



National Generators Forum

# The role of hedging contracts in the existing NEM prudential framework

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A Critique of the draft PricewaterhouseCoopers  
Review for the AEMC

4 November 2009



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## 1 Executive Summary

The Australian Energy Markets Commission (AEMC) commissioned PricewaterhouseCoopers (PwC) to review:

- the risks associated with the existing reallocation arrangements (RA) in the National Electricity Market (NEM) prudential framework and options to enhance these arrangements
- the risks associated with the proposed models for futures offset arrangements (FOA) and options to enhance these arrangements
- the maximum credit limit methodology (MCL).

The review forms part of the work program identified by the AEMC in its earlier review of a Rules Change proposal to introduce FOA.

PwC has reviewed two FOA models and focuses on Model 2 (the FOA model), as well as the current Reallocation Agreements and the Maximum Credit Limit in its draft report for the AEMC, *Review into the role of hedging contracts in the existing NEM prudential framework, September 2009*, released in early October and has made a number of recommendations relating to the proposed FOA, as well as the existing RA and MCL. The National Generators Forum has commissioned Seed Advisory Pty Ltd (Seed) and Taylor Fry Pty Ltd (Taylor Fry) to undertake a desktop review of the PwC report.

The preferred FOA model would, in exchange for certain conditions affecting the nominated futures positions, reduce those participants' MCL and the level of prudential security held by the NEM, as well as altering the form of the prudential security held by the Australian Energy Market Operator (AEMO) against (the risk of) a loss to market participants from a participant default.

In approaching our review, we initially examined the proposals affecting the RA, the evaluation of the introduction of the FOA and the possible changes to the MCL individually. However, as the discussion of the FOA model below indicates, evaluation of the FOA on a NEM participants' exposure is inextricably related to the wider question of what protection the MCL is intended to provide in its current form and how changes to the MCL or proposals such as the FOA should appropriately be analysed. Reflecting our view of the necessary analysis required to assess a change in the NEM prudentials, we believe that the discrete analytical approach undertaken by PwC which looked at each of the issues, RA, FOA and MCL largely in isolation will miss the impact of key interdependencies and interrelationships. For example, we believe the analysis underlying PwC's recommendation for a minor augmentation of the prudential arrangements in association with a RA is inappropriate. If an appropriately integrated and structured analysis were to be undertaken, the results may be materially different.



### ***Evaluating the FOA***

In looking at the FOA, we have adopted a standard analytical framework for evaluating the risk and cost of loss in the event of default. The framework is discussed in detail in Section 2. Focusing on the direct effects of the introduction of the FOA<sup>1</sup> in the light of this analytical framework suggests the following questions need to be answered about the FOA model:

- Does the proposed reduction in the MCL associated with an FOA present a risk to the prudential framework of the NEM that would increase the (risk of a) loss to participants in the event of default?
- Does the altered form of the security associated with an FOA present a risk to the prudential framework of the NEM that would increase the (risk of a) loss to participants in the event of default?
- Are the restrictions imposed in the proposed FOA likely to be effective in safeguarding the position of the NEM in the event of default?
- Are there significant net benefits to the NEM that should be considered in evaluating the proposal?

### ***PwC's Evaluation of the Futures Offset Arrangements and the NEM Prudential Framework***

These questions have not been answered in a way that would allow the AEMC or market participants to assess the merits of the proposal. The AEMC cannot be confident that its overriding objective of enhancing the operation and efficiency of the prudential regime is achieved by the proposal.

- The statistical tests performed are inappropriate, given the structure of the underlying data, casting serious doubt on the statistical validity of the relationships identified. The data should be analysed using alternative statistical techniques recognised as appropriate for the underlying relationships. Our recommendations on this issue are in Section 3.3.
- PwC's analysis is limited to a special, limited case of the FOA model. PwC analyses the case where there is a single Futures Lodgement Price (FLP), no withdrawals from the Security Deposit Account (SDA) over the life of the contract and the underlying futures position is held to maturity. Model 2 provides that: the FLP is the closing price on the day of lodgement for a period from 90 days in advance of the period covered by the futures contract to, effectively, two days before the futures contract expiry; withdrawals from the SDA can be made when prices fall; and, provided 10 days notice is given, the FOA position can be closed and an alternate security provided to the AEMC. PwC does not model the need for, or the effect of its recommendation that the retailer be required to top up its SDA when futures margins payments

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<sup>1</sup> Section 3.3 discusses the possible indirect effects of the introduction of the FOA.



received are insufficient to cover the retailer's total obligations to the NEM.

