown in figure 10. After this the products of APX-ENDEX are listed.

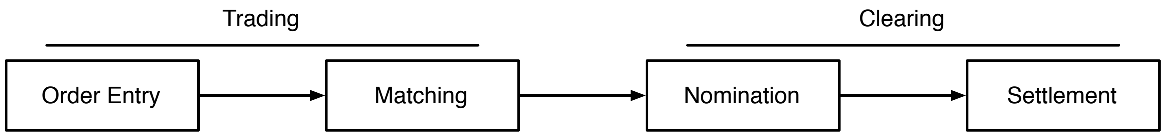


Figure 3: General steps of transaction cycle

2.2.1 Trading

As can be seen the first two steps happen within the trading environment, which facilitates two kinds of trading: by auction or continuous[1].

Trading by auction The trade by auction happens one day before the delivery day, and involves the following steps[2] (APX-ENDEX, 2009, 2010e):

1. In the morning the trading members can enter orders, in a 'closed order-book' manner. This means that the bid and ask orders are not publicly visible.
2. After the close of this phase the auction algorithm is run. This algorithm fits demand and offer curves on the orders in the order book, resulting in the 'market clearing price' for the commodity to be delivered on the next day.
3. The orders that align with this market clearing price are then matched, resulting in a number of contracts that make up the 'market clearing volume' for that day. The rest of the bids and offers are rejected.

Continuous trading Continuous trading happens before or on the day of delivery in the following way (APX Commodities Limited, 2009b; APX-ENDEX, 2010d):

1. After market opening the bid and ask offers of the trading members are eligible for trading, up to the expiry time of the respective instruments.
2. Continuous trading utilises an 'open order-book', meaning that the latest bid and ask prices and volumes are visible for all trading members.
3. A bid price in this manner for a certain volume is interpreted as the highest price for which a party is willing to buy, while an ask price is the lowest price for which a party is willing to sell a certain volume. Depending on market different order types can be put in, deciding for instance whether orders may be partially matched or have to be 'filled-or-killed'.
4. If an bid order and ask order align in terms of prices, volumes and type they will instantly be matched which will generate the corresponding contracts.

[1]It is also possible to put trades that have taken place outside the trading platform of APX-ENDEX (so-called 'Over The Counter' or OTC trades) forward for clearing, as long as both parties are clearing members.

[2]Simplified version, in reality a complex algorithm combines the bids and offers across the day ahead auctions in 'CWE' or Market Coupling Western Europe (NL,BE,FR,DE,L).

2.2.2 Clearing

After bids and offers are matched, the corresponding contracts are generated and enter the 'clearing' part of the operations. The steps taken are nomination and settlement.

Nomination Nomination is the process of letting the transmission service operator (TSO) know about the amounts of power or gas that a certain party is going to deliver or off-take from the grid/hub.

Nomination can be done single or double sided. Single sided means that APX-ENDEX handles the nominations for all parties involved in a trade. When nomination has to be done double sided every party to a transaction sends in a nomination by itself (Elia, 2010; Energiekamer, 2009). The TSO then checks to see if the nominations align before accepting them. To be able to do single sided nomination there has to be a legal basis for the special position of the energy exchange in the balance responsible contracts/grid code and/or in the law. The advantage of being able to do single sided nomination is that the exchange is always right, eliminating any risk connected to inconsistencies between nominated amounts.

Settlement Settlement deals with fulfilling the obligations of the contracts (APX-ENDEX, 2010a), requiring physical and financial settlement.

A transaction is physically settled for APX-ENDEX upon irrevocably delivery. This means that the obligation to deliver has been handed over to the TSO, as depicted in figure 4.

Financial settlement happens when the financial obligations of the trading member become 'unrealised settlement', meaning uninvoiced payments. These amounts are accrued up until final settlement when the member's cash account is debited or credited, which currently varies across the markets and happens for instance on the next business day, the first business day of the next week or later (APX-ENDEX, 2010e, 2010d).

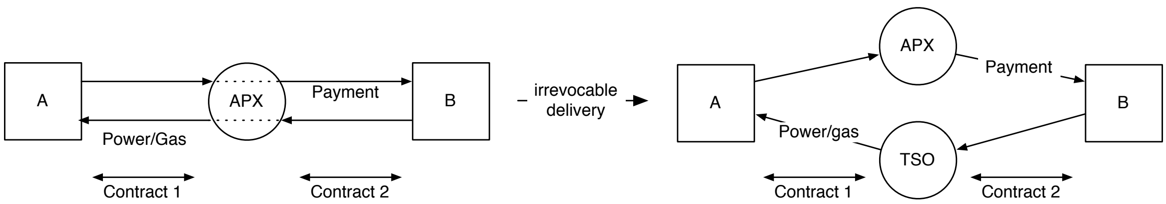


Figure 4: Irrevocable delivery

2.2.3 Markets and Products

This section introduces the instruments and markets for which APX-ENDEX facilitates trading and clearing. This is a summary, the full listing of products and timelines of operations are included in Appendix A.

Market overview Tables 2 and 3 show an overview of the markets of APX-ENDEX with corresponding start dates, amount of members and volumes traded. This overview clearly shows that not all markets are equally liquid.

Power	NL		UK		BE	
	Day-ahead	Continuous	Day-ahead	Continuous	Day-ahead	Continuous
Start	1999		2000		2005	
# members	57		60		38	
Volume Oct '10	2,968 GWh	0	0	1,013 GWh	923 GWh	22 GWh

Table 2: Power markets overview

Gas	NL	UK NBP	UK OCM	BE
Start	2003	2001	1999	2005
# members	77	75		74
Volume Oct '10	880 GWh	0	10,035 GWh	0

Table 3: Gas markets overview

Product overview The products traded on the spot markets are standardized instruments with defined volumes per timeframe. Every country and market has its own set of traded instruments, which are available for trading before or on the day of delivery.

For power the instruments are defined as MWh in a timeframe of:

- 15 minutes
- 30 minutes
- Single hour, two hours, four hours or six hours
- Every hour of the day ('Baseload')
- Every peak hour ('Peak')
- Every hour of the weekend

For gas, which has a less instantaneous nature than power, the instruments are defined in Therms or MWh per Day over the following timeframes:

- Gas delivered over the course of a day, or from moment of trading up and until the end of day
- Gas delivered per day of the working days of the next week
- Gas delivered per day of the weekend / month

Reflection on differences between products and markets

Form of trading

Trading by auctions is only seen in the power markets and not in the gas markets. The difference stems from the fact that the characteristics of electrical power are fundamentally different from natural gas. Firstly, electricity can not be stored, resulting in a big spread in hourly prices over the course of a day, while the price of natural gas is quoted at least per part of day and more stable. For trading the function of an auction mechanism that calculates prices for 24 separate hours is therefore better suited than continuous trade (although in the UK trading in electricity does happen by continuous trading) (APX Commodities Limited, 2009b; Belpex SA, 2010).

Market coupling

The day-ahead auctions of the Netherlands, Belgium, France, Germany and Luxembourg are combined via 'CWE' or Coupling Western Europe. This means that the auctioning algorithm in the markets implicitly combines bids and offers of these markets, which optimises the interconnector capacity between these countries and comes to a more uniform price for the whole region. Market coupling however only happens for the power markets, not for the gas markets. The reason can be sought in that there is already a more uniform price due to continuous trading, but also in the fact that interconnectors aren't necessarily helpful; while electricity transport is instantaneous, gas transport reduces the efficiency due to the needed compressor stations (APX-ENDEX, 2010e).

Market operator

For some of its markets APX-ENDEX is designated as 'market operator' and thus has a special position. In such a market, the nominations of the market operator are firm and irrevocable after sending in the nominations; meaning that its clearing function is only exposed to credit risk. This is the case in the Belgium power market and in Gas UK (OCM) (Elia, 2010; Gas Transport Services, 2010).

Nomination regimes

Aside from the earlier made distinction between single sided or double sided nomination, another difference present in the markets is between nomination before or after delivery, the so called 'exposed nomination'. This currently only happens in the Belgium power market, where the intra-day trading has to be nominated on D+1 before 13:00. The advantage is that trading can happen on the trade platform of APX-ENDEX very short before delivery starts (up to 5 minutes prior) without initial needed checks by the TSO (Elia, 2010).

Imbalance regimes

Where in most of the markets a balance responsible party needs to be in balance with its nominated amounts per fifteen minutes, half an hour or hour, in the British gas market this is per day only (any differences are closed against the system average price automatically). This intra day market is also the market where the TSO has to buy and sell gas quantities to balance the net. In the other markets this balancing mechanism is kept separate from the intra-day market. This does not necessarily improve liquidity; given for instance that in the Netherlands the imbalance market functions very well, this inhibits liquidity on the intra-day because normally imbalance charges would be cheaper than trading the position intra-day (Energiekamer, 2009; Elexon Ltd. 2010; Elia, 2010; Joint Office of Gas Transporters, 2010).

2.3 What kind of counterparty risks does APX-ENDEX face in its operations?

The definition of counterparty risk is: 'The risk that the counterparty in a contract will not live up to its contractual obligations' (Investopedia, 2010).

The contractual obligations of APX-ENDEX arise from the role of central counterparty, namely one party delivering power or gas and getting paid and one party receiving and paying for this commodity. The obligations are depicted again in figure 5.

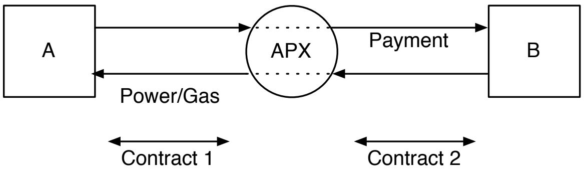


Figure 5: Contractual obligations

The associated risks of these obligations are:

Credit risk The risk that the trading member defaults on the payment obligation.

Delivery risk The risk that the trading member defaults on the obligation to deliver power or gas. In closing out this position APX-ENDEX faces two types of risk (depending on the market):

- market risk (are there parties in the market to trade with for a fair price? Which means that market risk in this sense breaks down into liquidity risk and price risk)
- imbalance risk (in the case that APX-ENDEX is unable to close out the position in time and faces imbalance charges from the TSO)

Other contractual obligations, as listed below, are defined as out of scope (see also section 1.2).

- Obligations to other counterparties not directly linked to operations, such as banks, are defined as out of scope. One notable risk however is the concentration risk of holding all the cash accounts at one private settlement bank (ABN-AMRO)(ESCB-CESR, 2009).
- The associated legal risk that comes with the clearing and settlement operations is assumed to be regulated by the European 'Settlement Finality Directive 2009/44/EC' (European Commission, 2009), which guarantees that finality of settlement and that default procedures, including margin requirements, are enforceable in case of the default of a trading member. It falls outside of the scope of this research to ascertain this, which is why it is assumed that these procedures and requirements are enforceable.

2.4 What happens in case of a default by a counterparty?

The default of a counterparty is defined as:

- the failure, or prospective failure in the opinion of APX-ENDEX, of the counterparty to meet its commitments due to an insolvency event, non-compliance with clearing rules or regulatory or legislatory steps.

In case of a default the member involved is designated as 'defaulting clearing member', setting in motion these steps (APX-ENDEX, 2010a):

1. Suspend clearing and settling of new transactions.
2. Terminate any unsettled transactions.
3. Close out any open positions by selling them out to a third party or shifting them to another clearing member, or face imbalance charges; the resulting costs of this make up the 'Termination Amount'.

2.5 How is APX-ENDEX exposed in case of a default by a counterparty?

The exposure of APX-ENDEX in case of a default depends on whether the defaulting member has a net buy or net sell position and on the market in which it happens.

2.5.1 Net buy position: credit risk

- In this case, APX-ENDEX is exposed to the principal amount of the transaction (risk profile set out in table 4 below).
- The timeline of the potential exposure runs from 'matching' until 'financial settlement'.

	Probability	Impact	Loss
Default of counterparty	1 in 10 years	Moderate	Up to principal amount contract

Table 4: Credit risk profile

2.5.2 Net sell position: delivery risk

- If a member defaults on a net sell position, depending on the market APX-ENDEX has to either close out the position and/or if that is no longer possible face imbalance charges.
- The timeline of the potential exposure runs from 'matching' until 'irrevocable delivery'.
- The extend to which APX-ENDEX is exposed to delivery risk differs from market to market. Table 5 below outlines the exact risk profiles in each market. Argumentation and sources are in Appendix F - Delivery risk profiles. These profiles assume no operational risk.

Power NL	Probability	Impact	Loss
Counterparty default after nomination E-Program	< 1 in 10 years	High, up to nominal volume against imbalance price	Position * imbalance price
Ext. inconsistency E-programs (Day-ahead)	2˜3 times per week	Only if not fixed between 14:00-23:59	Volume difference * imbalance price
Ext. inconsistency E-programs (Intra-day)	high (time pressure)	-none-, if E-program not accepted, contracts are void	-none-

Power UK	Probability	Impact	Loss
Notification not accepted due to party being in level 2 credit default	Low	APX-ENDEX could end up with an unbalanced position for SELL contracts	Cost of close-out and/or imbalance
Accepted notifications cancelled (party in level 2 credit default)	Low	APX-ENDEX ends up with unbalanced position for SELL contracts	Cost of close-out and/or imbalance

Power BE	Probability	Impact	Loss
Nomination not accepted	None	-none-, nominations single sided and accepted as-is as a match	-none-

Gas NL	Probability	Impact	Loss
Nomination not accepted	None	-none-, nominations single sided and accepted as-is as a match	-none-
Accepted nomination is rejected	Low	APX-ENDEX ends up with unbalanced position	Cost of close-out and/or imbalance

Gas UK	Probability	Impact	Loss
OCM - nomination not accepted	None	-none-, nominations single sided and accepted as-is as a match	-none-
NBP - double sided nomination not accepted (no counter nomination or wrong quantity)	Moderate	Could end up in imbalance, automatically closed against system price	Quantity against system buy/sell price
Counterparty defaults after acceptance of nomination	Low	Could end up in imbalance, automatically closed against system price	Quantity against system buy/sell price

Gas BE	Probability	Impact	Loss
Nomination rejected or unequal to counter nomination (double sided)	Low	Unbalanced position since nomination set to zero for relevant hours	Max: nominal value + 50%

Table 5: Delivery risk profiles

2.6 Conclusions

This chapter answered research question 1: What kind of exposure does APX-ENDEX have to to counterparty risks as central counterparty in its gas and power spot markets?

Tables 6 and 7 outline the exposure to the counterparty risks found in the operations of APX-ENDEX.

Risk	**NL**	**UK**	**BE**
Credit	Principal amount of contract		
Market	Cost of close out		-
Imbalance	Cost of imbalance		-

Table 6: Exposure on counterparty risks in Power spot markets

Risk	**NL**	**UK - OCM**	**UK - NBP**	**BE**
Credit	Principal amount			
Market	Cost of close out	-	Cost of close out	
Imbalance	Cost of imbalance	-	Cost of imbalance	

Table 7: Exposure on counterparty risks in Gas spot markets

3 Research Question 2 - Counterparty risk cover

This chapter sets out to answer research question 2: What methods are there for a clearing house to cover the exposure to counterparty risks?

To answer this question first the historical development of clearing houses is examined, followed by a summary of the different ways to cover for counterparty risks available from literature and recommendations. After this the prudent level up to which to cover the risks is discussed, as well as the ways to cover counterparty risk used by the clearing members in bilateral trading.

3.1 Historical development of clearing houses

The first clearing house to be established was the Banker's Clearing House in London in 1832 (Millo, Muniesa, Panourgias, & Scott, 2005), which provided a safe place for the check runners of the banks to exchange and offset checks. In 1883 the Chicago Board of Trade created a similar clearing house to facilitate margin posting and settling of contracts (Kroszner, 2000).

In its initial form, this clearing house didn't offer any guarantees but was established to reduce the costs of margin posting and settlement of contracts by standardizing the products and quality level of the commodities. This setup facilitated thus only direct clearing; purely bilateral. The clearing house had two rules in effect as risk management, namely that it had the right to ban defaulting members and to inspect the financial accounts of a member for which it had insolvency doubts (Millo et al., 2005).

The main advantage of this clearing setup was the ability to settle contracts through offset, resulting in a reduction of over 80% in the number of checks handled in the first 10 weeks. However, due to the 'direct clearing' nature there were no guarantees in place that guarded a member against defaulting counterparties. The members themselves dealt with this by forming trading 'rings'; group of traders which traded the same type of commodity. This allowed members of that ring to offset trades against the ring (Kroszner, 1999), and to be substituted for one another in case of a default (Millo et al., 2005). This setup of 'ring clearing' proved unsuccessful though, when in 1902 a single bankruptcy brought down 42% of the members of the board (Kroszner, 2000).

In the late 19th century, European coffee and grain exchanges took the next step and made the clearing house a counterparty in all transactions (Kroszner, 2000). This meant that in case of a default, the house would still make full payment, collecting as much funds as possible from the defaulting party and drawing on a fund the members of the exchange had contributed to. The further adoption of this system however was hindered by the notion of moral hazard; members with a high credit rating didn't want to be supporting the less creditworthy ones (Kroszner, 1999).

The moral hazard in this is that participants may be encouraged to take more risks in trading since they share only in a part of the losses. In other words, it might sometimes be cheaper for a trading member to default on a position than to close it out. This is what went wrong at the Hong Kong Futures Guarantee Corporation, where after the stock market crash in October 1987 an emergency guarantee fund was established separately from the clearing house. Therefore, the responsibilities of monitoring risk and covering the losses where separate, which ultimately led to the collapse of the clearing house (Hills et al., 1999).

Therefore, it is better to give the trading members an incentive to pay attention to risk management (BIS, 2004). The main approach to this is to cover defaults first by the margin posted by the defaulting member, then by the amount posted by that member to any guarantee or clearing fund and only if there are residual losses cover these by contributions of other members (Hills et al., 1999; BIS, 2004; Jackson & Manning, 2005).

The next step towards this setup was the establishment of the Board of Trade Clearing Corporation (BOTCC), which was founded by the Chicago Board of Trade in 1925. Members where required to buy shares in this clearing house (Kroszner, 2000). In the event of a default the clearinghouse could draw on margin posted by the defaulting member, a reserve fund financed from retained earnings of clearing and a claim on members to purchase extra shares if necessary (Kroszner, 2000; Millo et al., 2005).

In 1919, with the establishment of the Chicago Mercantile Exchange, the final step to what is referred to as 'complete clearing' was taken. The risk capital structure was changed to the setup where in case of default the clearing house could draw on the margin of the defaulting member, than on the margin of the other members and lastly all members together were liable for any unsatisfied default from the clearing house (Millo et al., 2005).

3.2 Possible elements of a risk capital structure

The possible coverage elements of a risk capital structure from literature and recommendations are split into two categories, namely coverage for normal and extreme market conditions (BIS, 2004; ESCB-CESR, 2009). The recommended ways to cover counterparty risks under normal market conditions are to:

- Setting participant requirements such as minimum credit ratings or parental guarantees, and apply strict access rules such as sufficient financial resources and robust operational capacity (Bank of Finland, 2004; ESCB-CESR, 2009).
- Enforce position and trade limits that limit the central counterparty's exposure to risk (Hills et al., 1999; Knott & Mills, 2002).
- Set margin requirements.
  - Since this requires members to pledge collateral to the CCP, this poses an opportunity cost. Therefore, it is necessary to weigh prudence versus the opportunity cost in setting the level of this requirement (Bernanke, 1990). It would not be efficient to set margins to cover all market circumstances; a mutualisation of the residual risk above a certain threshold would be a better way to cover the exposure to extreme market conditions (Knott & Mills, 2002; BIS, 2004). Such a setup would also give the proper incentive for the clearing members to take an interest in CCP's risk management because they have a limited exposure to defaults of other members (Hills et al., 1999).
  - It is recommended that liquid assets are to be kept as collateral (BIS, 2004) and that these can only be counted if there is a high degree of assurance that a CCP can draw on them for the anticipated value when needed (ESCB-CESR, 2009).

The possible ways for a CCP to mutualize residual risk due to extreme market conditions are to:

- Set up a default fund (Bernanke, 1990). Either paid in by the members or build up from accumulated profits (Bliss & Steigerwald, 2006) such a fund would pay out after the margin and fund contribution of the defaulting member proves to be insufficient to cover the loss (Jackson & Manning, 2005). Losses covered by the fund could be shared equally among the remaining members, or weighted proportionately towards how much they were trading with the defaulting member (Hills et al., 1999).
- Take out insurance to cover part of the loss (Knott & Mills, 2002; ESCB-CESR, 2009). However, as pointed out by Bernanke (1990), insurance deals badly with systematic risk (which will probably be the case in extreme market circumstances). In property markets for instance it is therefore not possible to insure against force majeure. For CCPs however it is less workable to explicitly exclude systematic risk, first because it is difficult to define, and secondly since there would be correlation between such a limit and market behaviour of participants.
- Lay down a claim on its members to cover any uncovered losses (Bernanke, 1990).