- PwC's proposed amendment to the FOA model may overestimate the benefit to the NEM of the FOA model. PwC recommends that the retailer be required to top up their SDA when futures margins payments received are insufficient to cover the retailer's total obligations to the NEM. This change may mean that at times of high spot price volatility, the retailer's SDA consists of a large proportion of cash top ups relative to futures margins payments received. In these circumstances, the estimated benefit to the NEM from the FOA model is questionable.
- The analysis of the results included in the draft report overlooks significant periods when it appears that the identified relationships do not hold. PwC's finding of a strong and reliable relationship between spot and futures prices is the basis for its finding that the FOA model should be accepted, as this relationship provides market participants with comfort that, in the event of a market participant's NEM exposure exceeding its adjusted MCL at any time, the anticipated cash flows from the nominated futures position will offset the exposure and can be captured in a SDA. If this relationship is not strong and reliable, then the nominated futures position cash flows may not provide the required security, for example when performance under appropriately designed stress tests is measured, different time periods are selected or other states than NSW, with similarly liquid futures markets, are considered. Our comments on these issues are in Section 3.3.
- More significantly, the framework adopted for considering the operation and intent of the NEM's prudential framework provides no robust analytical measures for assessing the potential effect of the FOA model on the risk of loss to a market participant in the event of default at a desired level of confidence. In particular, PwC does not discuss the likely relationship between high spot prices, the Probability of Default and the expected Loss Given Default. In the absence of this discussion, conclusions on the merits of the FOA model are very difficult to draw and, in our view, the favourable conclusions drawn by PwC are unsupported.
  - The shape of the loss distribution in the NEM is particularly important in evaluating PwC's recommendation that, if NEM is concerned about the potential additional exposure relating from the termination risk associated with the FOA model, an additional day should be added to the MCL period. If the risk of default is at its highest when spot prices are high, then there is likely to be a very significant difference between the size of the loss that could be incurred by NEM participants and the additional cover provided by a further day in the MCL calculation.
- Modelling the distribution of potential losses in the event of default is also critical to the assessment of alternatives to the current MCL calculation, several variants of which are presented by PwC, with a



recommendation that a forward looking approach using futures be strongly considered for implementation in states where the futures market is sufficiently liquid to support the inclusion of futures prices.

- More than a decade has passed since the inception of the NEM. The accumulated experience of the performance of the market allows this analysis to be undertaken. In its absence, standard statistical comparisons of the Probability of Default, the Loss Given Default and participant Exposure under the range of proposals considered in the PwC report cannot be made. The framework we suggest for analysing the MCL and the impact of the FOA model on the MCL is outlined in Section 2.
- The restrictions placed on the nominated futures positions may not provide significant protection to market participants in the event of default. In particular, we believe that SFE Clearing Participants (SFCEP) will not allow cash flows from the nominated positions to be quarantined in the event of a default by the SFCEP's customer on other positions held, exposing market participants to a greater potential loss than assumed in the model<sup>2</sup>.
- In any event, the restrictions placed on the nominated futures positions may reduce market participant use of the facility or, alternatively, restrict the management of a market participant's hedging portfolio in a way that imposes significant costs on that market participant<sup>3</sup>. In either of these cases, the benefits calculated by PwC from the proposal are unlikely to be realised and, where these issues represent a significant cost to potential users the assumed 25 percent take-up of the proposal underlying PwC's benefit cost calculation will not be achieved.
- When assessing the benefits of FOA's, PwC's calculation of the Net MCL relief also significantly overestimates the benefits by including the difference between the Prudential Margin and the Example MCL. To the extent that bank guarantees are used to provide these requirements, the direct cost to participants is the cost of the bank guarantee, not the full amount of the requirement<sup>4</sup>.