3.3 Coverage level

In the previous section the split was suggested between the cover for normal and extreme market conditions when setting up margin requirements.

Normal market circumstances occur in general between 95 to 99% of the time (Knott & Mills, 2002; Lam, Sin, & Leung, 2004). Prudent coverage levels of 98% and 99% are furthermore suggested by respectively (Lam et al., 2004) and (ESCB-CESR, 2009). In other words: the risk capital available would under normal market circumstances have to cover 95 to 99% of the losses.

With regard to the coverage under extreme market conditions it is recommended that 'a CCP should limit its exposures to potential losses from defaults by its participants so that the operations of the CCP would not be disrupted and non-defaulting participants would not be exposed to losses that they cannot anticipate or control' (ESCB-CESR, 2009).

3.4 How do trading members handle counterparty risk?

The ways employed by the trading members to handle counterparty risk by themselves in bilateral (over-the-counter or OTC) trading align closely with the above mentioned ways of coverage[3]. They set a credit limit based upon the score of a credit rating, current CDS spreads, tangible net worth or historical simulation. Trading then happens primarily within standard framework agreements such as EFET European Federation of Energy Traders (2010):

- European Federation of Energy Traders (EFET)
  - The EFET agreement is a master agreement that stipulates the general conditions for trading of a certain energy commodity between two parties. This agreement is entered in by two parties so their traders can freely trade directly with each other without having to negotiate the exact terms for every single contract.
- Cross-product Master Agreement (CPMA)
  - This framework agreement facilitates netting of all the open obligations between two parties at the time of a close-out. In this way it allows the parties to work with a net exposure to each other for OTC trades.
- Credit Support Annex (CSA)
  - The CSA can added to a trading framework agreement. It stipulates a certain threshold (usually set at the unsecured credit limit for a counterparty) above which any gains and losses are exchanged between the counterparties on a daily basis (in cash or within the limit of a Letter of Credit).

[3]From interviews held with stakeholders, see Appendix E for more information

3.5 Conclusions

This chapter answered research question 2: What methods are there for a clearing house to cover the exposure to counterparty risks?

Possible ways to cover for the exposure to counterparty risks are outlined below and depicted in figure 6.

- To cover for normal market conditions
  - Set participant requirements
  - Enforce position and trade limits
  - Set margin requirements
- To cover for extreme market conditions
  - Set up a default fund
  - Take out insurance
  - Lay down a claim towards members to cover losses

The boundary between normal and extreme market conditions is the percentage of losses that would be covered by the risk capital allocated for normal market conditions. From literature and recommendations come different suggestions for this boundary that are generally between 95% and 99%. Given that the choice of this boundary could have quite an impact on the opportunity costs associated with certain collateralization policies, it is for now left undetermined and will be addressed in the comparison of collateral calculation methods in research question 5.

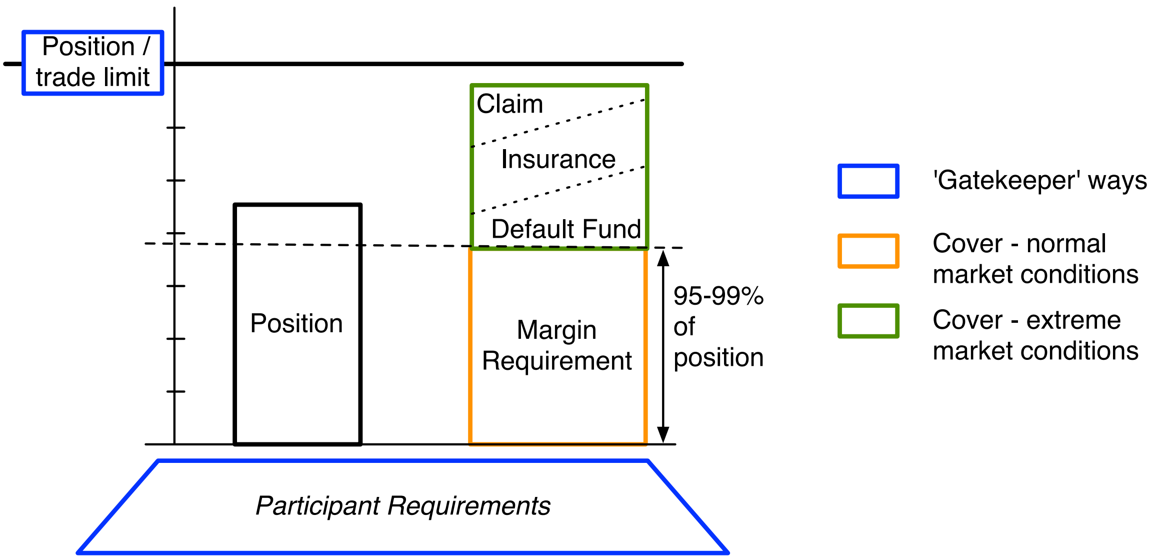


Figure 6: Coverage methods - graphically

4 Research Question 3 - Assessment risk capital structure

This chapter sets out to answer research question 3: Does the current risk capital structure need to be amended?

To answer this question first the current risk capital structure is discussed, followed by the expectations of the stakeholders on this subject. A confrontation of this with the outcomes of research question 2 results in a conclusion whether an amendment is necessary.

4.1 What is the current risk capital structure?

The current risk capital structure was introduced in 2007, first for the Dutch and Belgian Power DAM and later, in 2008, also for UK Power and the operations in Gas (NL,UK,BE).

The risk capital structure prior to this revision consisted of the following elements (RMCS, 2007):

- Initial margin: to cover the administrative costs of a default, set at a fixed amount (€ 10,000).
- Accrued Transaction Collateral: A deposit in an amount sufficient to cover the exposure of the member on buy orders corresponding to sales that have been delivered, set to 100% of the accrued net value of the contracts.
- Variation collateral: to cover the market risk borne for that member on the next trading day, set at a level equal to the last 28 days of a member's gross buying position history.

The main problem with this structure was that collateral could only be used to cover losses resulting from a default of the member by which it was posted. Any losses exceeding the individual collateral posted by a member had to be covered by APX-ENDEX itself. This meant that there was quite a high possibility of a single default resulting in the insolvency of APX-ENDEX.

Therefore the structure was amended to incorporate a mutualized default fund next to the individual collateral. This current structure is depicted in figure 7.

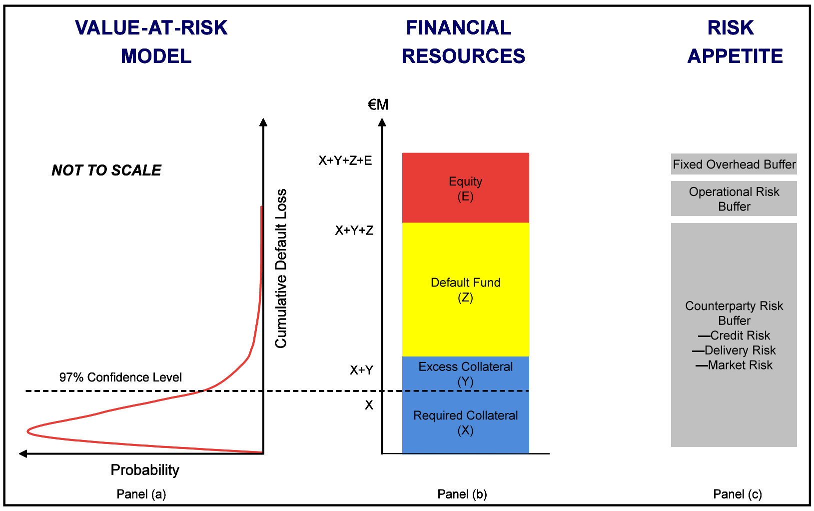


Figure 7: Current APX-ENDEX spot market risk capital structure

In this structure the individual collateral requirement is set at a level that will cover 97% of the losses resulting from the default of a clearing member. Any losses exceeding the initial collateral are covered first by the default fund contribution of the defaulting member, followed by the contributions of other members to the default fund.

The size of the default fund is fixed on a multiple of 1x the individual collateral, to move with the exposure the CCP has to the member.

4.2 What are the expectations of the stakeholders about the risk capital structure?

The clearing members expect to be able to trade energy in liquid markets against competitive fees (comparable to the fees of brokers)[4]. Margin levels should be comparable with other markets, and sufficient to ensure that in the event of a default the functioning of the clearing house remains unaffected. Finally, the stakeholders want to be only marginally exposed to a default of a third party.

The clearing members name as a reasonable worst-case scenario the default of a dominant player on its obligation to deliver; which is in line with the recommendation by ESCB-CESR (2009).

4.3 Given the risks and coverage methods, is there a need to amend the current elements or boundaries of the risk capital structure?

4.3.1 Elements

Comparing the current risk capital structure with the ways found to cover for counterparty risks finds that all the methods that can be used to cover against this risk under normal market conditions are currently in use. Furthermore, the sensible method to cover for extreme market conditions is also in use; a loss mutualising default fund.

The other two methods, insurance and a residual claim on members, are not currently in use and also less suitable to cover for counterparty risk for a central counterparty in energy spot markets.

Insurance offers a method to mutualize losses, and could be done cheaper by an insurer if it can pool risks into a portfolio. However, such a portfolio would then consist of insurance to central counterparties, who in times of extreme market conditions (which are very hard to predict and quantify) would all be exposed to a higher risk. Thus, having one insurer would increase rather than decrease the risk, leading to the conclusion that default protection through insurance is not a viable method in this case.

Furthermore, in case of a default fund clearing members only share losses after they have occurred. Instead of having to pay up a premium to keep the cover, the only costs for a default fund is the haircut taken by APX-ENDEX on the interest on the financial security which will most probably be cheaper. The final argument is that in case of a default and resulting payout from the default fund, the non-defaulting participants keep a legal claim on the funds that were used to cover the losses (Bliss & Steigerwald, 2006).

The second option, of having a residual claim on members, is not a viable method since 'non-defaulting members should not be exposed to losses that they cannot anticipate or control' (ESCB-CESR, 2009).

To conclude, the identified counterparty risks are covered by the methods from literature and recommendations, and hence also by the current setup.

[4]From interviews held with stakeholders, see Appendix E for more information

4.3.2 Boundary

The current split between the distribution of losses lies at 97%, meaning that the first 97% of potential losses are covered by individual collateral. The remaining 3% of losses (under extreme market conditions) are covered by the default fund that all members contribute to. The chosen level thus lies within the boundary of 95% - 99% which is considered prudent.

The choice for 97% came from the original cover of the old system, and was furthermore supported by the claim that 'normal' market conditions in energy markets occur 97% of the time. As discussed earlier in the conclusions of the previous chapter, this parameter is left undetermined for now and will be addressed in research question 5.

The choice of this parameter is not only influenced by desired prudentiality levels and opportunity costs however, but also by the attitude that clearing members have to the mutualisation of losses. Sliding this parameter from 95% to 99% (figure 8) results in a higher level of own responsibility and follows the line of thought of some of the clearing members that they rather not be exposed to the default of another member with whom they might not even be trading.

One things stands though, also in the opinion of clearing members: the normal functioning of the clearing house should be guaranteed by the risk capital structure, also in times of extreme market conditions.

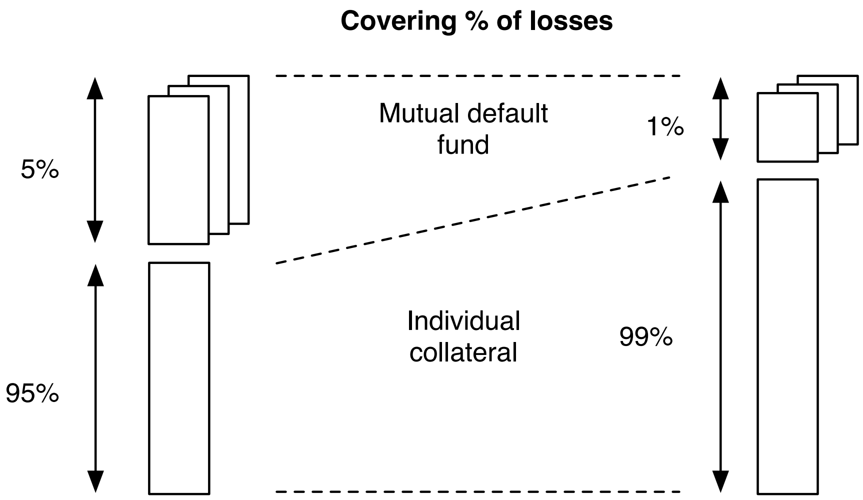


Figure 8: Scale individual collateral versus default fund

4.4 Conclusions

This chapter answered research question 3: Does the current risk capital structure need to be amended?

The confrontation of the current risk capital structure with the counterparty risks and coverage elements does not lead to an amendment of the elements of the risk capital structure. The boundary between normal and extreme market conditions and the distribution in size of the individual collateral and default fund contribution however is to be determined in testing the alternative methods in research question 5.

5 Research Question 4 - Calculation methods

This chapter sets out to answer research question 4: What methods are there to calculate the collateral requirement for the exposure to counterparty risk?

The chapter starts off with a review of the current collateral methodology and the characteristics of the data available. After this a literature review is done on collateral methodologies followed by a benchmark of methods in use by other energy exchanges / energy clearing houses. Then the opinion of the stakeholders on the current methodology is discussed. From all these different inputs possible areas of improvement are identified and alternative methods constructed.

5.1 Current situation

5.1.1 Method

This section explains the current collateral setup of APX-ENDEX. First off it is important to note that there is a difference between auction and continuous markets when it comes to how the exposure to losses is secured.

In auction markets the outcome of the day ahead auction is only known after the auction has been run. From this moment onwards it is assumed that the exposure is fixed and does not change in value anymore.

The collateral requirement is thus equal to the forecasted full exposure, which will not be exceeded with a certain confidence level, that APX-ENDEX has towards the member after the auction is run and contracts are created.

The price of continuously traded instruments can move up or down between transaction and delivery. In the event of the default of a member, APX-ENDEX has to close-out or replace the open position of the defaulting member.

The timehorizon for this is 24 hours, since this is the grace-period that a member has to lodge extra financial security if this becomes necessary due to a certain price move. This does however mean that sometimes the member does not have one business day (taken from Friday to Monday) as grace-period, possibly leading to close-out due to the fact that banks are closed.

The exposure that has to be covered is thus the price movement between today's price and tomorrow's price. This can be expressed in a percentage that with a certain confidence level will not be exceeded; hence this percentage of the price of the instrument has to be lodged as 'margin'.

Auction

The current collateral methodology for the trade by auction is setup to cover 97% of the exposure to a member by an individual collateral amount, and mutualize the residual risk through a default fund to which all members contribute (APX-ENDEX, 2008, 2010b).

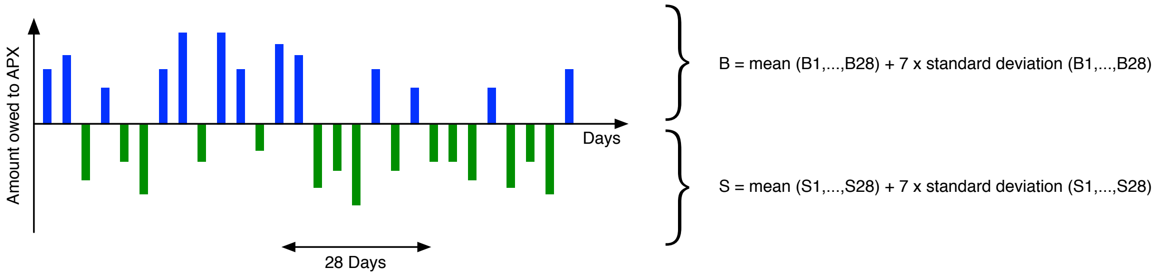


Figure 9: Collateral calculation methodology - Auction

The size of the collateral requirement is determined based on the past 28 days of trading behaviour in the way depicted in figure 9:

$B = \hat{\mu}_B + 7\hat{\sigma}_B$ and $S = \hat{\mu}_S + 7\hat{\sigma}_S$

where:

$\hat{\mu}_B$: Mean of the net buy (or $\hat{\mu}_S$: sell) amounts in the 28 days up to and including the last Monday.

$\hat{\sigma}_B$: Standard deviation of the net buy (or $\hat{\sigma}_S$: sell) amounts in the 28 days up to and including the last Monday.

The collateral requirement (is then calculated as follows:

- Power NL: $Collateral\ Requirement = max[B, S] + max[B, S]$
  - (once for the individual part, once as default fund contribution)
- Power BE:
  - $If\ B > S$:$Collateral\ Requirement = B + B$
    - (more buyer than seller in past 28 days, cover individual + fund contribution)
  - $If\ S > B$:$Collateral\ Requirement = S$
    - (more seller than buyer in past 28 days, due to no delivery risk in Power BE only fund contribution)
- Power UK:
  - The auction for Power UK is currently not functioning (no trading). When the BritNed interconnector cable between the Netherlands and the UK will come into operation in April 2011 this market will be relaunched and collateral policies reviewed.

The collateral requirement is currently calculated weekly. This happens on Tuesday (taking into account the positions in the last 28 days up and until the position of Monday). The new collateral requirement is then applicable from the auction on Wednesday (covering the positions of Thursday onwards).

Continuous

For the instruments that are traded continuously there is a margining system in place. The different elements of this system are depicted in figure 10 below.

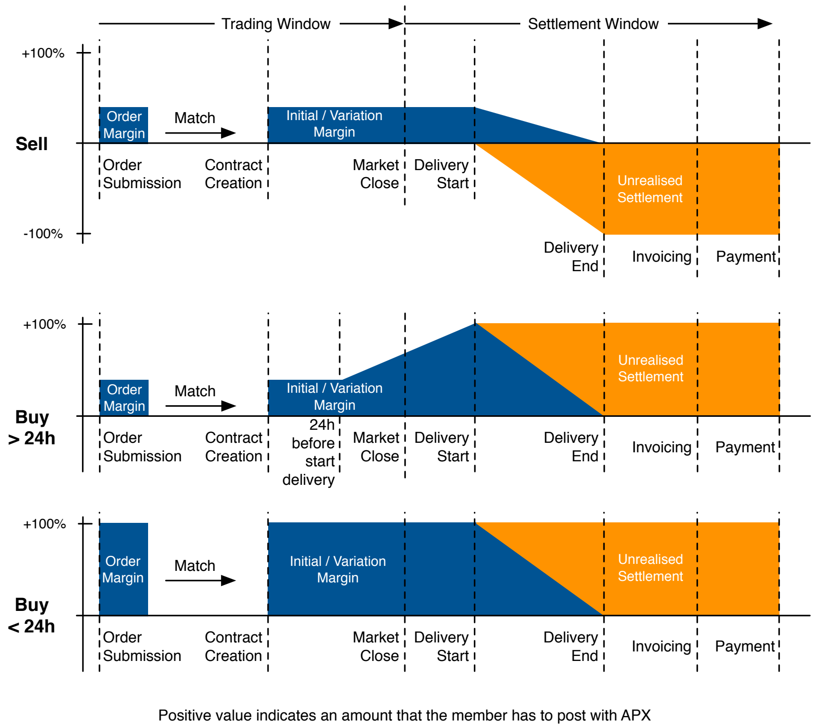


Figure 10: Margining timeline - Continuous trade

From left to right the different elements that are charged are:

- Order Margin: to be able to enter the order into the system the member has to have enough financial security posted with APX-ENDEX to support the 'order margin' amount. This amount is sized equally to the 'intial margin' that would be charged once the order is matched. In essence this margin is thus in place to ensure that the member has enough financial security available to support the matching of the order.
- Initial Margin: this element covers the 24 hour price difference between the current day ahead price (Pt-1) and the close-out price in case of a default (Pt).
  - The amount required is a margin in percentage points of the day ahead price to cover for this price movement: the initial margin parameter (IMP). This parameter is currently setup to cover:
    - ▷ For sell: $P(P_t - P_{t-1} \leq P_{t-1} \cdot IMP_{SELL}) = 0.97$
    - ▷ For buy:$P(P_{t-1} - P_t \leq P_{t-1} \cdot IMP_{BUY}) = 0.97$
  - The buy parameter for instruments that are equal to or closer than 24 hours to delivery is 100% to lock-in the credit risk before delivery of the product starts. This is done to ensure that the member has enough financial security posted to support the resulting invoice once the product is delivered.
- Variation Margin: this element is calculated on the hourly margin run to mark the price of the order (for the so far undelivered part) to the latest market price, to make sure that margining happens on the latest price.
- Unrealised settlement amounts to the full value of any (un)invoiced payment obligations from the member to APX-ENDEX or vice versa due to the transactions that have been carried out. To lock in the credit risk this element has to be covered for 100%.

The residual risk not covered by the (individual) initial margin is covered by a default fund, much like how this functions in the auction markets. The contribution however is defined differently; rather than a separate amount, 50% of the amount already posted as initial margin may be used as default contribution in case of a default.

- An extra element currently in place only for Power UK is the 'Position Limit' for sell positions.
  - In the UK the balancing operator (Elexon) may cancel any nominations up to 1 hour prior to delivery if a party in question is in 'level 2 credit default' for more than 24 hours (meaning its' outstanding exposure is higher than 90% of its' credit limit).
    - ▷ This being the case, APX-ENDEX assumes that it should in general be to close out positions that are more than 4 hours away from this deadline.
    - ▷ The first 3 hours prior are deemed to result in imbalance charges for APX-ENDEX. Based upon an analysis of these imbalance prices the company has come up with a parameter for what the imbalance price would be for these hours with a 99% confidence level, namely £201/MW.
    - ▷ The member decides upon its' own 'Position Limit' that it will have in each half hour settlement period. It may not trade above this limit and furthermore the amount: '*Position Limit amount* times *position limit parameter*' is deducted from its financial security available for trading.

Default Fund

As already discussed the default fund is designed to cover the residual risk not covered by the individual collateral / margin. The contribution to this fund differs between auction and continuous trade, as depicted in figure 11.

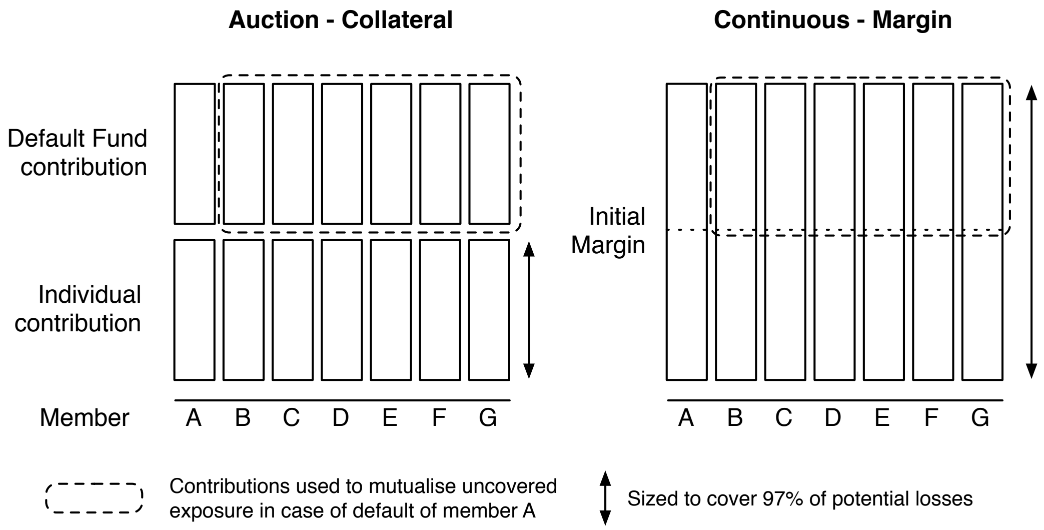


Figure 11: Individual and Default fund contribution difference

As can be seen from the figure the fund contribution for continuous trade is defined as a part of the paid in initial margin, where for auction trading a separate fund contribution has to be done. The slight difference is thus that a defaulting participant in the auction market would have contributed to the default fund since it will use up its own default fund contribution first. For a defaulting participant in the continuous markets this results in using the default fund 'sooner' since such an extra contribution is not there.

5.1.2 Data

Auction

The data available for the auction is the daily net cash-flow amounts of the Dutch and Belgian Power Day-ahead markets. In this dataset the initial zero positions are disregarded (when members where not trading yet). Any positions of zero after the first non-zero position day are taken into account to reflect actual trading behaviour.

The descriptive statistics of the resulting datasets are in table **??**. The correlation of hourly prices from 22-Nov-2006 until 22-June-2010 between the Netherlands and Belgium is 85,7%, which comes at no surprise because these markets function under a market coupling regime.

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To get a better insight in the tail risk of these markets, it was tried to fit a probability distribution to these datasets. First with a normal distribution, but since the data exhibits 'heavier' tails also a T-Scale distribution was fitted. The density and probability plot with these fits are visible in figure 12 for Power NL.

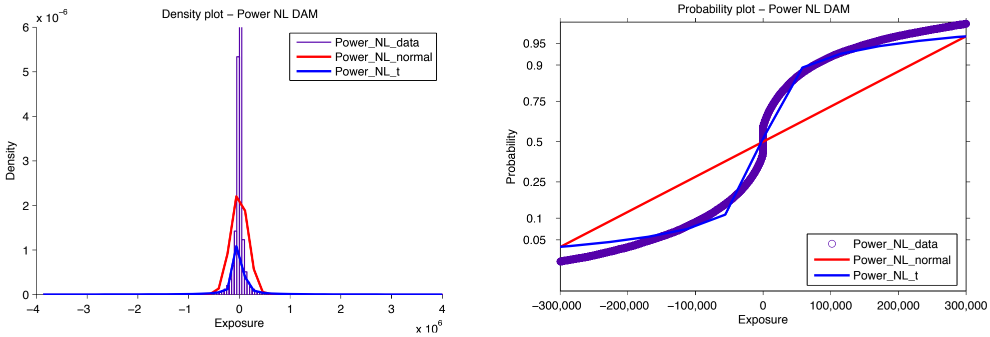

Figure 12: Density and probability plots with fitted distributions - Power NL

Judging from the visual evidence it is clear that there is not a very good fit between the fitted distributions and the data for Power NL. This is confirmed by a formal Chi-square goodness-of-fit test ($\alpha = 0.05$) that rejects the hypotheses that the data follows a Normal distribution (degrees of freedom: 1, test statistic: 604, critical value: 3.84) or a T-Scale distribution (df: 6, test statistic: 3,116, critical value: 12.59). The fitting and testing for Power BE yields even worse results (Normal, test statistic: 10,709, T-Scale, test statistic: 12,520).

Therefore, the fitted distribution can not be used for the simulations and backtesting of the collateral setup for auction markets; the 'real' distribution of historical data has to be used.

Continuous

For the continuously traded instruments there is less 'real' data available due to the illiquidity of some of these markets. Therefore a third-party price series has to be used to get prices for every day. The price series used come from Platts, one of the premier information providers in the energy markets. The exact explanation of which series are used and how they are established can be found in Appendix G.

For Power UK and Gas UK the real price of delivery of power or gas 'on the day' is known and published by the TSO, namely for power the MIDP or 'Market Index Data Price' and for gas the SAP or 'System average price'. For the other markets the price move from D-1 to D could be approximated based on the movement between two day-ahead prices.

To focus the research on the alternative methods only the instrument 'UK Gas NBP Day-Ahead' (NBP-DA) will be examined for now. This instrument is chosen since there is both a reliable Day-ahead price and price for gas 'on the day' available (SAP).

The descriptive statistics for the returns between the day-ahead and on-the-day prices for this instrument are in table 8.

Descriptive statistics	UK-NBP-DA - Daily Returns
	06 Jun 2007 - 23 Sep 2010
No of observations	822
Mean	0.1154
Median	0.20
Standard deviation	7.45
Min	-49.3
Max	37.7
Skewness	-0.61
Kurtosis	9.6139
Jarque-Bera test (a = 0.05)	p<0.001

Table 8: Descriptive statistics - NBP - DA

Also for this instrument it was tried to fit a normal and T-Scale probability distribution to the return series, as depicted in the density and probability plot in figure 13.

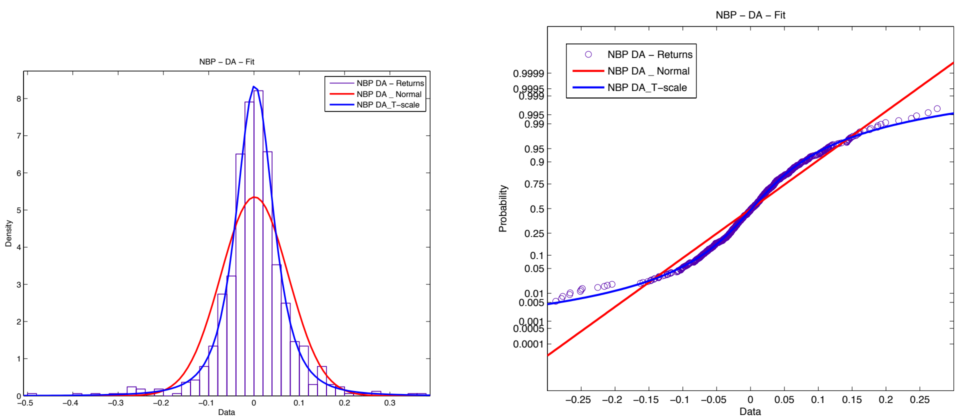

Figure 13: Density and probability plot with fitted distributions - NBP Gas Day-Ahead

The normal distribution does not seem to fit well with the data, confirmed by a formal Chi-square goodness-of-fit test ($\alpha = 0.05$) that rejects the hypothesis that the data is normally distributed (degrees of freedom: 2, test statistic: 71.22, critical value: 3.84). The T-Scale distribution seems to have a much better fit with the data, especially around the centre. But a formal Chi-square test rejects the hypothesis that the data follows the T-Scale distribution (df: 4, test statistic: 11.97, critical value: 9.49).

Thus also for the simulation and backtesting of the margins for continuous markets the 'real' distribution of historical data has to be used.

5.1.3 Performance

This section examines the performance of the current collateral and margin methodologies. Three things are excluded from this simulation: unrealised settlement, excess collateral/margin and risk of financial securities.

Unrealised Settlement As discussed earlier under the explanation of the margining cycle for continuous trade unrealised settlement is the full value of any (un)invoiced payment obligations from the member to APX-ENDEX or vice versa resulting from the transactions that have been carried out. To lock in the credit risk this element has to be covered for 100%. This amount is therefore added to the collateral requirement for auction markets and/or is deducted from available financial security for continuous markets. As such, it is independent from the simulation to test the adequacy of the method and therefore excluded.

Excess collateral/margin The simulation models assume that the member puts up exactly the amount of collateral that APX-ENDEX demands of it. In reality this would firstly be hard to do since the member has to send in a formal request to return any excess financial security and secondly impractical for the traders of the member since it leaves very little space for them to trade. Therefore, the amount of security is normally higher than the requirement, with 'excess collateral/margin' being the difference. Since any money pledged by the member is used before any money from the default fund in the case of a default, the assumption that there is no excess collateral can safely be made since it leads to a more prudent outcome.

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Associated risk of financial securities Clearing members have to deposit the collateral requirement / margin either in cash or by means of a letter of credit from an trustworthy financial institution. Although the Basel II standards would put a risk charge of 20% on the letters of credit they are assumed for simplicity reasons to be risk-free just as cash. This assumption can safely be made since the credit policy of APX-ENDEX (2010c) demands letters of credits from at least A- rated financial institutions located in the EU and limits the amount of financial security that may be pledged by letter of credit.

Auction

The 'performance' of the collateral system for the auction is assessed on how well it covers the resulting exposures of each day (total uncovered exposure), and how well it covers the losses in two stress-test scenarios.

For total uncovered exposure it is assessed how well the individual collateral covers the daily exposures and to what extend the default fund is used.

The stress-test scenarios are:

- The members with the biggest two net buy exposures in the market default.
- The member with the biggest net buy exposure and three random members default. This scenario is run 10,000 times for each day and then averaged to ensure a good approximation of 'three random' members. The scenario 'biggest + three median defaults' that was used in past analysis by APX-ENDEX was also examined but not included since although the result is close to the one with three random members, the latter one is more robust since it is independent of the size of the positions of participants in the market.

This surpasses the BIS (2004), ESCB-CESR (2009) recommendations of making sure that a default of the party to which the central counterparty has the biggest exposure would be covered.

When the performance was examined two high peaks where found in the data, on the following days:

11th August 2003 On this day TenneT issued a 'code red' for the Netherlands following a drastic decline in backup power supply. The reason was the warm weather that imposed cooling water restrictions and resulted in some power plants having to be throttled down (Brinkhorst, 2004).

22 May 2007 On this day the interconnector between Belgium and France was congested/out of order, resulting in a price peak in Belgium (CREG, 2007).

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Remarks on performance - Auction

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- The high peak in 2003 illustrates an idiosyncrasy of the current system: high peaks have an influence on the collateral calculation for the following 5 weeks (4 week lookback + weekly calculation). This is also visible from the sample member profile[5].
- - Removed -
- Since there is currently daily settlement on the Dutch and Belgian Power DAM markets it might be beneficial to make the move to daily calculation of the collateral requirement. That would allow the volatility markup factor to decline since it has to account for the volatility per day rather than per week.

[5]In reality though the collateral requirement will never 'drop' to zero; because APX-ENDEX has the sole discretion to establish the collateral requirement (indiscriminately of any calculation methodology) the collateral requirement in such a case will be set to a certain level by the operations and finance department for sporadically trading members.

Continuous

The current fixed margin set for NBP-DA is pictured in figure 14[6].

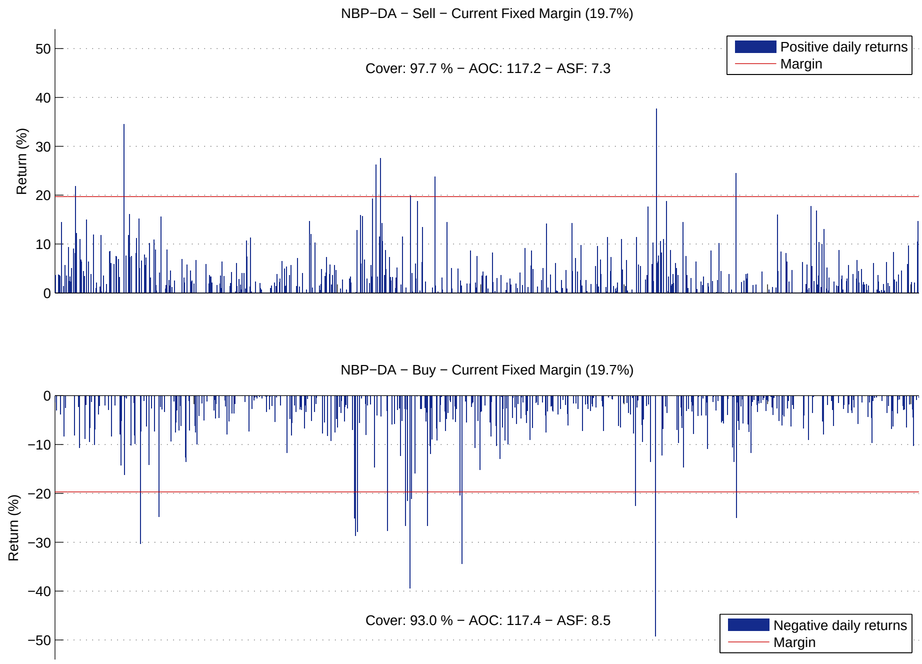

Figure 14: Current Margin Performance - NBP-DA

The performance of the margining methodology for continuous trade cannot reliably be determined by backtesting the parameters on actual trade data. Due to the illiquidity of some of these markets there is only a limited amount of 'real' trades available, which when used would bias the results. Therefore the resilience of the margining methodology for certain stress-test scenarios is approximated using historical simulation.

The stress-test scenarios tested are for a default by a member with a position of 20% in one or several instruments in one market (taken from an older analysis by APX-ENDEX of it's continuous collateral method), and in addition on a position of 30% and 40%; to align this with the mean defaulting exposure in the stress-test for the power markets.

The stress-test scenarios are calculated using a 'notional portfolio' setup, where certain distributions of member positions over the instruments are compared. Since the margin is calculated as percentage of the price the volume in each instrument is not important, it is the relative size of the open interest of instruments compared to each other that matters.

For this stress-test the following notional portfolio amounts are defined (as taken from old analysis of APX-ENDEX):

- DA: 7,500,000 Therms/Day (or 220,000 MWh)
- Weekend: 7,500,000 Therms/Day
- Working-Days-Next-Week: 7,500,000 Therms/Day

[6]The margin for buy orders Day-Ahead done less than 24 hours ahead is 100%, the picture shows performance of the margin parameter for trades happening further in advance

The outcomes of the stress-test are listed in table 9.

Gas UK - NBP		Default scenario		
		20%	**30%**	**40%**
Mean fund use		0.07%	0.11%	0.15%
	1	10.1%	16.2%	23.3%
Highest peaks fund use	2	9.3%	14.6%	20.5%
	3	6.3%	9.8%	13.7%

Table 9: stress-test analysis - Gas UK NBP market

Remarks on performance - Continuous

- The current analysis works with a 'counted' coverage parameter; which means that the number of breaches to number of days ratio is the basis for setting up the margin parameter. However, the claim 'margin will be sufficient on 97% of the days' is not the same as 'margin will cover 97% of the exposure'. Thus: take the absolute amount of the uncovered exposure compared to the absolute total exposure to setup margin parameters. This is probably the reason why the current cover in figure 14 does not reach 97%.
- The decision to cover the price move from day to day rather than the full value of the order is based on the assumption that there is enough liquidity in a certain market to make it possible to trade out of a position if necessary. For the illiquid NBP (12 trades in 2010) it would perhaps be possible to trade out a position through the OCM market, but what would happen for a transaction on the Belgium Gas Zeebrugge hub with only 56 trades in 2010?
- Mutualisation of residual risk through a default fund assumes there are several participants contributing, if the market is illiquid however this assumption could lead to a great underestimation of the risk.

5.2 Input

This section outlines the input gathered from a review of literature, a benchmark against other power exchanges and central counterparties and input gathered from the stakeholder interviews.

5.2.1 Benchmark

A summarized overview of the benchmarked energy exchanges / energy clearing houses in other markets in table 22 on page 67. These were selected since they facilitate trading in a similar way to APX-ENDEX for spot markets (auction / continuous) and have collateral policies publicly available.

Findings

The benchmark shows that there are three general approaches in operation to establish the level of collateral:

- Collateral level depending on trading behaviour - parametric
  - The level of collateral comes from a parametric formula, for instance: 17 * the max load * mean price in the last 12 months.
- Collateral level depending on trading behaviour - statistical
  - A confidence level that the exposure will not exceed with a probability of 95-99%. Calculated along the lines of mean + several times the standard deviation.
- Fixed limit
  - A fixed limit where the amount of available credit is increased when selling. Common for continuous markets, and as can be seen from the table in use at the Polish Power Exchange.

5.2.2 Literature review

The literature review was done on articles on the following subjects. The results are included in the next section when alternatives are generated.

- Different margin setting strategies
- Value-At-Risk models
- Econometric models to generate volatility forecasts

5.2.3 Stakeholders

Overall there is a split in opinion between the larger and smaller parties when it comes to the collateralization policy of APX-ENDEX. Since the larger parties tend to be able to borrow money more cheaply they have less opportunity costs, while for smaller parties these costs sometimes inhibit trading via the exchange. The biggest issue that members have with the collateral methodology for Power NL is that they have to collateralize both net buy as well as net sell positions, where this is not so common in the major energy markets in Europe (Nord Pool Spot and the markets clearing through ECC). Another issue brought up is that the historic potential 'default fund' losses have been very low, leading to the question whether the fund is correctly sized? A positive side of the current system that is stressed by parties: collateral (both individual + fund contribution) moves with own activity.

5.3 Generate alternatives

This section combines the input from the previous sections with the input from the literature review and generates alternative approaches for margining and collateralization.

As discussed in the current performance section, the collateral requirement for the auction is setup to cover tomorrows position, whereas the continuous margin covers the price move over the next 24 hours. Both up to a certain confidence level.

5.3.1 Auction

Simple moving average

Why is this a feasible alternative?

- The simple moving average is the method currently in use to calculate the collateral requirement for the auction. It might be worthwhile to examine the performance for varying parameters (Lam et al., 2004).

How to use?

- Given the observations (positions or returns) in the past T days (Obs_{t-1}, Obs_{t-2}, ... , Obs_{t-T})
- Calculate μ_t and σ_t^2 for each day in the following way:
- $\mu_t = \frac{1}{T} \sum_{i=1}^{T} Obs_{t-i}$
- $\sigma_t^2 = \frac{1}{T-1} \sum_{i=1}^{T} (Obs_{t-i} - \mu_t)^2$
- Set Value-at-Risk for day t: $VaR_t = \mu_t + k\sigma_t$

Parameters to decide?

- T: Lookback period. Currently set at 28 days, try for shorter and longer periods.
- k: volatility upmark. Vary this parameter to fit the VaR to a certain coverage level.

Exponentially weighted moving average

Why is this a feasible alternative?

- Possibly this is an improvement over the simple moving average, placing a lower weight on (extreme) events that happened further in the past (Lam et al., 2004).