### ***PwC's Evaluation of the Maximum Credit Limit and Reallocation Arrangements***

The inclusion of a forward looking element in the calculation of an MCL is likely to improve its effectiveness and efficiency and enhance the credit quality of the NEM. However, we believe that the analysis undertaken by PwC needs to be enhanced to enable a more robust assessment of the proposed MCL.

- The use of an annual summary in PwC's analysis is too broad to properly assess the underlying behaviour of the MCL versus retailers' total outstandings. A finer weekly or monthly summary would provide more

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<sup>2</sup> This view appears to be shared by AEMO and PwC. See the discussion in Section 3.

<sup>3</sup> See the discussion in Section 3.

<sup>4</sup> See Section 3 for discussion.



useful information on the relationship between MCL breaches, that is, whether or not there are any tendencies for breaches to be related, as a result, for example of one high priced day following another (autocorrelation).

- PwC identified no material risks with the current RA process. However, PwC recommended that to cover termination risks of an RA to the NEM an incremental day could be added to the MCL prudential period. PwC's assessment fails to take account of the contingent nature of the particular risk (the identified risk depends on the risk of a prior event, in this case, the failure of a generator) and that probability of default is at its highest when spot prices are high. In practice, one additional day's MCL, calculated as an average day, may be insufficient to adequately cater for this risk, given its nature.

#### ***Our Recommendations: FOA, MCL and RA***

The AEMC should not proceed with implementing the PwC recommendations until further more robust, integrated and statistically sound analysis is undertaken. We recommend that:

- As a starting point, the AEMC and market participants analyse the current prudential arrangements in the light of the intention of the Rules, the understanding of the market participants and standard loss provisioning techniques. This analysis would clarify the definition and form the basis for a common market understanding of the 'reasonable worst case scenario', as well as defining an agreed set of statistical parameters defining the loss distribution of the NEM. These would underpin the prudential framework in the NEM and enable further enhancements, in particular the FOA, to be assessed more appropriately. That analysis should use the extensive data available on the performance of the NEM and consider the literature on the performance of the Australian and other similar electricity markets.
- In light of that analysis, more robust, integrated and statistically sound approaches should be used to reanalyse the FOA and its impact on the prudential arrangements, with particular reference to the size and duration of divergences between futures margins and pool exposures and the potential for market participant losses during these periods.
- In addition to these analyses, the AEMC should clarify the likelihood that SFECPs will quarantine nominated futures positions in the event of a default of a futures market participant on other futures positions and provide participants with legal advice on the effectiveness of other proposed mechanisms to reduce the risk of claw-back in the event of default<sup>5</sup>.

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<sup>5</sup> In particular, the suggestion that the duplication of the SFE's calculations by the AEMC provides protection against claw-back.



- Potential changes to the MCL and the RA should also be analysed in a similar statistical, integrated and consistent manner to the FOA and the overarching intent of the prudential arrangements. This analysis would take account of the performance of the NEM over time and its implications of proposed changes for Expected Losses under the existing MCL arrangements and potential additions and changes. In particular, any recommendations that have the potential to increase NEM participants' exposure in the event of default should take into account the relationship between load and price in considering what additional prudential support is required to offset the incremental risk to NEM participants.

### ***Structure of Our Report***

Section 2 introduces the standard framework used to analyse the potential for loss in provisioning against default and explores its implications for the NEM prudential arrangements, including the alternatives presented by PwC in its draft report. Section 3 reviews PwC's analysis of and recommendations on the FOA model and indicates the issues we believe need to be explored and our recommended approaches. Section 4 looks at other issues raised by PwC's report, relating to the RA and the MCL and our recommendations relating to those issues.

The detailed scope of work required by the NGF is included in Appendix A. Appendix B lists references cited in the text, including references relating to the preferred statistical tests.

### ***Disclaimer***

This report has been undertaken on behalf of the National Generators Forum in accordance with the terms of our engagement letter and proposal. We have based our recommendations on discussions with NGF members and a desktop review of publicly available information, in particular the PricewaterhouseCoopers draft report and AEMC FOA models.