How to use?

- Given the observations (positions or returns) in the past T days (Obs_{t-1}, Obs_{t-2}, ... , Obs_{t-T})
- Calculate μ_t and σ_t^2 for each day in the following way:
- $\mu_t = (1 - \lambda) Obs_{t-1} + \lambda\mu_{t-1}$
- $\sigma_t^2 = (1 - \lambda) (Obs_{t-1} - \mu_{t-1})^2 + \lambda\sigma_{t-1}^2$
- Set Value-at-Risk for day t: $VaR_t = \mu_t + k\sigma_t$

Parameters to decide?

- λ: smoothing parameter ($0 < \lambda < 1$), regulating how reactive the forecast is to peaks in the timeseries observed. Normally set between 0.75 (reactive, little persistence) to 0.98 (very persistent, not so reactive).
- k: volatility upmark. Vary this parameter to fit the VaR to a certain coverage level.

5.3.2 Continuous

Fixed margin

Why is this a feasible alternative?

- Current system of fitting a margin to all historical data available.

How to use?

- Take all the historical daily returns and set the margin at such a level that these equations are satisfied:
  - For sell: $P(P_t - P_{t-1} \leq P_{t-1} \cdot IMP_S) = (1 - \alpha)$
  - For buy:$P(P_{t-1} - P_t \leq P_{t-1} \cdot IMP_B) = (1 - \alpha)$
- Set VaR for day t: $VaR_{SELL,t} = IMP_S \quad \& \quad VaR_{BUY,t} = IMP_B$

Parameters to decide?

- Initial Margin Parameter: Vary this parameter to fit the VaR to a certain coverage level.

Simple moving average & Exponentially weighted moving average

Set in the same way as for the auction, but then on past T returns rather than positions, see section 5.3.1

GARCH(1,1)

Why is this a feasible alternative?

- Financial returns tend to be not normal, show volatility clustering, high peaks and 'heavy tails'. If a series exhibits this behaviour this is captured well by a generalised auto-regressive conditional heteroskedastic (GARCH) model.
- The earlier fit found that the return series are not normally distributed, and an Engle ARCH test($\alpha = 0.05$) and Ljung-Box test ($\alpha = 0.05$) find that the return series show auto-regression and auto-correlation. Therefore a GARCH model might provide a good fit (Chiu, Chiang, Hung, & Chen, 2006; Costello, Asem, & Gardner, 2008).

How to use?

- The GARCH(1,1) model is defined as follows:
  - $r_t = u_t + \sigma_t \varepsilon_t$ with $\varepsilon_t \sim D\,(0, 1)$
  - $\sigma_t^2 = \omega + \alpha\,(r_{t-1} - u_t)^2 + \beta\sigma_{t-1}^2$
  - where ε_t is drawn from some i.i.d. distribution D, ω, α, $\beta > 0$ and $\alpha + \beta < 1$.
- Estimate the parameters with an applicable maximum likelihood estimator (dependent on choice of distribution or residuals), to come up with a prediction of the conditional mean and standard deviation for the return on the next day.
- Set the margin for day t to the Value-at-Risk: $VaR_t = \mu_t + k\sigma_t$

Parameters to decide?

- N: length of the lookback period in days used to estimate the parameters ω, $\alpha\,\&\,\beta$
- k: volatility upmark. Vary this parameter to fit the VaR to a certain coverage level.

RiskMetrics

Why is this a feasible alternative?

- The RiskMetrics approach is a cross between the GARCH(1,1) and EWMA processes that assumes that $\mu_t = 0$ (Fuss, Adams, & Kaiser, 2009)

How to use?

- In RiskMetrics, μ_t is set to 0 and the return process can be expressed as:
- $r_t = \sigma_t \varepsilon_t$ with $\varepsilon_t \sim i.i.d.$ The variance is then modeled as:
- $\sigma_t^2 = \lambda \sigma_{t-1}^2 + (1 - \lambda) r_{t-1}^2$, with $(0 < \lambda < 1)$.
- Set Value-at-Risk for day t: $VaR_t = k\sigma_t$

Parameters to decide?

- The parameter λ is often set to values between 0.9 and 1. For daily data, RiskMetrics advises using $\lambda = 0.94$.

Historical Simulation VaR

Why is this a feasible alternative?

- A simple method to estimate the Value-at-Risk directly from a certain quantile of a historical sample (Cotter & Dowd, 2006).

How to use?

1. Take a sample with length T days from the past daily returns.
2. Order the sample in ascending order.
3. With an estimation window size of T, the αth percentile of the return distribution is $P_\alpha = T \cdot \alpha$ rounded to the nearest integer
4. The $100(1 - \alpha)$ VaR is given by the observation number $(1 + P_\alpha)$ from the ordered sample.

Parameters to decide?

- T: Length of the lookback interval in days

Bandwidth

Why is this a feasible alternative?

- Working with a fixed margin combined with a bandwidth for volatility would possibly allow for a lower margin level in less volatile times, since the margining method follows volatility, and automatically makes a margin requirement adjustment if the volatility surpasses a certain threshold (Lam, Yu, & Lee, 2010).

How to use?

- Setup two parameters, k ($k > 0$)and b ($0 \leq b \leq 1$). k controls the desirable margin level and b controls the width of the band for making margin changes.
- At day one, with the volatility forecast equal to $\hat{\sigma}_1$, set the required margin to $k\hat{\sigma}_1$and the bandwidth to $k\hat{\sigma}_1 [1 \pm b]$.
- The required margin as well as the bandwidth stay the same until for one day t the volatility forecast $\hat{\sigma}_t$ gives a required margin $k{\cdot}\hat{\sigma}_t$ that exceeds the upper or lower bounds of the bandwidth. Then, reset the required margin as $k\hat{\sigma}_t$ and the bandwidth as $k\hat{\sigma}_t [1 \pm b]$.
- This new bandwidth and required margin will then remain the same until the next breakout.

Parameters to decide?

- The parameter k controls the coverage level of the margining methodology.
- The parameter b controls the frequency of margin changes.

Fit Margin

Why is this a feasible alternative?

- Fitting the margin to a fixed amount is the method currently in use. However, this is only done every couple of years when APX-ENDEX comes round to evaluate it's margin setting methodology. Therefore, this alternative tries to formalise this by automatically fitting the margin after a certain timeframe.

How to use?

- After time I, vary the margin parameters for buy & sell to satisfy these equations for the lookback window:
  - For sell: $P(P_t - P_{t-1} \leq P_{t-1} \cdot IMP_S) = (1 - \alpha)$
  - For buy:$P(P_{t-1} - P_t \leq P_{t-1} \cdot IMP_B) = (1 - \alpha)$
- Set VaR for day t: $VaR_{SELL,t} = IMP_S \quad \& \quad VaR_{BUY,t} = IMP_B$

Parameters to decide?

- T: length lookback window
- I: Interval to adjust margin

5.4 Conclusions

This chapter answered research question 4: What methods are there to calculate the collateral requirement for the exposure to counterparty risk?

The generated alternative methods are listed in tables 10 and 11. These alternatives are scaled to fit (where applicable) to cover 95 to 99% of the exposure with individual collateral/margin, as found in section 3.3 to be the prudent boundary between normal and extreme market conditions.

Method	**Parameters**
Simple moving average *(SMA)*	$T = 7 \ldots 360$
Exp. weighted moving average *(EWMA)*	$\lambda = 0.7 \ldots 0.99$

Table 10: Alternative methods - Auction

Method	**Parameters**
Fixed *(FIXED)*	-
Simple moving average *(SMA)*	$T = 7 \ldots 360$
Exp. weighted moving average *(EWMA)*	$\lambda = 0.8 \ldots 0.99$
GARCH(1,1) *(GARCH)*	$N = 400 / 1000$
RiskMetrics *(RISKM)*	$\lambda = 0.8 \ldots 0.99$
Historical Simulation VaR *(HISTVAR)*	$T = 500, 1000, 1500$
Bandwidth *(BW)*	$b = 0.2$, 0.7. Volatility Forecast: SMA,EWMA
Fit Margin *(FITMARGIN)*	$T = 180, 360, 1000$; $I = 7$, 28, 60, 180

Table 11: Alternative methods - Continuous

6 Research Question 5 - Test alternative methods

This chapter answers research question 5: How does the performance of the alternative collateral calculation methods compare to the performance of the current methodology?

To answer this question criteria are defined on which the alternatives are scored. After this the outcomes are discussed to see if and how the alternatives outperform the current methodology, and a stress-test is done to see how the alternatives perform under extreme market conditions.

6.1 What criteria can be used to for the comparison of collateral calculation methods?

From the literature review of collateral methods come suggestions how to compare margin setting methodologies to one another. The principal two factors to take into account are prudentiality and opportunity costs (Bernanke, 1990; Hills et al., 1999; Knott & Mills, 2002).

The prudentiality of a collateral calculation method is measured in how much of the potential exposure is covered by the calculated amount of collateral. To reach a high level of prudentiality it is advisable to aim for a high coverage level of exposure. However, a high level of prudentiality leads to a high collateral requirement. This results in the following dilemma that clearing houses face: If the collateral level is set to low, it may not be enough to cover losses. On the other hand, if the collateral level is set to high, this leads to high opportunity costs for members.

The framework put forward by Lam et al. (2004) provides a method to compare collateral setting methodologies and get an insight in the trade-off between these two factors. The framework defines measures for 'prudentiality' and 'opportunity cost', explained below with figure 15 as visual guide. The 'Magnitude Loss Function' suggested by Sarma, Thomas, and Shah (2003) is added to the measures of prudentiality to provide a better insight in the magnitude of the shortfall.

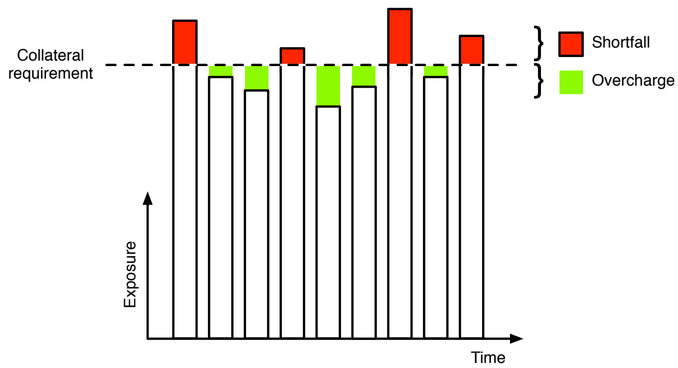

Figure 15: Exposure compared to Collateral Requirement

6.1.1 Measures of prudentiality

- Coverage Probability
  - is a measure of the prudentiality of a margining strategy, defined as the probability that the margin (M) collected is sufficient to cover the losses (L) arising from a default:
  - $Coverage\,Probability\,(CP) = P(M > L)$
  - In words: the coverage probability is 1 minus the sum of the red tops in figure 15 divided by the sum of the total exposures in figure 15, i.e.: $CP = 1 - \frac{\sum ShortFall}{\sum Exposure}$.
- Expected Shortfall
  - is a measure of prudentiality, expressed as a factor of the value of the instrument being measured (the value itself has a factor of 1), to eliminate a bias to position size. A prudential margin should have the effect that the margin collected (M) is enough to cover the loss (L). The expected margin shortfall is therefore defined as:
  - $ESF = E\left[(L - M)^+\right]$ where: $(L - M)^+ = \begin{cases} 0 & if\, M \geq L \\ L - M & if\, M < L \end{cases}$
  - In other words: expected shortfall, estimated as 'average shortfall', is the amount of losses not covered by collateral (the average of the red tops in figure 15).
  - The problem with using an simple average is that the 'magnitude' of the shortfall isn't taken into account; there is an equal weight on small amounts of shortfall and on large shortfall amounts. To solve this the 'Magnitude Loss Function' was added as a measure of prudentiality.
- Magnitude Loss Function
  - This method is used to get an insight in the amount of collateral shortfall that can be expected to happen from time to time ('the representative peak size') by taking the square root of the summed squared shortfall:
  - $MLF = \sqrt{\sum l_t}$, with l_t defined as:
  - $l_t = \begin{cases} 0 & if\, M \geq L \\ (L - M)^2 & if\, M < L \end{cases}$
  - This can be perceived as a weighed average which has a heavy weight on the higher peaks; due to the squared term, bigger violations of the margin level count heavier (e.g., two violations of 10 are less 'bad' than one of 20, since$10^2 + 10^2 = 200 < 20^2 = 400$).

6.1.2 Measure of opportunity costs

- Expected Overcharge
  - is a measure of the opportunity cost involved with a certain margin setting methodology. This measure is also expressed as a factor of the value of the instrument being measured. Seen from the viewpoint of the investor, paying an amount of margin (M) is seen to be excessive if the actual loss resulting from her/his position amounts to L smaller than M. The expected overcharge is therefore defined as:
  - $EOC = E\left[(M - L)^+\right]$ where: $(M - L)^+ = \begin{cases} M - L & if\, M \geq L \\ 0 & if\, M < L \end{cases}$
  - In other words: expected overcharge, estimated as 'average overcharge', is the amount of excess collateral (the green gaps in figure 15).

6.2 Findings Auction

This section examines the performance of the alternative methods in calculating the collateral requirement for the auction. First the matter of netting between the Netherlands and Belgium is addressed, followed by the actual performance comparison of the methods for different parameter settings. Lastly the boundary and determination of the default fund contribution are discussed and a stress-test is done to test the robustness of the findings.

6.2.1 Netting between markets

After handling the operations for the Belgian Power Exchange (Belpex) for the past years this firm was taken over by APX-ENDEX towards the end of 2010. This opened up the possibility to take a combined approach for the collateralization of exposures resulting from the Dutch and Belgian power auctions.

There is a draft setup on how to handle netting of positions and the calculation of the collateral requirement across the two countries. This draft setup is examined below and improvements are suggested.

Individual collateral

Due to the difference in delivery risk between the two markets (see the examination of counterparty risk in section 2.5.2) it is not possible to do a simple addition to come to the 'net' position. For the Netherlands collateral is to be held for the principal value of the position, regardless whether the member has a net sell or net buy position on a given day. For Belgium collateral is only requested up to the principal value of the net buy position that a member has on a day[7].

Due to this difference the netting between the two countries should happen on exposure, rather than just adding or subtracting the daily net positions. The exposure in the Netherlands is then equal to the absolute net position for a day, while the exposure for Belgium is positive for buy and negative for sell. The negative exposure stems from the fact that for Belgium a net sell position means that APX-ENDEX will owe funds to the member which are not exposed to any delivery risk. This negative exposure can then be used to offset any positive exposure in the other country, up to the point where the exposure for a given day is 0. An example on how this system functions for different positions across the two countries is depicted in figure 16.

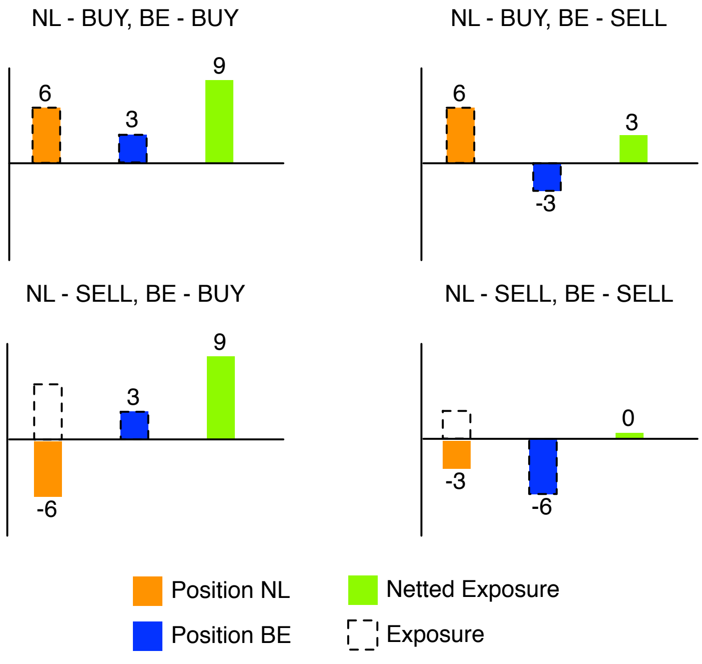

Figure 16: Netted exposure example

[7]This is only true under the assumption that the hourly positions of a day may be netted by simple addition to come to one net position for that day.

The netting formula to come to the net exposure for the individual collateral calculation on day t is thus given as:

$$NET_t = max\,(0,\, |NL_t| + BE_t)$$

With:

- NL_t: Net cash position in the Netherlands for day t
- BE_t: Net cash position in Belgium for day t

The difference between the 'netted exposure' approach discussed here and the current draft netting approach of APX-ENDEX is that the 'netted exposure' approach outputs only positive values ($NET_t \geq 0$ for all t) for exposure, which simplifies the formulas to calculate the collateral requirement.

This eliminates the three 'if .. then' formulas that capture what has to happen for varying positions (buy / sell) in different countries to account for the difference in delivery risk. Having only a positive exposure as output also eliminates the need to calculate the collateral amount on both the positive and negative values and take the maximum amount of the two. An graphical example for a member that is trading in both countries can be found in Appendix D.

Default Fund contribution

The netting solution to come to the contribution to the default fund differs from the one for the individual collateral. The amounts payed up by the members for the (netted) individual part are adjusted for delivery risk and can at times be zero, when a party has been a net seller in the markets.

The reasoning behind setting the individual collateral is that if a member poses a greater exposure to the clearing house it should pay up a greater amount. But to come to the positions needed to calculate the default fund contribution of a member, it would not be fair to distinguish between net sellers and net buyers. The reason is that the sellers also receive a 'benefit' from the clearing house in the form of guaranteed payment.

In other words, when the members would be obliged to contribute to the default fund in proportion to how much they contribute as individual collateral, the net sellers would generally have to put up a lower amount than the net buyers while still receiving the benefit of guaranteed payments for the amounts of energy they have sold.

In the current separately collateralized markets this is not an issue for the Netherlands, because there collateral is charged on both buy and sell positions in an equal manner and the default fund contribution is linked 1:1 to the individual collateral amount. This means that net buyers and net sellers pay up an equal amount.

For Belgium due to the absence of delivery risk the net sellers do not have to post the individual part of the collateral requirement when the collateral amount calculated for sell is greater than the amount for buy. All parties are required to put up a default fund contribution though, sized to the amount of benefits they receive from the clearing house.

The amount of default fund contribution a member needs to contribute is thus not directly linked to what kind of position it has, but rather how much benefit it receives from the guarantees given by the clearing house. In the 'netted' case for the Netherlands and Belgium combined, this benefit can be quantified as the simple addition of the positions in each country.

The netting formula to come to the net exposure for the default fund contribution on day t is thus given as:

$$NET_t = |NL_t + BE_t|$$

With:

- NL_t: Net cash position in the Netherlands for day t
- BE_t: Net cash position in Belgium for day t

6.2.2 Methods and parameter choices

The two possible methods to evaluate, as identified by research question 4, are stated in table 12 with associated parameters.

Method	**Parameters**
Simple moving average *(SMA)*	$T = 7 \dots 360$
Exp. weighted moving average *(EWMA)*	$\lambda = 0.7 \dots 0.99$

Table 12: Alternative methods - Auction

The difference between these two methods is how they weigh past observations in calculating the forecasted mean and volatility for the next day. To get an insight in this difference, the weights for different parameter setting for these two methods are shown in figure 17.

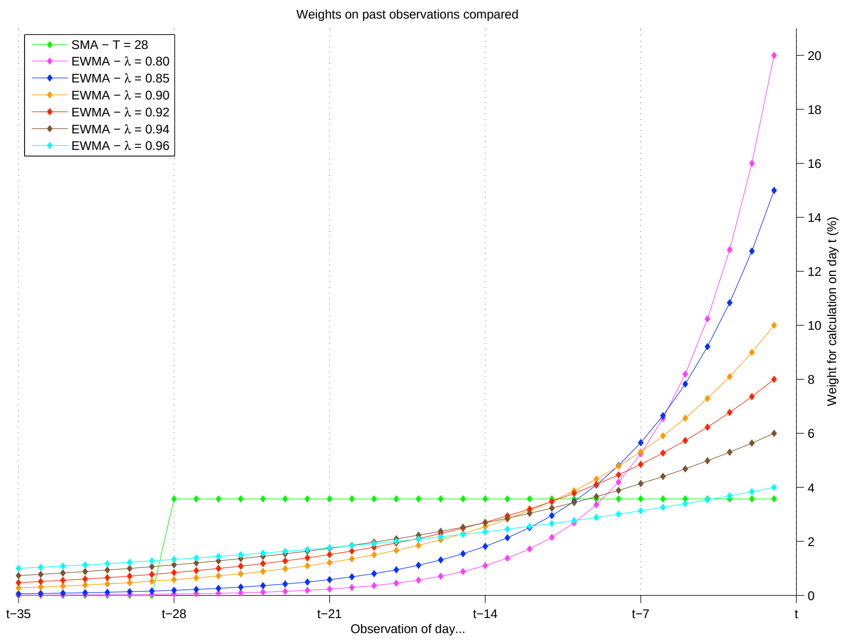

Figure 17: Weights on past observations - SMA versus EWMA

SMA The simple moving average method places equal weights on the observations for the length of the lookback window. This means that a single peak in a sample of otherwise comparable positions has an influence on the collateral amount for the duration of the lookback window. At the end of this lookback window it will 'dropping out' of the sample, leading to a sudden drop in collateral requirement. The parameter T thus controls how long past observations have an influence on the collateral requirement.

EWMA The exponentially weighted moving average takes on a more 'fluid' approach in the calculation of the collateral requirement, by placing exponentially declining weights on past observations. The parameter λ controls the persistence of past observations. As visible from the graph lower values for λ such as $\lambda = 0.80$ lead to higher weights on the observations in the first days after a peak, while higher values for λ result in higher persistence in weights. In terms of collateral requirement calculations this will lead to a calculation method that is either highly reactive to peaks but will quickly decline again when market conditions return to normal, or result in a more persistent level of collateral that is less reactive to peaks. Because of the recursive formula of EWMA it would be required to change to daily collateral calculation.

To get a grip on what the choices of parameter mean for the actual collateral requirement, figure 18 shows the resulting individual collateral charge on a sample of actual member exposures.

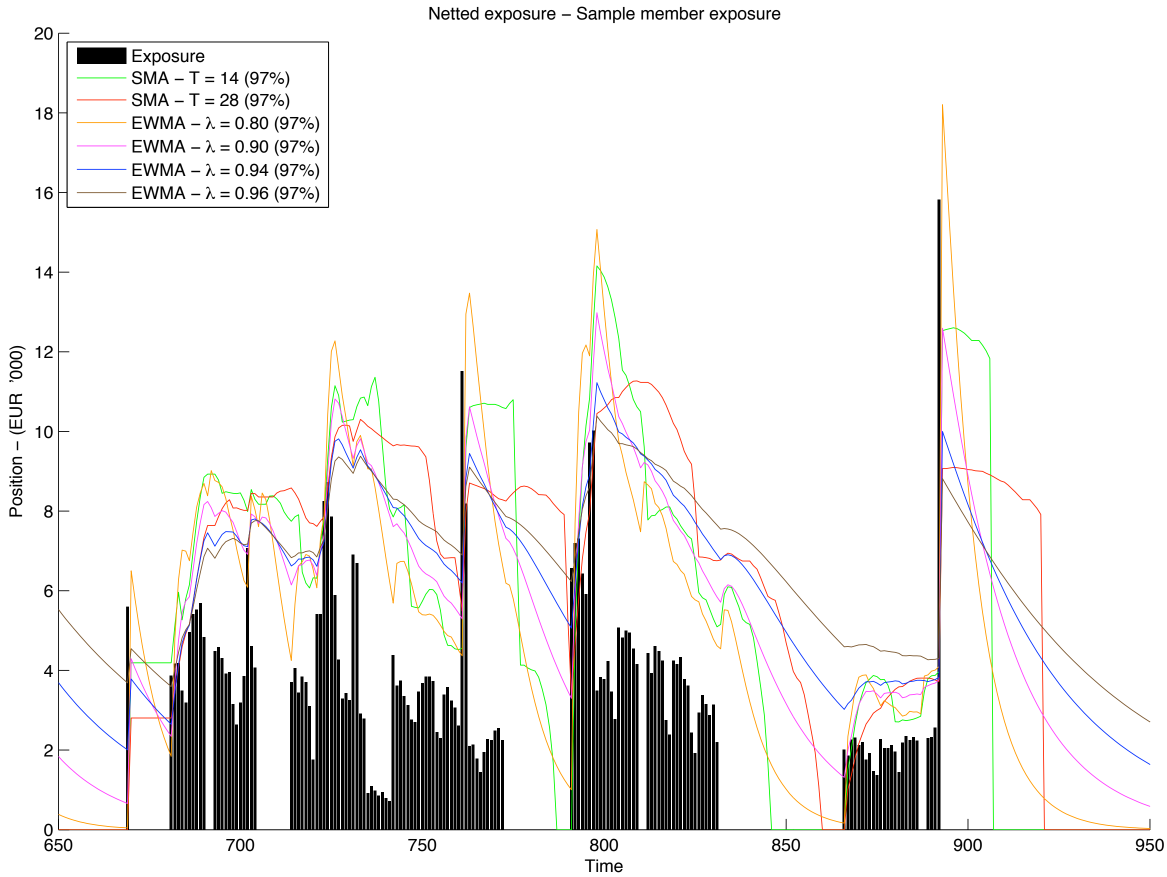

Figure 18: Member exposure sample - Individual Collateral

The figure confirms the earlier observation that for SMA the parameter T controls how long peaks have an influence, which can be seen from the 'steps' in the graph when a peak exits the sample. It also shows the difference for EWMA between a low value for λ, leading to a very reactive collateral regime, and a higher value for λ, leading to a smoother collateral regime.

What makes the exponentially weighted moving average an attractive alternative is how it let's the collateral requirement decline after a peak when market conditions allow for this. The decline will happen fluidly based upon the parameter choice which is made by answering the question 'how persistent does the collateral level have to be?'. This is a choice that has more rationale behind it than the question for the parameter setting of the simple moving average, which could be put down in words as 'how long do market conditions stay the same?'

The trade-off in having a low EWMA parameter setting that let's the collateral requirement decline quickly is that it will place a much higher weight on a peak in the first days after the occurrence, driving up the collateral requirement for those days. This is visible from figure 18 in that the collateral requirement for $\lambda = 0.80$ jumps up to twice the height of the SMA $T = 28$ collateral requirement.

Such a reaction to a sudden peak in trading behaviour would be unacceptable since it would for a few days require a very high collateral amount from the trading members. Because of this, judging from the reaction of the calculation methods in the figure, $\lambda = 0.90$ is chosen as lower boundary for the evaluation of the EWMA method. An upper boundary could be set that sets the same weight on the observation one day after a peak as the current methodology $\left(\frac{1}{28} = 0.0357\right)$: $(1 - \lambda) = 0.0357 \rightarrow \lambda = 0.9643$. The upper boundary is thus set at $\lambda = 0.96$.

The collateral requirements and scores on prudentiality and opportunity cost measures where calculated for the current method (SMA, $T = 28$) and the alternative method with parameter settings between the lower and upper bound as setup above ($0.90 \leq \lambda \leq 0.96$). The results are plotted in figure 19.

This graph shows for a given choice of parameter and coverage boundary the corresponding overcharge (in times of exposure) and amounts of individual collateral shortfall that are expected to happen from time to time. Since the overcharge and expected shortfall are calculated on the individual collateral part this graph is independent from choices regarding the proportion of the default fund.

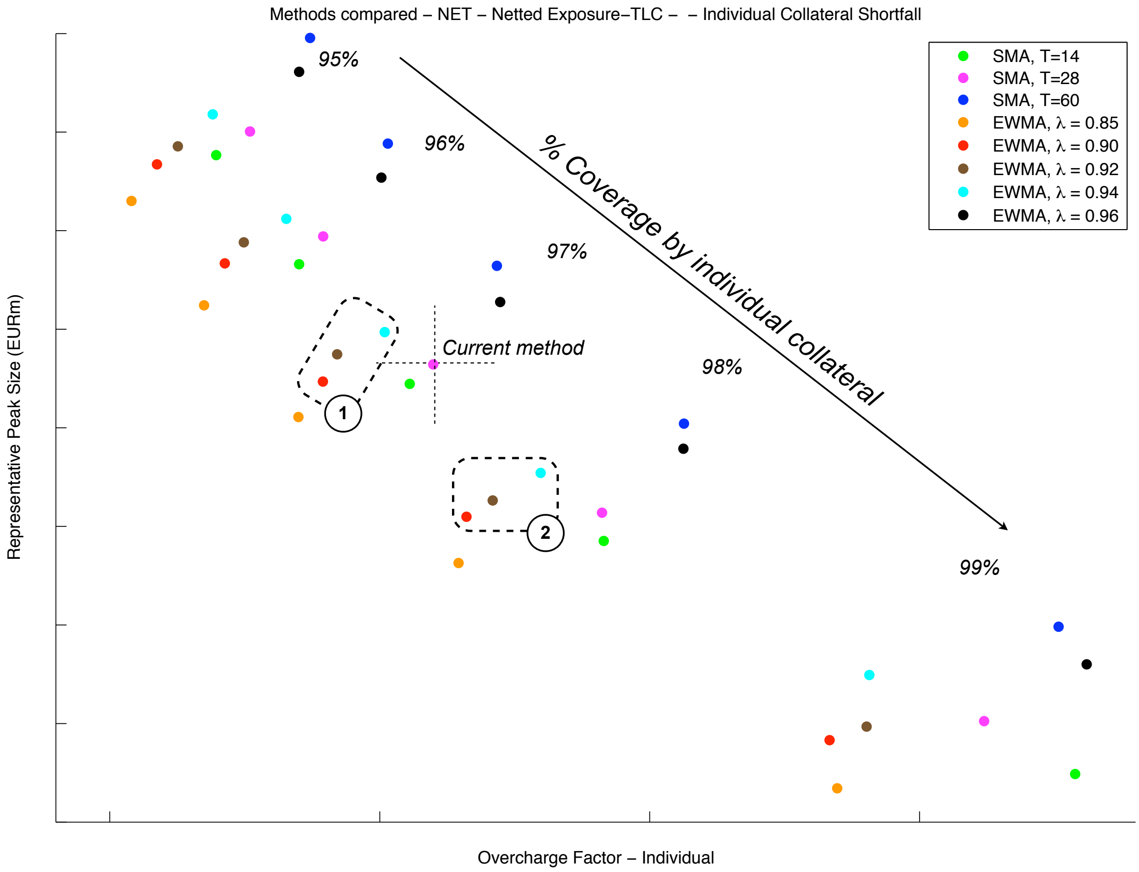

Figure 19: Auction methods compared - overcharge factor versus representative peak size

Starting from the score of the current method, better performing methods can be found by moving in either of two directions:

1. For the methods fitted to cover 97% of the exposure with individual collateral the EWMA methods with parameter $\lambda \leq 0.92$ outperform the current method on both expected individual shortfall and overcharge factor.
2. Another direction of improvement would be to step to the methods fitted to a coverage level of 98%. This gives a substantial decrease in expected peak size against a small increase in the overcharge factor. The possible parameter choices for EWMA are $0.90 \leq \lambda \leq 0.94$.

The comparison of performance shows that the more persistent choices of parameter for EWMA ($\lambda = 0.96$) lead to worse performance than the moderately persistent choices ($0.90 \leq \lambda \leq 0.94$). This can be explained by the fact that a more reactive collateral regime is quick to ramp up the collateral requirement directly after a peak, which will immediately cover any subsequent peaks in the days after this. The more persistent regime leads to a smaller jump in collateral requirement which results in uncovered exposure for subsequent days with peaks.

It can be concluded that the EWMA model is a viable alternative to the current SMA calculation methodology for the parameter settings $0.90 \leq \lambda \leq 0.94$. The choice in coverage level is further examined in the next section.

6.2.3 Individual collateral coverage boundary and default fund

Having identified the parameter settings that give a possible improvement over the current collateral calculation method, this leaves the boundary choice and default fund contributions to be decided. With the default fund contribution calculated in a different way it is no longer possible to talk about the fund in proportion to the individual part of the collateral requirement. Instead the fund is calculated and then added to the individual collateral part with a certain weight; together making up the collateral requirement.

As discussed under research question 2 the boundary between the individual cover and the default fund cover should be set on between 95% to 99%. Sliding this boundary from 95% to 99% increases the individual responsibility of members to cover their own exposure while decreasing the chance that non-defaulting members have to cover losses of a defaulting member. This also implies that the default fund could be smaller for higher individual coverage, hence taken into account against a lower weight.

In the current risk capital structure this boundary is set at 97%, with the default fund contribution being equal to the individual part of the collateral requirement (i.e. 1:1).

To examine different settings for this boundary and fund proportions, they are plotted for the current and alternative methods in figure 20 on the average overcharge on the total collateral requirement (individual + fund) and the representative peak of 'real fund use'. Real fund use in this sense is the residual uncovered exposure after applying the individual collateral and the default fund contribution.

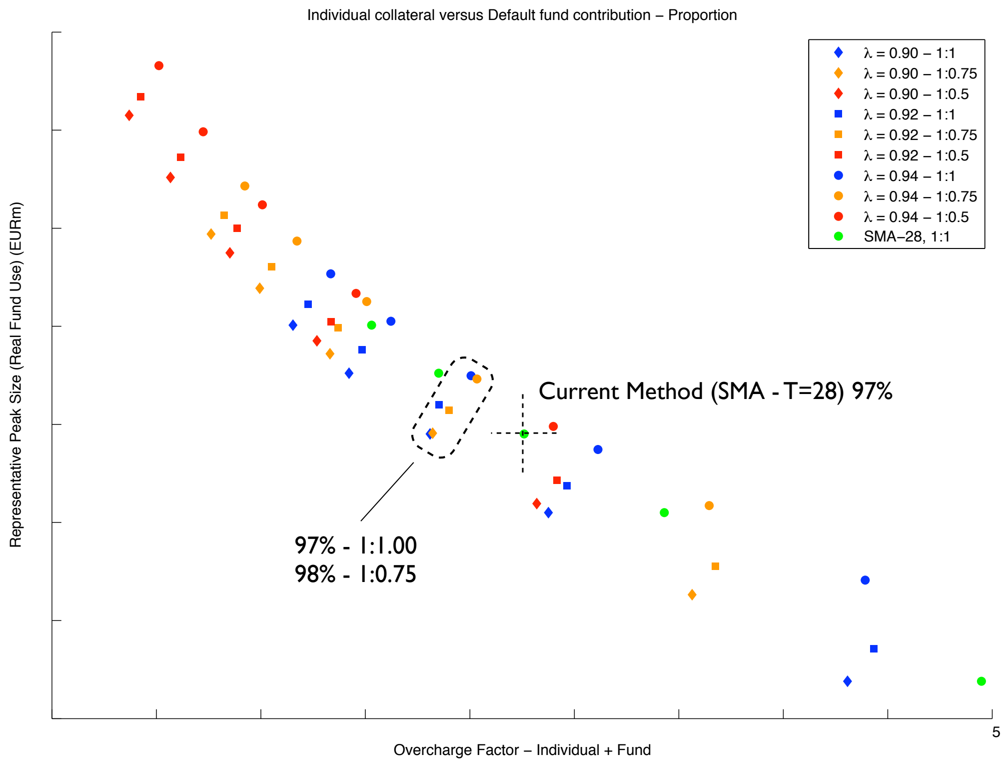

Figure 20: Relation boundary and individual versus fund proportion

The figure shows that $\lambda = 0.90$ shows an improvement over the current methodology, with the outcome almost equal for a boundary of 97% with fund weight of 1.00, and for boundary 98% with a fund weight of 0.75. This illustrates the inverse relationship between the coverage boundary and the needed size of the default fund.

The other parameter settings for λ for coverage boundaries 97% and 98% and respective fund weights of 1.00 and 0.75 show an improvement over the current method in terms of overcharge, but against a slight increase in the amount of uncovered exposure that is to be mutualized ('real fund use').

6.2.4 Stress test

The previous sections have identified that the EWMA approach with parameter settings $0.90 \leq \lambda \leq 0.94$ outperforms the current SMA approach with parameter $T = 28$ for certain coverage levels.

This didn't assess though whether the cover of the whole risk capital structure would be enough to withstand extreme market conditions. Therefore, the two stress test scenarios from research question 4 were done for the EWMA alternatives, having the parties with the biggest two exposures default and having the party with the biggest exposure + three random parties default.

- Removed -

6.3 Findings Continuous

This section shows the findings for the performance comparison of alternative margin setting methodologies for the continuous markets. It follows the same structure as the previous findings for auction section, firstly addressing netting followed by a review of the scores for the methods with different parameter settings, then discussing the boundary and fund proportion choices and lastly a stress-test on the alternative methods.

6.3.1 Netting between markets

Netting for continuous markets does not require an elaborate setup since all margins are tied directly to the volumes of instruments traded. The 'offsetting' effect that can be achieved is to put all margin requirements for the different markets together in one legal entity, which will allow netting between the different continuous margin elements (e.g. for a sell transaction in one market and buy transaction in another this would allow for an offset between initial margin and unrealised settlement).

6.3.2 Methods and parameter choices

Initial review

To limit the amount of alternative methods that need to be investigated in-depth, the different alternatives are implemented and fitted to reach a coverage level of 97%; in-line with the current approach for continuous margining. The results are depicted in figures 21, 22 and 23, with the scores on average overcharge in table 13.[8].

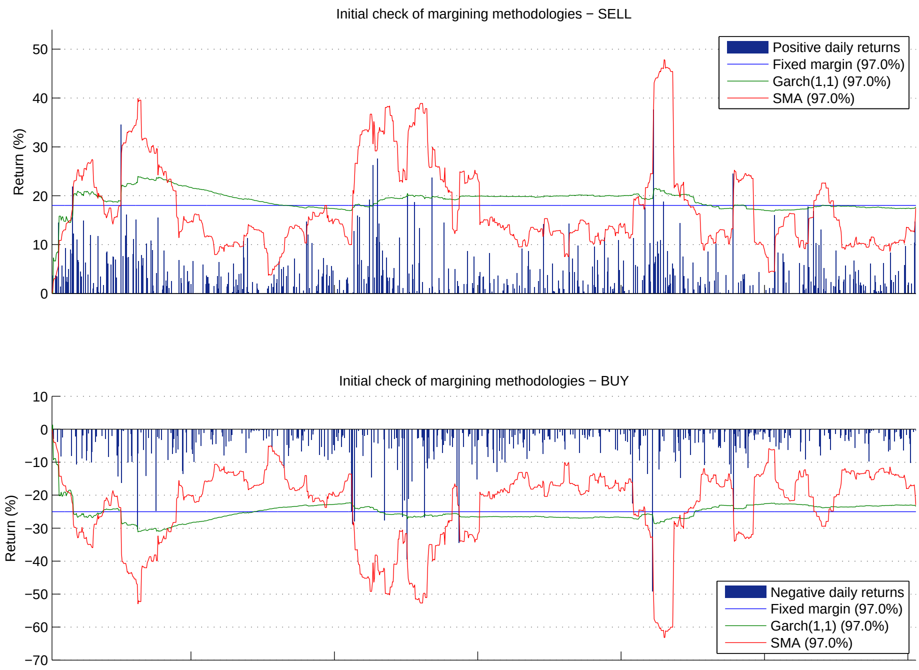

Figure 21: Continuous Margining Alternatives (1/3) - SMA, Garch(1,1), Fixed

[8]Parameters used; SMA, lookback: 28 days, EWMA/RiskMetrics ($\lambda = 0.94$), Garch(1,1) $N = 400$, Bandwidth-SMA($b = 0.7$), Bandwidth-EWMA($b = 0.2$), Fit Margin (Interval: 28 days, Lookback: 360 days)