## 2 Analysing the Risk of Loss in the National Electricity Market

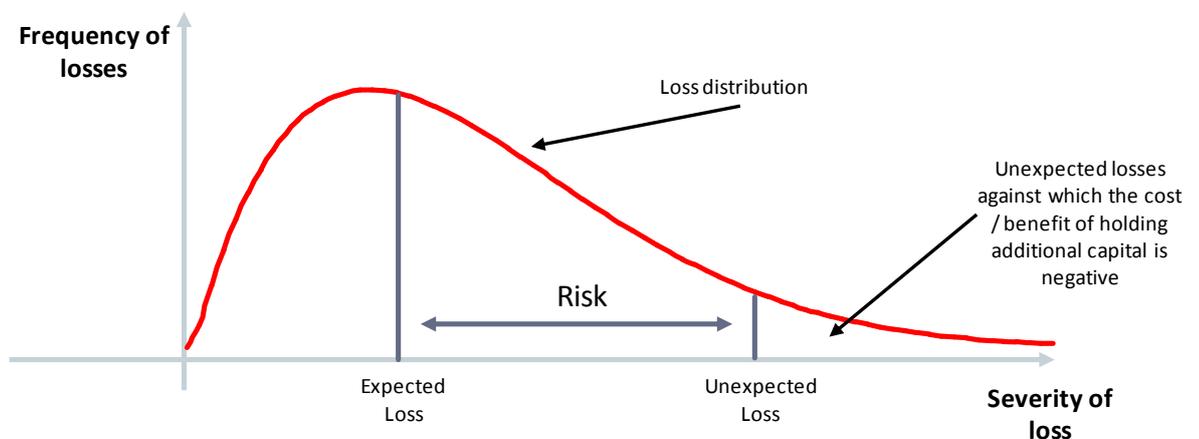
There are well defined and commonly used approaches to modeling and analysing the level of credit risk and potential exposures arising from parties defaulting on their obligations. This section outlines a framework that can be used to analyse and quantify credit risk and credit exposures and discusses its implications and application to our subsequent analysis.

### 2.1 Credit risk analysis framework

A key element of quantifying and understanding credit risk involves the specification of a loss distribution. A loss distribution is a statistical representation of the potential range of financial losses that can be experienced when a party defaults on its obligations.

Loss distributions are typically skewed and long tailed to represent the potential for extreme financial outcomes arising from low probability events. Diagram 1, below, provides an example of a typical loss distribution and some of its key elements.

**Diagram 1: Loss distribution**



When managing credit risk there are two key elements within the loss distribution that need to be determined, **Expected Loss** and **Unexpected Loss**:

**Expected Loss (EL) is statistically derived and represents the expected value of the loss distribution at a 50% probability level**

$$EL = PD \times LGD \times Exposure$$



Where:

**PD** is the **Probability of Default** which represents the likelihood of a party defaulting on their obligations

**LGD** is the **Loss Given Default** which represents the proportion of the exposure that is unsecured and hence unrecoverable. A fully secured exposure would have an LGD of 0 percent. An unsecured exposure would have an LGD of 100 percent.

**Exposure** is the underlying exposure.

These inputs typically also have their own statistical (probability) distribution and depend on a number of risk drivers or factors. The key risk drivers for the NEM are summarised in Section 2.2.

**Unexpected Loss (UL) is statistically derived and indicates the exposure at the desired probability/confidence level of the loss distribution.**

The **Unexpected Loss** is usually set at the maximum level of acceptable risk and is regarded as the level beyond which the cost of holding further capital or security outweighs the benefits.

In the case of the NEM, the **Exposure** is the statistical distribution of the sum of participants' Total Outstandings at any point in time. The **Loss Given Default** is the statistical distribution of the residual after the MCL is applied to Total Outstandings<sup>6</sup>. In the absence of any statistical information, the **Probability of Default** needs to be tested using scenarios that attach a Probability of Default to attributes such as the credit rating of market participants, their size or capital structure.