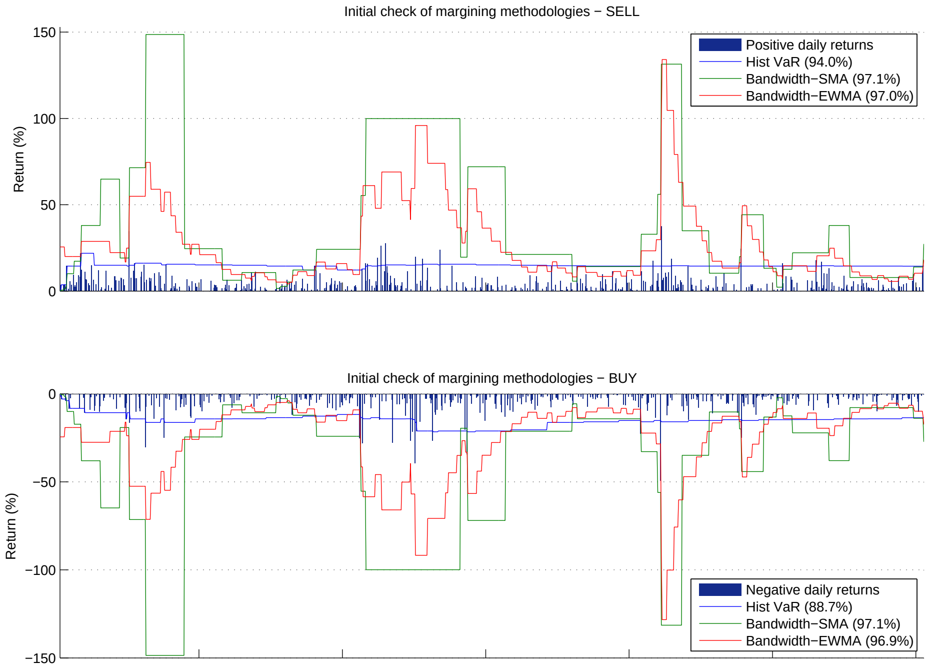

Figure 22: Continuous Margining Alternatives (2/3) - HISTVAR, Bandwidth-SMA/EWMA

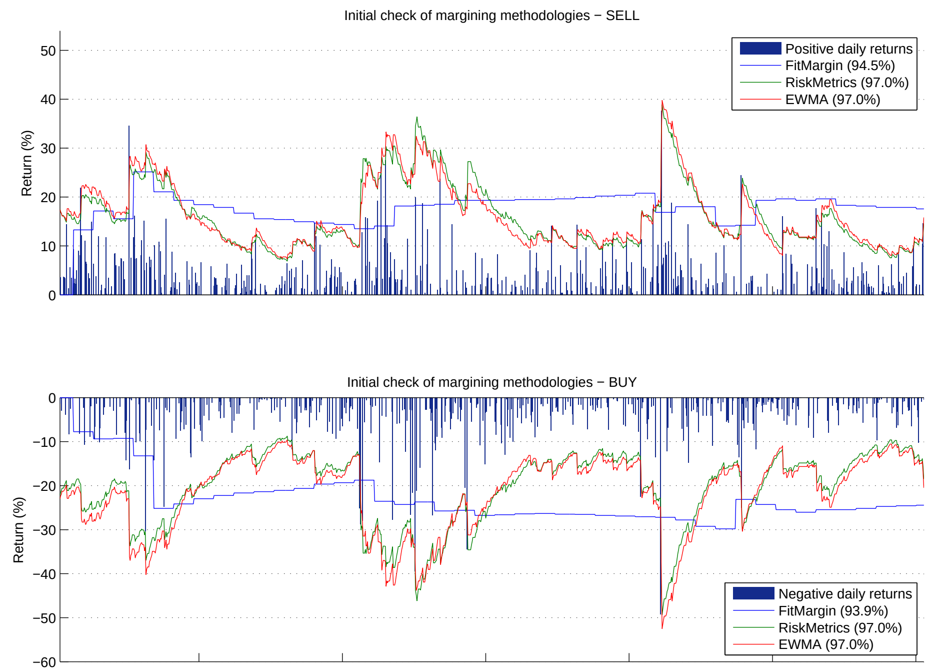

Figure 23: Continuous Margining Alternatives (3/3) - FitMargin, RiskMetrics, EWMA

Method	*97%*	**Average Overcharge Factor**
FIXED	-	119.1
SMA	$T = 28$	118.5
EWMA	$\lambda = 0.80$	117.8
	$\lambda = 0.94$	116.6
GARCH(1,1)	$N = 400$	119.8
RiskMetrics	$\lambda = 0.80$	116.7
	$\lambda = 0.94$	116.1
HISTVAR	$T = 500$	n.a. (does not reach 97%)
	$T = 1500$	n.a. (does not reach 97%)
Bandwidth-SMA	$b = 0.7$	139.1
Bandwidth-EWMA	$b = 0.2$	125.0
Fit Margin	$T = 360$; $I = 28$	n.a. (does not reach 97%)

Table 13: Average Overcharge Factor scores - Continuous Margin Methods

As visible from the graphs and the table not all methods have a correct 'fit' with the actual returns, reach the required coverage level of 97% or show potential improvement over the current 'fixed' method. Therefore, the following methods are excluded after this initial review:

Historical VaR The margin set based upon the historical 97% quantile in the moving lookback period does not reach to the required coverage level. Changes to the length of the lookback period did not improve the outcome, leading to exclusion of this method.

Bandwidth-SMA & Bandwidth-EWMA The bandwidth method comes from an article on the margining of futures. Energy prices are more volatile than futures though, as is visible from the graphs. The method would increase (or decrease) margin once the daily calculated margin requirement breaches a certain level. Due to the spiky behaviour of the returns however this happens quite soon. A more narrow bandwidth would solve this, but as the bandwidth narrows the model approaches the underlying volatility forecast model, giving little improvement over applying such a model directly. Hence, the methods are excluded.

Fit Margin As can be seen from the graphs, fitting the margin after certain intervals does not give an improvement over fitting a margin to each side (buy and sell) over the entire dataset (the 'Fixed' margin alternative). Therefore the 'Fit Margin' alternative is also excluded.

RiskMetrics The RiskMetrics alternative ends up very close to the EWMA alternative. This is not surprising since the formula for these two alternatives is almost equal, the only difference between the two is that RiskMetrics assumes the mean return to be zero, while the EWMA alternative includes a forecast for the mean. Given this redundancy and the fact that the assumption of a mean of zero does not lead to a better result the RiskMetrics alternative is excluded.

In depth review

The remaining methods with applicable parameter settings are outlined in table 14.

Method	**Parameters**
Fixed *(FIXED)*	-
Simple moving average *(SMA)*	$T = 7 \dots 360$
Exp. weighted moving average *(EWMA)*	$\lambda = 0.8 \dots 0.99$
GARCH(1,1) *(GARCH)*	$N = 400 / 1000$

Table 14: Methods up for in depth review - Continuous Margining

The performance of these methods is plotted on the overcharge factor versus representative peak size of margin breaches (in percentage points) in figure 24.

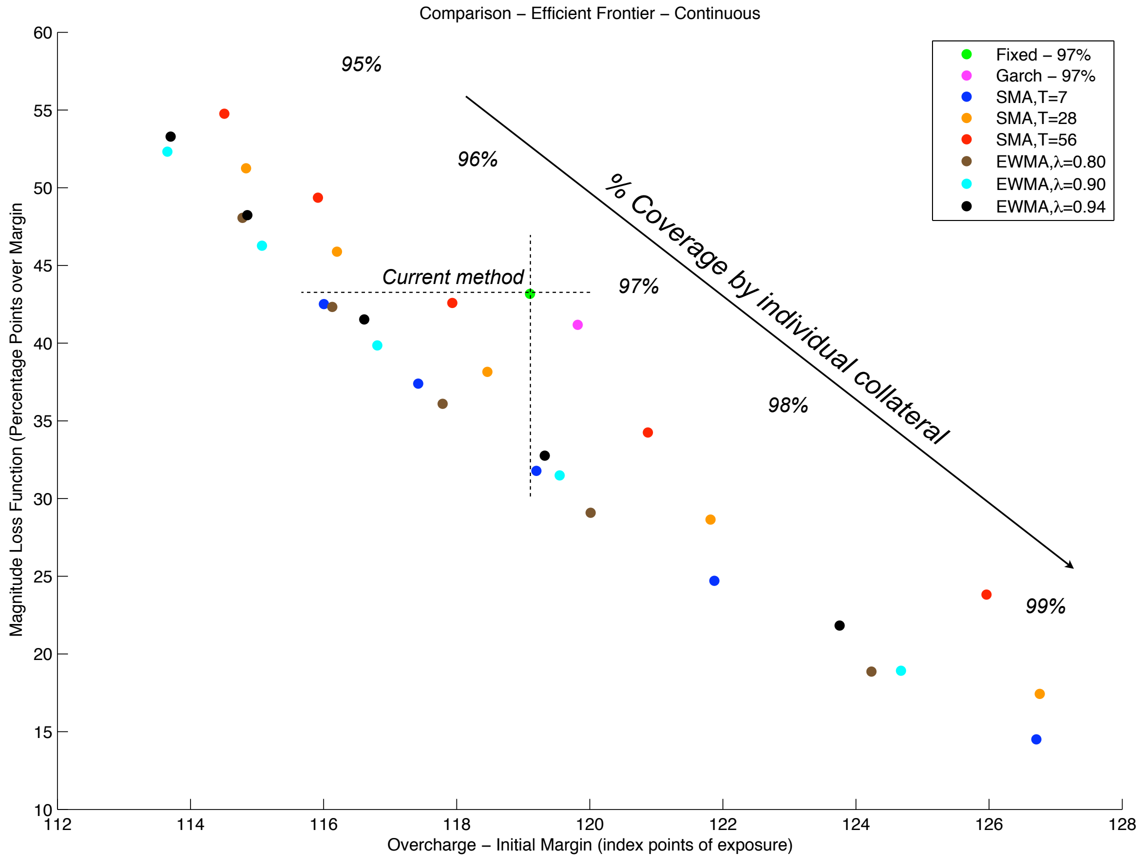

Figure 24: Continuous methods compared - overcharge factor versus representative peak size

Methods with possibly improved performance lie below and to the left of the current method in the plot, since these would give an lower expected size of margin breaches against the same cost (overcharge) or lower cost against the same expected size of breaches. The selected methods are the reactive SMA method with $T = 7$ and the EWMA methods with parameter $0.80 \leq \lambda \leq 0.94$, these are further examined with the aid of a stress-test in section 6.3.4.

6.3.3 Individual collateral coverage boundary and default fund

The boundary between the individual cover and the default fund cover is currently set at 97%, with the default fund 'contribution' defined from 'within' the initial margin. The part of the (individual) initial margin being available for mutualisation of extreme losses is currently set at 50%.

Since the fund 'contribution' is defined from within the initial margin the choice of the proportion of initial margin available for mutualisation is independent from any extra overcharge. Given that most of these markets, including the one for the instrument under consideration in this research, are quite illiquid, the somewhat 'high' amount of 50% of initial margin being available for mutual use is prudent.

The one remaining choice for the continuous margining methodology would be the boundary of how much of the price movements should be covered by the initial margin. This is again a choice based on the rationale of individual responsibility, setting this boundary higher in the 95% to 99% interval assumes bigger personal responsibility.

6.3.4 Stress test

To assess the robustness of the methods that have a possibly improved performance over the current fixed margining approach a stress-test is carried out, for which the outcomes are listed in table 15.

Gas UK - NBP		**Default scenarios**					
		Current (fixed)			SMA, $T = 7$		
		20%	**30%**	**40%**	**20%**	**30%**	**40%**
Mean fund use		0.07%	0.11%	0.15%	0.19%	0.30%	0.44%
	1	10.1%	16.2%	23.3%	31.2%	53.4%	83.1%
Highest peaks fund use	2	9.3%	14.6%	20.5%	22.7%	38.8%	60.4%
	3	6.3%	9.8%	13.7%	21.8%	37.3%	58.1%

Gas UK - NBP		**Default scenarios**					
		EWMA, $\lambda = 0.80$			EWMA, $\lambda = 0.94$		
		20%	**30%**	**40%**	**20%**	**30%**	**40%**
Mean fund use		0.10%	0.16%	0.24%	0.09%	0.14%	0.20%
	1	44.4%	76.2%	118.5%	32.0%	54.9%	85.4%
Highest peaks fund use	2	10.0%	17.2%	26.7%	11.4%	17.6%	24.2%
	3	7.4%	11.4%	15.7%	9.7%	15.0%	20.6%

Table 15: Stress-tests - Continuous - EWMA versus current

As can be seen the 'reactive' approaches lead to a result on the stress-test that is worse than the fixed method. One possible explanation for this is that where the method reacts well to peaks by increasing the margin, it also let's the margin decline beyond the 'fixed' level of the current margin in less volatile times. Therefore the shortfall at the next occurrence of a peak is bigger and since these margins scale by the volume this shortfall is multiplied by total volume.

In contrast to this bad result of the more reactive method, table 16 lists the outcomes of the stress tests for the updated 'current' methodology; having a fixed margin fitted to 97% coverage over the entire dataset. This solution clearly outperforms the reactive and current solutions.

Gas UK - NBP		**Default scenarios**		
		Updated - Fixed Margin Levels		
		20%	**30%**	**40%**
Mean fund use		0.01%	0.02%	0.02%
	1	3.5%	6.0%	9.3%
Highest peaks fund use	2	2.1%	3.6%	5.5%
	3	1.1%	1.6%	2.1%

Table 16: Stress-tests - Continuous - Fixed

6.4 Conclusions

This chapter answered research question 5: How does the performance of the alternative collateral calculation methods compare to the performance of the current methodology?

The conclusions are outlined in the next sections for auction and continuous separately.

6.4.1 Auction

Netting between markets

The analysis finds that netting between the Netherlands and Belgium is possible for the exposure resulting from trading by auction, but that an adjustment has to be made for the difference in delivery risk. The approach thus proposed is one on 'netted exposure' rather than the current draft specification that what can be described as 'combined net positions'. The result is a netted exposure that needs to be collateralized, which simplifies the formulas needed for netting and calculating the collateral requirement.

It is further suggested that to come to the combined default fund contribution the netted total position is used, since this is an appropriate quantification of the 'total benefit' that the member receives from the clearing house.

Methods and parameter choices

The exponentially weighted moving average method is identified as a viable alternative with some attractive characteristics, the most important one being that it allows the collateral requirement to decline gradually when possible after a peak. The speed of this decline, and hence the persistence of the resulting collateral calculation method, is regulated by the persistence parameter ($0 < \lambda < 1$). A lower persistence parameter leads to a quicker decline but also a high increase in collateral requirement in the first days after a peak, while a choice of parameter with high persistence leads to a slower decline and less responsiveness to peaks. The analysis finds that EWMA outperforms the current collateral calculation method for choices of parameter for moderate to high persistence ($0.90 \leq \lambda \leq 0.94$).

Individual collateral coverage boundary and default fund

A comparison of the EWMA method with the parameter set to moderate to high persistence to the current method on different coverage boundaries of individual collateral and different proportions of individual collateral versus default fund contribution shows that a coverage level of 97% and 98% with respective fund weights of 1.00 and 0.75 show improvement and are almost equal in performance.

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6.4.2 Continuous

Netting between markets

All margins are tied to the volume of the instruments, thus netting is achieved by consolidating the margining of different markets in one clearing entity. This would allow for an offset of unrealised settlement against paid up margins, where applicable.

Methods and parameter choices

While the more reactive methods appear to show improvement on the expected shortfall and overcharge, the stress test done shows that the performance in covering extreme market conditions is quite poor. Therefore the current 'fixed' method is the preferred method of margining continuous trading.

Individual collateral coverage boundary and default fund

Since the default fund contribution is defined from 'within' the initial margin there is no extra overcharge due to an additional amount of financial security that needs to be pledged. The choice of boundary therefore depends on the level of required individual responsibility. Since the markets are relatively illiquid the choice of the somewhat 'high' amount of 50% of initial margin in the current system being available for mutual use is justified.

7 Conclusions & Recommendations

7.1 Conclusions

This research consisted of two parts. In the first part the counterparty risks involved were identified, the ways to cover for these risks were investigated and an assessment was done whether the current risk capital structure is adequate given the risks found. The second part of the research focused on the main coverage element; the amount of financial security requested from the members. In this part several alternative methods of calculation were setup and tested against the current method.

The conclusions derived from the findings are summarized below; first on the elements of the risk capital structure and secondly on the performance of the alternative calculation methods for setting the collateral requirement (for the auction) and margin levels (for continuous trade).

7.1.1 Risk capital structure

The investigation of the risk capital structure showed that the current risk capital structure of APX-ENDEX employs all the viable elements suggested by literature and recommendations for central counterparties to cover for counterparty risk.

A confrontation of this structure with the different counterparty risks that APX-ENDEX faces did not lead to suggestions for amendments to the risk capital structure.

7.1.2 Findings - Auction

Before assessing the performance of the alternative methods it was investigated how the currently separate collateralization regimes of the Netherlands and Belgium could be captured in one combined collateral requirement. The suggested approach comes up with a netted exposure figure for each day, taking into account the difference in delivery risk between these two markets, which lowers the amount of collateral that is required and simplifies the formulas used to calculate the collateral requirement.

Subsequently the performance of the formulated alternative methods was assessed. This analysis identified the exponentially weighted moving average (EWMA) as a viable alternative to the current simple moving average (SMA) approach, with the following advantages:

- EWMA lets the collateral requirement decline gradually when possible. However, there is a trade-off in choosing the parameter that controls the slope of the decline; setting this parameter to low persistence leads to a quicker decline but also a high increase in collateral requirement in the first days after a peak, while a choice of parameter with high persistence leads to a slower decline and less responsiveness to peaks.
- There is a rationale behind the choice in parameter setting for EWMA; namely in how persistent the collateral level has to be.
- In quiet periods the collateral level as calculated by EWMA doesn't drop down to zero after a certain period like SMA would do. Also, EWMA needs a shorter warm-up period than SMA; after starting off from a certain set collateral level the method needs only a few days to adjust to the trading behaviour of the member in question.

In the performance tests EWMA outperformed SMA on expected individual collateral shortfall and overcharge on collateral, for moderate to high persistence choices of parameter.

Implementation of EWMA would require the collateral calculation to be done daily rather than the current weekly calculation.

7.1.3 Findings - Continuous

The performance tests done on the alternative margin setting methods for continuously traded instruments gave the impression that the more reactive methods outperformed the current fixed margin method. However, from the results of a stress-test it can be concluded that a fixed collateral level is more prudent and clearly provides a better cover than the reactive margining methods. The reason is that while the reactive methods let the margin decline when volatility allows for it, this in turn increases the magnitude of the shortfall when the next peak occurs. Given that the total shortfall scales with the position of a member, the resulting total uncovered exposure is higher than with a (non-declining) fixed margin.

Netting for the continuous markets can be achieved by consolidating the margining of different markets in one clearing entity. Since the margin is set per volume unit of the instrument traded such a combined margining approach would allow for an offset of unrealised settlement against paid up margins; where applicable.

Since the default fund contribution is defined from 'within' the initial margin there is no extra overcharge resulting from an extra amount of financial security that needs to be pledged to the default fund. The choice of coverage by the initial margin therefore only depends on the required level of individual responsibility.

Finally because the markets are relatively illiquid the choice of the somewhat 'high' amount of 50% of initial margin in the current system being available for mutual use is justified.

7.1.4 Areas for further research

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Another area for further research lies in the assumptions of the netting algorithm; the assumption is that the cash amounts per hour can be netted by simple addition to come to a net position for the day which is to be collateralized. The question is whether it would be more prudent to first net the hourly amounts between Belgium and the Netherlands and only after this take a daily net position to calculate the collateral requirement upon.

The default fund has been put into place to make the coverage of extreme risk cheaper by mutualising part of the exposure. There is one element of the margining setup for continuous markets though that does not yet have such a mutualisation of risk implemented, and as such requires a hefty amount of financial security from members. The element in question is the 'Position Limit' that covers the exposure that APX-ENDEX would have when already accepted nominations are cancelled for the UK Power Market. The calculations to set up the 'Position Limit Parameter' have been done for an individual cover up to a confidence level of 99%. A mutualisation of the extreme risk through the default fund could potentially lower the high charge of £ 201/MW.

7.2 Recommendations

Based on findings, the following recommendations are made to the Clearing Management Team of APX-ENDEX Clearing B.V.

Since the risk capital structure was found to be adequate, the following two sections outline steps to improve the handling and cover for counterparty risks for the auction and continuous trade.

7.2.1 Auction

- The netting approach for 'netted exposure' can be implemented to reduce the collateral requirement for members trading in both countries. While in essence this approach is the same as the current draft approach, it eliminates the 'if .. then' steps of the adjustment for delivery risk and thus simplifies the collateral calculation method. When applying this approach while keeping the rest of the calculation methodology the same, a drop in collateral level of 5% to 20% could be expected per member, depending on its trading behaviour.
- This research finds EWMA to be a viable alternative method for the calculation of collateral, with attractive characteristics. The next step would be to start a discussion with the members about possible implementation, with the choice of parameter being as follows: moderately persistent to highly persistent.
- - Removed -

7.2.2 Continuous

- The alternative methods that were tested for setting the margin for continuous trade did not lead to an improvement over the current method of having a fixed margin. It is recommendable to regularly review the adequacy of the fixed margin level for the different instruments and adjust them where needed.

One notable insight that can be taken from this research is that it is very hard to quantify the exposure to delivery risk; due to the lack of precedents and the inherent uncertainty of defaults. Combined with the fact that the position of a defaulting member would have to be closed out financially, potentially leading to large close-out costs, this leads to the conclusion that APX-ENDEX should strive for the special position in each of its market as 'market operator'; providing only a guarantee for the credit side of the transactions. This would allow for a grand reduction in collateral requirement; because if the sell positions do no longer carry a risk weight they can be used fully to offset the credit risk exposure of the buy positions.