The **Expected Loss** is the mean of the loss distribution formed from the Exposure, the LGD and Probability of Default. The **Unexpected Loss** is the outcome of the AEMC's policy decision on the interpretation and definition of the 'reasonable worst case'.

**Expected Loss** and **Unexpected Loss** are also impacted by the outcome of the AEMC's policy decision on the size and composition of the MCL.

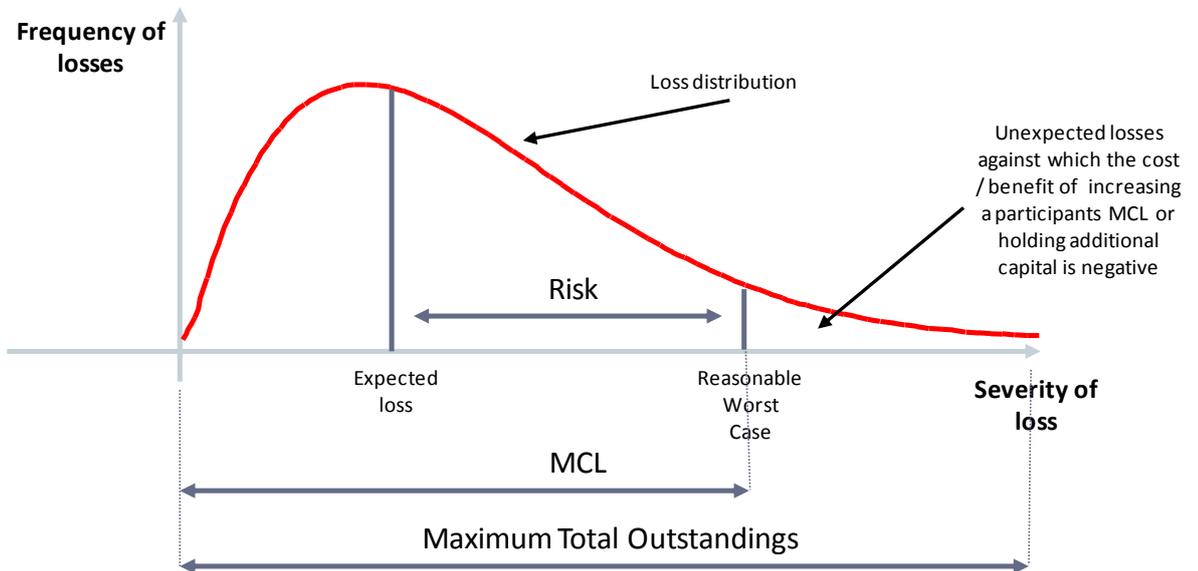
Diagram 2, on the following page, illustrates the key features of a loss distribution to a participant in the NEM.

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<sup>6</sup> Assuming that the MCL is available for application. In its unamended form, where the MCL takes the form of bank guarantees and Security Deposit Accounts, the assumption is that the MCL is effectively equivalent to cash.



**Diagram 2: Illustrative loss distribution for a participant in the NEM**



## 2.2 Implications for the NEM

We have used the framework outlined in Section 2.1 as an input in our subsequent analysis. This framework is used by some generation and retail participants in the NEM to quantify and manage their wholesale trading risk with counterparties including setting credit limits and quantifying credit exposures.

The National Electricity Rules defines the MCL and the prudential requirements for a participant with reference to the *reasonable worst case*. The definition of reasonable worst case is:

***‘A position that, while not being impossible, is to a probability level that the estimate would not be exceeded more than once in 48 months’***

Measured against the requirements of the standard credit risk analysis, this statement is a poor basis for understanding the level of Expected and Unexpected Loss intended as the outcome of the MCL. For the purposes of their analysis, PwC has interpreted the definition to mean a 98 percent (i.e. 47/48) level of confidence and, by implication, a normal curve as the basis for the loss distribution. However, we understand that other NEM participants have alternative interpretations<sup>7</sup>.

The NEM should consider adopting a more tightly defined description of the reasonable worst case and the intention of the prudential requirements, capable of testing and agreed by all participants in its intent and application.