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A Products & Operations

A.1 Power Auction (Day Ahead)

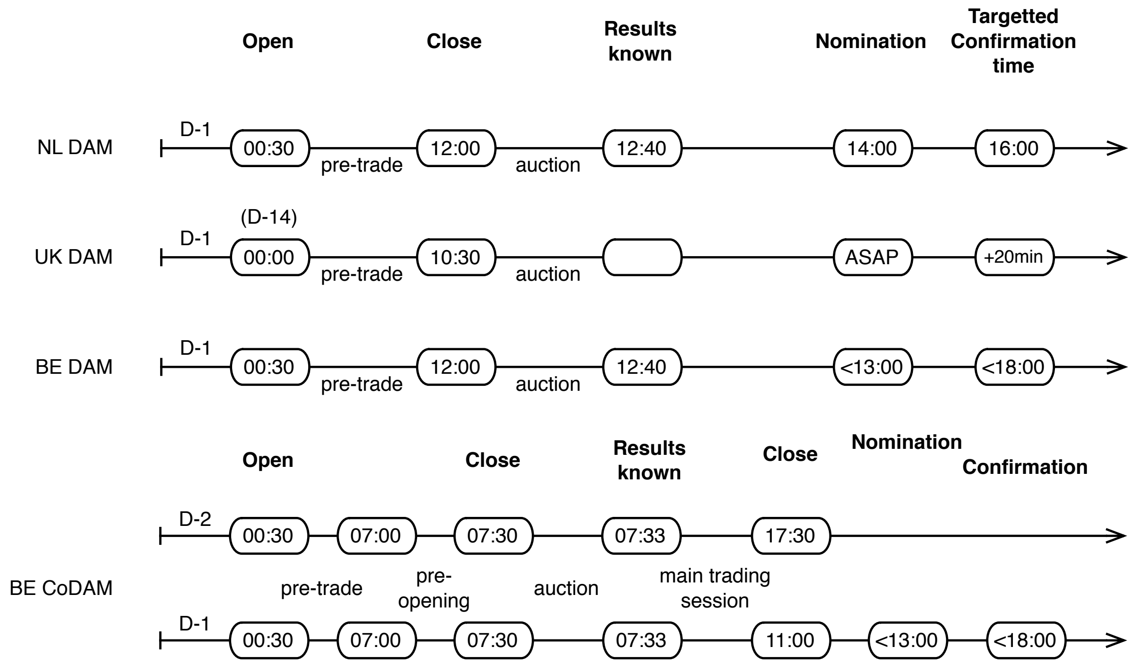

Figure 25: Power Day-Ahead Markets

The following power products are available to trade in the day-ahead auction:

Product		NL DAM	UK DAM	BE DAM	BE CoDAM
Hourly	24 separate hours	+	+	+	
Base	(00-24)	+[1]			+
Peak	(08-20)	+[1]			+
Off peak	(00-08),(20-24)	+[1]			+
Weekend	(00 Sa - 24 Su)				+

1) Available as 1 day or weekend (2 days)

Table 17: Power Day-Ahead products

Sources: APX-ENDEX (2010e), APX Commodities Limited (2008) and Appendix F.

A.2 Power Continuous Trade (Intra-day)

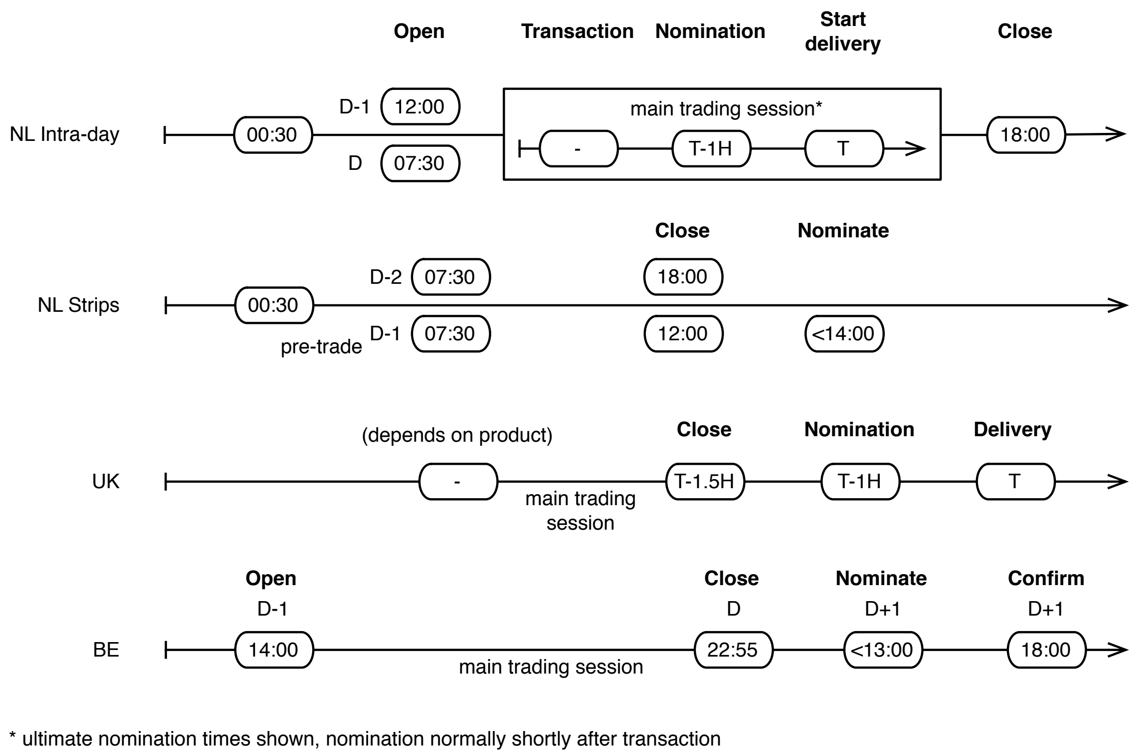

Figure 26: Power Intra Day Markets

The following power products are available to trade in the day-ahead auction (table below, expiry means how long before start of delivery the product closes for trading):

	NL		UK		BE	
Product	**# MWh**	**Expiry**	**# MWh**	**Expiry**	**# MWh**	**Expiry**
15 min	+	2 hours				
30 min			+	90 min		
1 hour	+	90 min			+	5 min
2 hour	+	90 min	+[1]	90 min		
4 hour			+[1]	90 min	+	5 min
6 hour					+	5 min

1) a lot more different products available (evening, weekend, etc), build up from these elements

Table 18: Power Intra-Day products

Sources: APX-ENDEX (2010e), APX Commodities Limited (2008) and Appendix F.

A.3 Gas before the day

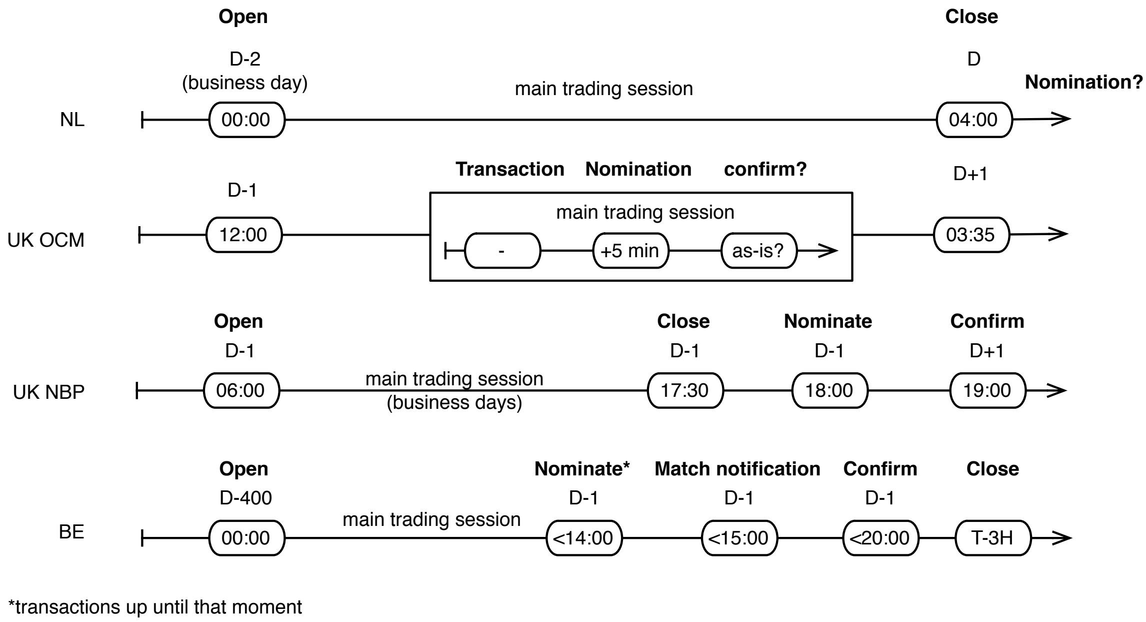

Figure 27: Gas Day-Ahead Markets

The following gas products are available for trading before the day of delivery.

	NL	**UK (OCM)**	**UK (NBP)**	**BE**
Product	**# MWh**	**Therms**	**Therms**	**Therms**
	Expiry: D 04:00	Expiry: D+1 03:35	Expiry: D-1 17:30	Expiry D 03:00
Gas Day	+	+[1]	+	+
Working Days Next Week	+		+	+
Balance of Week	+		+	+
Weekend	+		+	+
Month			+	
Balance of Month			+	
Locational Day(s)		+[2]		

1) available as physical day or title day

2) available as one day up to seven days

Table 19: Gas 'before the day' products

Sources: APX-ENDEX (2010d), APX Commodities Limited (2009a) and Appendix F.

A.4 Gas on the day

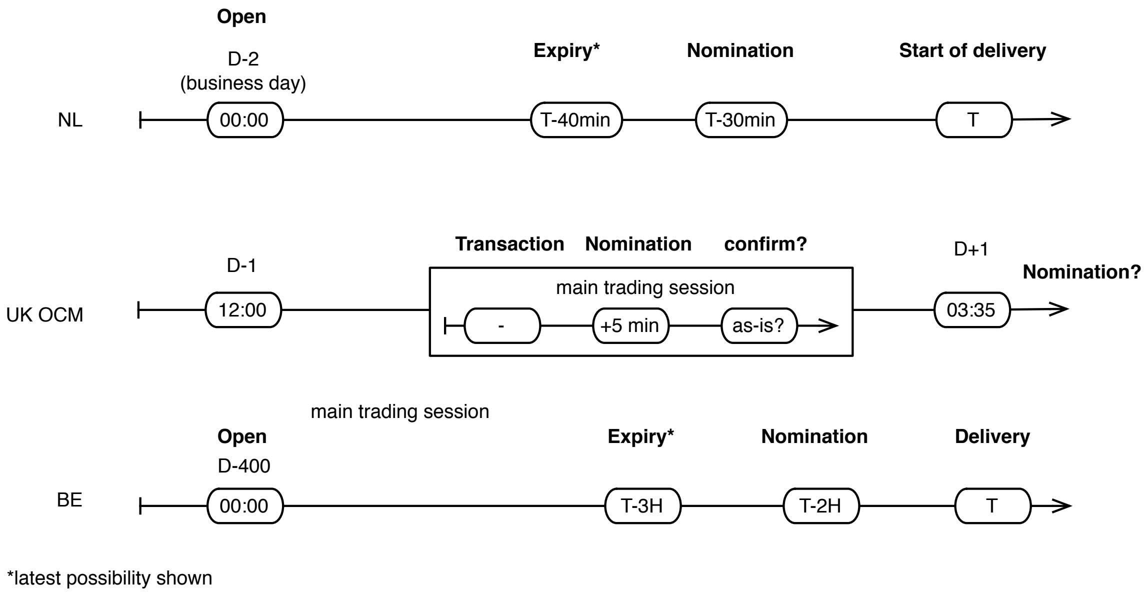

Figure 28: Gas Intra-Day Markets

The following gas products are available to trade on the day of delivery.

	NL		UK (OCM)		BE	
Product	**# MWh**	**Expiry**	**Therms**	**Expiry**	**Therms**	**Expiry**
Gas Day			+[1]	D+1 03:35		
Balance of Day	+	40 min			+	3 hours
Locational Day(s)			+[2]	D+1 03:35		

1) available as physical day or title day
2) available as one day up to seven days

Table 20: Gas 'on the day' products

Sources: APX-ENDEX (2010d), APX Commodities Limited (2009a) and Appendix F.

B Current Margins

All the current margins for continuous trade:

TTF	Buy	Sell	ZEE	Buy	Sell
DA	11.0%	11.0%	DA	15.3%	15.3%
BoD	11.0%	11.0%	BoD	15.3%	15.3%
WKND	7.4%	7.2%	WKND	11.5%	12.0%
WDNW	7.4%	7.2%	WDNW	8.5%	10.9%
BoW	11.0%	11.0%	BoW	15.3%	15.3%

NBP	Buy	Sell	Power NL	Buy	Sell
DA	19.7%	19.7%	DA Base	35.0%	35.0%
WKND	14.6%	12.9%	DA Peak	57.0%	57.0%
WDNW	9.2%	13.6%	DA Off-Peak	30.0%	30.0%
BoW	19.7%	19.7%	WKND Base	35.0%	35.0%
Month	5.8%	7.1%	WKND Peak	57.0%	57.0%
BoM	9.2%	13.6%	WKND Off-Peak	30.0%	30.0%

Power UK	Buy	Sell
Base Week	9.6%	13.1%
Peak Week	13.5%	16.9%
Other Base	34.2%	34.2%
Other Peak	42.4%	42.4%

Power BE	Buy	Sell
Hourly Instrument	n.a.	n.a.

Table 21: All current continuous margins

C Collateral method benchmark among other exchanges / CCPs

See table 22 on page 67.

Sources:

1.	OTE (2010)
2.	IESO (2010)
3.	EXAA (2007)
4.	ECC (2010)
5. & 6.	Nord Pool Spot (2010b, 2010a)
7.	Seed (2010)
8.	Energy Market Company (2010)
9.	California ISO (2010)
10.	Borzen (2010)
11.	Polish Power Exchange (2010)
12.	National Gas Exchange Canada (2010)

D Netted Exposure - Example

Member trading in both countries still receives the benefit of a 'discount' in individual collateral from selling in Belgium as depicted in figure **??** on page **??**.

- Removed -

	Exchange/CCP	Country	Commodity	Position	Cover	Calculate	Limit
1.	OTE	Czech Rep.	Power/Gas	Buy	Individual + Claim[1]	Imbalance historic price * trade position + valid unmatched bids + matched bids	
2.	IESO	Canada	Power	Buy/Sell	Individual + Claim[1]	Min: 7 * Daily off-take * $69.38 + 21 day mean market activity	75%
3.	EXAA	Austria	Power	Buy	Individual	mean + 3*st dev * $\sqrt{4}$ over past 30 days, min: EUR 100,000	
4.	ECC	Germany	Power/Gas	Buy	Individual + Fund	Mean + 3.5 * st dev, in last 12 months	
5.	NPS Power	Norway	Power	Buy	Individual	Net buy activity, last 7 days. Min: EUR 30,000	
6.	NPS Gas	Norway	Gas	Buy	Individual	Net buy activity, last 7 days. Min: EUR 12,500	75%
7.	AEMO	Australia	Power	Buy/Sell	Individual	Trade limit = Prudential requirement - prudential margin	
8.	EMC	Singapore	Power	Buy/Sell	Individual + Claim[1]	Unrealised settlement + (20 - # days with unsettled) * average last 90 settlement amounts	70%
9.	California ISO	USA	Power	Buy/Sell	Individual	Credit limit + security > Invoiced/uninvoiced settlement + expected transactions next 5 days	
10.	Borzen	Slovenia	Power	Buy/Sell	Individual	Est monthly exposure: 17 * max load * mean price (in last 12 months). Min: EUR 50,000	
11.	Polish Power Exchange	Poland	Power	Buy	Individual	Gross amount of purchase order < available collateral to allow match. Sell: increases limit.	
12.	National Gas Exchange	Canada	Gas	Buy/Sell	Individual + Fund[2]	Initial Margin + Variation Margin + Unrealised settlements	

1) Claim of residual losses to be put to active members at time of default
2) Non-mutual fund ($ 100 million) funded by NGX

Table 22: Collateralization methods at benchmarked energy exchanges

E Stakeholder interviews

Purpose The stakeholder interviews where held with different trading members. The purpose of these interviews was to get input on the following two things:

1. The current way of calculating collateral; to hear the praises or complaints with the current systems and gather ideas to improve it.
2. Hear how the member in question calculates and handles counterparty risk in bilateral transactions, to get an insight and gather ideas that could perhaps be taken over to central counterparty clearing.

Questions The interviews with different trading members happened over the course of 5 weeks. Prior to each interview the questions where send so the person being interviewed by e-mail. These questions where amended over the course of several interviews to get the input wanted from the trading members interviewed.

Interview The following two questions where the ones send out prior to the interview, the indented questions where added over the course of several interviews, but not send in advance. These where the topics the interviewer wanted input on, without channelling the initial reaction of the clearing member on the collateral methodology.

1. What is your opinion of the current risk capital structure (being individual collateral + default fund) and the way the level of required collateral is calculated?
    - Treat net buy and net sell differently?
    - Opinion on the exact calculation method for auction and continuous trade?
    - What do you consider to be a plausible worst-case scenario?
    - What are factors influencing the decision to trade via the exchange or OTC?
    - Opinion on cross-margining / netting across markets? Is this already done through your settlement bank?
2. How does your firm handle financial and delivery risks in general; so, which do you recognise, and how is the exposure calculated and covered?
    - Risk modelling?

The trading members with whom the interviews were held constituted of:

- Three producers
- Two traders/portfolio managers
- One TSO (TenneT)

F Delivery Risk Profiles

F.1 Power NL

Sources: (Energiekamer, 2009; TenneT, 2009)

The 'Systemcode' is drafted by the 'Energiekamer', the other source is the 'E-Program submission manual', drafted by TenneT. The first has a legal basis, the second is used to get a clearer picture of the whole nomination process.

Program responsibility

APX-ENDEX is a party with a 'zero-position' full PV (programme responsibility) and is thus able to put forward E-programs and be a counterparty in E-programs. Due to the 'full PV' status, APX-ENDEX can in theory also be held liable for imbalance due to different deliveries and off-takes of power than put down in the E-program; however, since APX-ENDEX does not have any connections this cannot be the case (hence the 'zero-position').

The choice to become a full PV after being a trade PV before was made to facilitate the market coupling of CWE (NL,BE,FR,DE,L), which came into force on the 9th of November 2010. The decision was necessary to make it possible to catch small round-off differences that arise because the French/German power exchange (EPEX Spot) works with a different amount of decimals in pricing.

Process of nomination

- Double sided nomination, where every party has to nominate prior to 14:00 D-1. (3.6.5/3.6.6 - Systemcode)
- Day-ahead:
  - Nomination daily before 14:00 on day D-1 for delivery on day D (3.6.5- Systemcode)
  - Upon receipt by TenneT of the E-program, and the program being internally consistent (thus summing up to zero): send acknowledgement of 'taking into consideration' or error message otherwise. (3.2. - Manual setting up E-Programs)
  - In case of external inconsistency: if this inconsistency is not resolved before the E-program comes into force, the conflicted part of the program will be invoiced to the PV parties involved against the imbalance price. (3.6.12- Systemcode)
  - An E-Program comes into force on 00:00 of the delivery day (3.6.16 - Systemcode)
  - TenneT has the right to 'withhold approval' of an E-program (3.6.13 - Systemcode). If this is done for APX-ENDEX or one of the parties that it has a transaction with however this means that in effect TenneT will withhold approval for the entire market (i.e. Approval for party A is withheld, thus APX-ENDEX is withheld, thus all parties that APX-ENDEX dealt with are withheld, etc). This is called 'chain inconsistency'. The parties that are externally inconsistent with each other have to solve this inconsistency as soon as possible since without an approved E-program it is not possible for any of the parties in the Dutch power market to trade with each other (since they do not know their confirmed position).
  - After checking that all programs of all PVs are internally and externally consistent TenneT will approve all E-programs by sending an automated response (7.3 - Manual setting up E-Programs)
- Intra-day:
  - Changed E-Program has to be send in at least 1 hour before it is supposed to come into force (3.6.19 - Systemcode)
  - In case there is an external inconsistency, none of the corresponding nominations are approved for the hour that the changes are inconsistent. (7.2 - Manual setting up E-Programs).

- When the changed nominations are not approved, the last approved E-Program stays in effect (not directly written down, but implied & discussed in meeting with TenneT).
- In case of non-acceptance of changes to an E-program intra-day, the contracts that APX-ENDEX has with the parties involved are void (APX-ENDEX, 2010a). The reason why this is possible for intra-day trading and not for the day-ahead auction is that for intra day the counterparties to a transactions are known to APX-ENDEX; for Day-ahead it is not possible to identify the direct link between two parties (due to the nature of the auction).

After irrevocable delivery

Failure after approval of E-Program is regulated by article 3.1 of the Systemcode.

The following things can happen:

- Loss of recognition of full PV rights (3.1a - Systemcode)
  - Transfer of responsibilities as set out in Article 3.1c.
- Full PV party in surseance or declared insolvent
  - It is possible for TenneT to sit with the parties involved and decide to postpone termination of PV rights, and put forward guarantee for extra costs (made for the sourcing of energy) to keep the party in business (max 10 days) (3.1b.1 - Systemcode)
  - The transfer of responsibilities set out in Article 3.1c (copied down below) starts either as soon as possible, or after the extra 'grace' period
- If supplier can no longer honor it's obligation to deliver
  - Also in this case it is possible for TenneT to sit with the parties involved and decide to put forward guarantee for extra costs (incurred for the sourcing of energy) to keep the party in business (max 10 days) (3.1b.1 - Systemcode)
  - The transfer of responsibilities set out in Article 3.1c (copied down below) starts as soon as possible, or after the extra 'grace' period if applicable.
  - In case the supplier has provided for a full PV party to take on the obligation to deliver in case of a default (3.1d.4a - Systemcode) this happens either immediately or after the possible 10 day period mentioned. This full PV party may invoice the large connections the APX-ENDEX price for deliveries made (3.1d.7 - Systemcode).
  - Otherwise transfer according to Article 3.1c.
- Article 3.1c - Transfer of responsibilities
  - Transfer of connections to other full PV parties if the connecting party has agreed this beforehand (3.1c - Systemcode)
  - If not agreed beforehand: transfer of small / large connections to the other full PV parties pro rata their number of small / large connections

Since APX-ENDEX has the status of 'Full PV' since November 2010 it is included in the transfer of responsibilities as set out in article 3.1c above. However, since APX-ENDEX does not have any physical connections this will in practice not result in any liabilities.

Conclusion: none of these things will harm APX-ENDEX in any way

Imbalance

The full PV parties are liable for the difference between their E-program and the actual physical delivery or off-take of the connections for which they carry PV responsibility (against imbalance price) (3.9.2 - Systemcode).

Delivery risk profile

To summarize, if a counterparty defaults:

- **Before the auction is run** then APX-ENDEX could put its' bids/offers on hold; leading thus to no exposure
- **After acceptance of the E-Program** then the Systemcode stipulates how this is handled between the Full PV parties. This goes pro-rata the number of connections, and since APX-ENDEX doesn't have any connections it is exempt.

Financial risk for APX-ENDEX could arise for the scenarios examined in the table below:

Power NL	Probability	Impact	Loss
Counterparty default after nomination E-Program	< 1 in 10 years	Possibly high	Position * imbalance price
Ext. inconsistency E-programs (Day-ahead)	2˜3 times per week	Only if not fixed between 14:00-23:59	Volume difference * imbalance price
Ext. inconsistency E-programs (Intra-day)	high (time pressure)	-none-, if E-program not accepted, contracts are void	-none-

To conclude, the only real financial threat to APX-ENDEX when it comes to delivery risk for the Power NL market is external inconsistency in the Day-ahead nominations. Even the default of a counterparty after the nomination of its' E-program can only harm APX-ENDEX if this E-program is externally inconsistent with the one that APX-ENDEX submits.

It is nowhere defined what TenneT would (or is required to) do with an otherwise consistent E-Program when it is known that the party in question will not be able to honour it's physical delivery or off-take obligations on the next day. Two scenarios can thus be identified:

- If TenneT would always approve a consistent E-Program, than the possible financial impact on APX-ENDEX is low. Given that external inconsistency happens 2 to 3 times per week while in the past 11 years it has happened only once with a smaller foreign party that the difference wasn't resolved in time and APX-ENDEX got a penalty charge, this leads to the conclusion that the likelihood of a loss occurring is very low (less than once per 10 years), while the impact is limited (maximum 100% of the volume times the imbalance price at that time). A very low likelihood of occurring and a limited impact would make this risk best covered through a mutualisation solution such as the default fund (Hills et al., 1999).
- If TenneT does in fact take into account whether a party will really be able to live up to the obligations in it's E-Program and would take part of the transactions out of the program before giving approval to the market, APX-ENDEX might very well be charged with any position that party had against the imbalance price.

Since for now it is unknown which of these scenarios would hold, the more prudent solution is to assume the second one is the case. Thus the line of the current collateralization strategy for Power NL (full collateral also on sell side positions) has to be upheld, while it would be a good idea to work on a special position for APX-ENDEX as market operator.

F.2 Power UK

Source: (Elexon Ltd. 2010)

Definitions

- Gate Closure: 1 hour before start settlement period (X-1, BSC)
- Settlement Period: Period of half an hour, first of the day: 00:00-00:30 (X-2, BSC)

Process of Notification (nomination)

- Single sided notification as ECVN Agent (P 1.5, BSC)
- Delivery/settlement period ECVN is put forward with effective from and effective to date, with volume in MWh per settlement period (4.16, BSC71)

Notification deadline

- ECVN has to be received before or at gate closure (4.17, BSC71)

Irrevocably delivered

- If the ECVN is valid (P 2.3.4) and not refused (P 2.5.1) it is force, but may be amended up until gate closure of the respective settlement periods it contains (P 2.3.5, BSC).
- An ECVN is valid when it is in compliance with BSC71, contains the correct elements, is coming from an authorised party and has hourly volumes within certain boundaries. Since nomination happens single sided by an automated system, generally ECVNs from APX-ENDEX will always comply with these conditions.
- If a party is using it's credit cover for more than 80%, but less than 90% for any settlement period, the party in question gets a notice that it has entered the 'Query Period'. This period starts at gate closure for the settlement period in relation to which the credit cover surpassed 80% and ends 24 hours later (or, in case this happens over the weekend, an extra 'level 1 default cure period' is granted). If the credit cover has not been brought back to below 75% by the end of this time the party is deemed to be in level 1 credit default. (H 3.2.2)
- If for any settlement period J the credit cover percentage of a Trading Party becomes greater than 90%, regardless of whether or not this settlement period falls in a Query Period or Level 1 Credit Default Cure Period, the Trading Party shall be in Level 2 Credit Default. (H 3.3.1.)
- The Trading Party will cease to be in Level 2 Credit Default with effect from Gate Close for the next Settlement Period in relation to which its Credit Cover Percentage becomes not greater than 90% (H 3.3.2).

Two time frames are defined when a party enters Level 2 Credit Default:

- Credit Default Refusal Period
  - This is the period from Gate Closure for Settlement period J until Gate Closure of the Settlement Period directly after the Settlement Period for which the Credit Cover Percentages becomes not greater than 90% (H 3.3.5 (i)).
  - Within this period any Energy Contract Volume Notifications that would have the effect of increasing the energy indebtedness are treated as refused and will not become effective (H 3.2.2, P 2.5.1 & 2.5.3)

- Credit Default Rejection Period
  - This is the period from Gate Closure for Settlement Period J+3 until Gate Closure for the third Settlement Period after the Settlement Period for which the Credit Cover Percentages becomes not greater than 90% (H 3.3.5 (ii)).
  - Within this period any Energy Contract Volume Notifications that are in force that have the effect of increasing the energy indebtedness are treated as rejected and will have no effect. (H 3.2.2, P 2.5.2 & 2.5.3)
- The moment of irrevocable delivery is thus Gate Closure

The following scenarios thus could harm APX-ENDEX financially

	Probability	Impact	Loss
Notification not accepted due to party being in level 2 credit default	Low (in	APX-ENDEX could end up with an unbalanced position for SELL contracts	Cost of close-out and/or imbalance
Accepted notifications cancelled (party in level 2 credit default)	Low	APX-ENDEX ends up with unbalanced position for SELL contracts	Cost of close-out and/or imbalance

F.3 Power BE

Source: (Elia, 2010; KB Beurs, 2005)

Nomination

- The 'marktbeheerder' (Exchange) nominates for itself and on behalf of its members (KB Beurs 2005, Art11.)

Nomination deadline

- The deadline for day-ahead nominations is 13:00 D-1, for intra-day: 13:00 D+1. (ARP-Contract, App 5, Art 1.4).

Irrevocably delivered

- Nominations from the 'marktbeheerder' are accepted 'as-is' and exempt from any imbalance charges, unless the imbalance stems from an operational error on its part (Art. 12.2.5, 12.2.6).
- The Point of irrevocable delivery is thus: the moment of nomination.

Delivery/settlement period

- Per 15 minutes of the delivery day (Art 12.1)

APX-ENDEX is thus exempt from any delivery risk for Power BE.

	Probability	Impact	Loss
Nomination not accepted	None	-none-, nominations single sided and accepted as-is as a match	-none-

F.4 Gas NL

Source: (Gas Transport Services, 2010)

Nomination

- Single sided nomination by the gas exchange operator, who (re)nominates, not only for itself, but also instead and on behalf of its customers (App 5, 3.3).

Nomination deadline

- Shipper or trader may send a nomination up to 400 days in advance of gas delivery day. Possibility for (re)nomination lasts until thirty minutes prior to the hour of delivery (App 5, 3.2).

Irrevocably delivered

- The confirmation and matching for a gas exchange operator or clearing party and its customers differs from the above as follows. A single sided (re)nomination GTS receives from a gas exchange operator or its clearing party is deemed a match. Counter Parties of the gas exchange operator or its clearing party receive a confirmation. (App 5.7).
- Point of irrevocable delivery: nomination.

Delivery/settlement period

- Hourly nomination for all hours within gas day (Art 3.1).

	Probability	Impact	Loss
Nomination not accepted	None	-none-, nominations single sided and accepted as-is as a match	-none-
Accepted nomination is rejected	[unclear at the moment]	APX-ENDEX ends up with unbalanced position	Cost of close-out and/or imbalance

F.5 Gas UK

Source: (Joint Office of Gas Transporters, 2010) - TPD

OCM - Regulated by Section D2 and Annex D-1

Delivery assured

- Each Trading Participant shall appoint the Trading System Operator as its User Agent, (and the Trading System Operator shall be required to act as each Trading Participant's User Agent) for the purposes of making Trade Nominations on behalf of Trading Participants pursuant to the acceptance of a Market Offer (Annex D-1, 2.1)
- The identity of a Trading Participant making a Market Offer will not be disclosed to any other Trading Participant at any time prior to or after acceptance of the Market Offer except where a Market Offer in respect of a Physical Market Transaction is accepted where following such acceptance the identity of the Originating User will be disclosed to National Grid NTS. (Annex D-1, 2.2)
- Following acceptance of a Market Offer the Trading System Operator will immediately inform both Trading Participants that a Market Transaction has been effected (and whether it is the Originating Participant in relation thereto) and which Market Offer has been accepted. It will make the single sided nomination to National Grid NTS not later than 5 minutes after the effecting of a Market Transaction (Annex D-1, 5.4).

NBP - Trade nominations between participants - Regulated by Section C

- The quantity of a trade nominations will be deducted in determining the daily Imbalance of the User making the Disposing Trade Nomination added in determining the Daily Imbalance of the User making the Acquiring Trade Nomination. (5.1.3)
- The quantities nominated by the two parties for a Trade nomination must be equal (5.1.2)
- A trade nomination shall not be effective and shall be rejected by National Grid NTS if the corresponding nomination is not for the equal amount, or when the trade nomination was submitted before the gas flow day, by 07:00 hours on the gas flow day; otherwise within 60 minutes before or after the first trade nomination was made. (5.1.2)
- A Trade Nomination may not be made: (a) earlier than 30 Days before the Gas Flow Day; (b) later than 04:00 hours on the Gas Flow Day (C 5.2.2.)
- For each User the "Daily Imbalance" in respect of a Day is the imbalance between the quantities (adjusted to take account of Trade Nominations including System Trade Nominations) treated as delivered to and off-taken from the Total System by the User on that Day (E 1.2.2).
- A "Daily Imbalance Charge" is an amount payable by or to a User in respect of a Daily Imbalance. Since APX-ENDEX does not deliver or off-take gas to the grid, it does not face 'Scheduling Charges' (for different deliveries/off-takes than nominated). (F 1.1.2).
- The quantity of gas comprising a User's Daily Imbalance shall be deemed to have been sold and purchased pursuant to a System Clearing Contract; - Where the Daily Imbalance is positive, the seller is the User and the buyer is National Grid NTS, the price is the System Marginal Sell Price. - Likewise where the Daily Imbalance is negative, the seller is National Grid NTS and the buyer is the User, the price is the System Marginal Buy Price. (F 2.2.1.)

Conclusion

- The moment of irrevocable delivery is thus 19:00 on D-1 (moment of confirmation, (APX Gas APX Commodities Limited, 2009a))
- When either of the counterparties does not make the required counter nominations, or makes a mistake in the quantity, APX-ENDEX could end up in positive or negative imbalance. This will automatically be closed out against the System Marginal Sell/Buy Price.

One problem:

- A Trade Nomination may be withdrawn by the User who submitted it at any time before the Gas Flow Day, but may not be amended or withdrawn within the Gas Flow Day (but without prejudice to any subsequent Trade Nomination). (C 5.2.4)

	Probability	Impact	Loss
OCM - nomination not accepted	None	-none-, nominations single sided and accepted as-is as a match	-none-
NBP - nomination not accepted (no counter nomination or wrong quantity)	Moderate	Could end up in imbalance, automatically closed against system price	Quantity against system buy/sell price
CP Default after acceptance of nomination	Low	Could end up in imbalance, automatically closed against system price	Quantity against system buy/sell price

F.6 Gas BE

Source: (Huberator Huberator SA, 2005)

Definitions (Art 1)

- Shipper - Any company holding capacity rights in the Fluxys Transmission System for delivery or redelivery of Natural Gas to or from the Zeebrugge Hub.
- Zeebrugge Hub Trading Platform - The trading platform, offered by the joint venture between the Hub Operator and APX-ENDEX Group, and which may be a Counterparty to the Customer.
- Delivery Curtailment Event - A continuous period during which the Customer, who is also a Shipper, is not delivering all or part of the quantities of Natural Gas, last confirmed by the Hub Operator before such curtailment event, to the Zeebrugge Hub. A Delivery Curtailment Event stops as soon as the Customer's deliveries have been restored. The Hub Operator will for the first five hours following the start deliver Natural Gas (automatic back-up), this is extended afterwards (additional back-up) if necessary. The costs are charged through to the customer.
- Redelivery Curtailment Event - A continuous period during which the Customer, who is also a Shipper, is not off-taking all or part of the quantities of Natural Gas, last confirmed by the Hub Operator before such redelivery curtailment event, from the Zeebrugge Hub. A Redelivery Curtailment Event stops as soon as the Customer's redeliveries have been restored. The Hub Operator will for the first five hours following the start take off Natural Gas (automatic off-take), this is extended afterwards (additional off-take) if necessary. The costs are charged through to the customer.

Automatic balancing (Section 2.3)

- The customer's net position at the Zeebrugge Hub Trading Platform has to be balanced by delivery to or redelivery from the platform. This requires an additional Daily Transfer Notice based on the original nomination, as a hub customer for a delivery to or an off-take from the Customer's Hub Platform Code. This is called the Automatic Customer Daily Transfer Notice.
- The Hub Operator may cover the Customer's Imbalance by delivering Shortfall Gas to or taking delivery of Excess Gas from the Customer's Hub Platform Code in case the Customer's net position at the Zeebrugge Hub Trading Platform is not balanced (Section 2.3).

Customer Daily Transfer (CDT) Notice (Section 2.2.1)

- The CDT is used by the customer to provide the Hub Operator with the Nominated Hourly Deliveries and Nominated Hourly Redeliveries. This happens Double Sided (Operating Procedures, App A, 4.1.1)
- It is made to:
  - The Customer's code as a Shipper in case the Customer as a Shipper delivers Gas to the Zeebrugge Hub or receives Gas from the Zeebrugge Hub;
  - The Customer's Hub Platform Code(s) in case the Customer, as a member of the Zeebrugge Hub Trading Platform, delivers Gas to the Zeebrugge Hub Trading Platform or receives Gas from the Zeebrugge Hub Trading Platform in accordance with Section 2.3.

Balance check (Section 3)

- The Hub Operator shall determine the customer's effective hourly deliveries and redeliveries and inform the customer of the outcome by issuing a Hub Operator Confirmation Notice. Any mismatches remaining after the grace period for correction has passed result in all nominated hourly deliveries or redeliveries be deemed zero.
  - In case of such a mismatch for the quantity of energy nominated by the Customer being a Shipper for Delivery into the Zeebrugge Hub or redelivery out of the Zeebrugge Hub, the matched quantities will be the lesser of the quantities of energy nominated by the Customer as Shipper and the quantities of energy nominated by the Customer, being a Shipper, to the Hub Operator. (Sec 6)
- The Hub Operator Confirmation Notice is send before 20:00 on day D-1, thereafter together with a DMT or, as soon as possible but not later than two hours after the Hub Operator has received all necessary information to determine that deliveries to the Customer or deliveries by the Customer at the Zeebrugge Hub will be or have been curtailed or reinstated. It contains the effective hourly deliveries and redeliveries, including amounts of automatic and additional back-up/off-take, and the shortfall gas or excess gas needed to balance the position of the customer. (Section 2.4.2).
- If the Hub Operator has to supply the customer with automatic or additional back-up or shortfall gas or has to provide the service of automatic or additional off-take quantities or take off excess gas, this will be against the best possible market price available; capped at lowest 50% of the ZIG Day-ahead or ZIG weekend index price for off-take/excess gas and max 150% of the ZIG Day-ahead or ZIG weekend index price for back-up/shortfall gas.

Conclusion

- APX-ENDEX is not physically delivering Natural Gas to the Zeebrugge Hub, but functions as a central counterparty within the Zeebrugge Hub Trading Platform, and as such is thus not a shipper.
- This means that if a counterparty does not nominate the correct amount or defaults, the nominations for that hour are deemed to be zero, leaving APX-ENDEX with an unbalanced position.
- Due to the provisions for shortfall or excess gas in accordance with Section 2.3 however this unbalanced position will be automatically balanced when necessary, with the price capped at lowest 50% of the day-ahead index for excess gas and maximum 150% of the day-ahead index for shortfall gas.

	Probability	Impact	Loss
Nomination rejected or unequal to counter nomination (double sided)	Low	Unbalanced position since nomination set to zero for relevant hours	Max: nominal value + 50%

G Data - Timeseries

Platts timeseries used are below, methodology is:

- Platts data: Unable to do volume weighted approximation of average price per day since volume is unknown, therefore take midpoint between high and low for each day.
- Platts publishes the 'market-on-close' price, as of 12:00 for power day ahead contracts and 16:30 London time for all gas contracts. Source: input from brokers and exchange.

Series used:

- NBP - Day-Ahead: NGAAA00 (provided by Platts)
- NBP - OnTheDay: System Average Price (provided by APX-ENDEX for National Grid Plc.)

Series give the 'dayahead price' of the commodity on a given day

- now, if there is real data available
  - shift to day-ahead price 'for' day & take real price for day
- if no real data
  - compare 2 day ahead price on the day with each other

Validate price series

Correlation for current Platts series (for Gas UK: NBP - Day-Ahead) : 97,4% with the System Average Price (the price for gas on the delivery day.

H Reflection

Although on the outset the scope of this research seemed to fit nicely in the six months reserved for a master assignment it turned out to be a bit more work than expected; in part by my drive to get the full analysis done on both auction collateral and continuous margining, and secondly by the inherit complexity and the numerous ways the elements under investigation can or have an influence on one another.

I enjoyed working on the quantitative elements of the research, modelling the current situation and thinking creatively to get the abstract collateral aspects into Matlab. The qualitative side of the research took some more effort from time to time to get done; plowing through regulatory documents of up to 800 pages and getting a grip on the slippery issue of delivery risk. Although I found it hard to do, the drive to get to the bottom of things was also motivational.

The personal learning objectives set for this project where to work along the academic way, which didn't work out so well for my bachelor assignment, and to sharpen my project management skills in a professional environment.

The first objective, working along the academic way, was chosen because I tend to work very pragmatic, which doesn't align so well at times with the more step-wise academic way to build up a research project. In this research I positively incorporated elements from the academic way in my way of working, in that I found out that having a clear structure and questions helps to be efficient in getting where you are trying to go. My pragmatic approach for instance made me drown from time to time in all the literature that I had gathered, but the academic approach pulled me through by helping to select what was helpful to answer a certain question.

The second objective, increasing my project management skills, was chosen to apply the skills I already have from my extra curricular activities in a professional environment. This worked out quite well, given that my deadlines where achieved and the project completed within the timeframe and requirements stated. Lessons learned where to work on the external inputs first because getting the results will generally take longer than you expect, and that using the existing knowledge within the company (such as legal or regulatory affairs in this case) gets the answers faster than trying to do everything by yourself.

I look back on a great six months tackling this research project for my Master thesis. It was a great introduction to the energy industry and quantitative risk management and I would like to thank APX-ENDEX for providing me with this opportunity!

March 4th, 2010,

Wouter IJgosse