<sup>7</sup> See the discussion in Section 4.1 relating to this issue

For example, the *reasonable worse case* could be defined as the *Unexpected Loss* in the NEM, that is, the level of exposure for a given degree of confidence or probability where the benefit of holding further capital would be outweighed by the cost. With this as a basis, market participants could evaluate competing proposals for changes to the MCL, as well as the introduction of FOA model and proposed changes to the RA.

Table 1 below summarises the key risk drivers of the PD, LGD and Exposure for the NEM and at a conceptual level how implementing an FOA, amending the MCL methodology and altering the RA framework will impact each of these.

**Table 1: Application of credit risk analysis framework for the NEM**

Item	Key risk drivers	Implication for analysis
Probability of Default	<ul style="list-style-type: none"> <li>• Retailer’s capital structure</li> <li>• Retailer’s hedge portfolio</li> <li>• Retailer’s underlying pool exposure</li> <li>• Retailer’s cash flow (mis)matches</li> <li>• Settlement time period</li> </ul>	<ul style="list-style-type: none"> <li>• The probability of default of a retailer is unlikely to be directly impacted by the design of the FOA or the MCL methodology</li> <li>• However, second order effects such as the effect of the restrictions on the FOA on the retailer’s hedging strategy and portfolio may have some impacts.</li> </ul>
Loss Given Default	<ul style="list-style-type: none"> <li>• Form of guarantee (e.g. Bank guarantee, cash, futures position)</li> <li>• Adequacy of calculated MCL to represent the required level of prudentials at the agreed level of confidence</li> </ul>	<ul style="list-style-type: none"> <li>• The LGD would be influenced by the difference in credit quality of a bank guarantee versus the expected future deposits into an SDA, i.e. is an FOA equivalent in credit quality, security and terms to a bank guarantee?</li> <li>• In addition, the adequacy of the level of guarantee based on the MCL calculation methodology would impact the LGD, i.e. an underestimated MCL would result in a near certain loss in the event of default, i.e. an LGD of greater than zero</li> </ul>
Exposure	<ul style="list-style-type: none"> <li>• Retailer’s load volatility</li> <li>• Historic actual pool prices</li> <li>• Future pool prices</li> <li>• Pool price volatility</li> <li>• Settlement time period</li> </ul>	<ul style="list-style-type: none"> <li>• The underlying exposure is a function of the retailers’ total outstandings to the NEM and not likely to be directly impacted by the design of the FOA or the MCL methodology.</li> </ul>

The key input to the loss distribution that is influenced by the design of an FOA and by proposed amendments to the MCL methodology is the **LGD**. For example, reducing the level of MCL so that its effect is less than the intended effect and/or reducing the credit quality of the form of security can significantly impact the LGD. If these factors are changed without appropriately assessing the impact on the NEM’s loss distribution, the resultant **Unexpected Loss** could increase, increasing the risk that the commonly understood definition of a reasonable worst case is no longer applicable to the same level of confidence or probability.



The FOA and MCL methodologies can also have a second order impact on the PD. These effects should be considered also as part of any analysis.

The following Sections detail our findings in relation to PwC's analysis of the FOA, MCL and RA and, where relevant, use this framework.



### 3 The Futures Offset Arrangement Model

The PwC report analysed two FOA models. Based on their discussions with stakeholders they concluded that Model 1 was not suitable and confined their further analysis to Model 2. Our assessment and all references below relate to Model 2 and PwC's subsequent enhancements.

#### 3.1 Futures Offset Agreements: Key Characteristics

The FOA model would, in exchange for certain conditions affecting the nominated futures positions, reduce those participants' Maximum Credit Limits (MCL) and alter the form of the prudential security held by AEMO against a loss to all market participants from a participant default. Table 2, below, describes the key details of the FOA model, based on the Working Examples provided to PwC<sup>8</sup>.

#### 3.2 Futures Offset Agreements: PwC's Recommendations

PwC concludes that FOA model proposal is likely to be "of significant value to retailers while not significantly adding to the NEM risk."<sup>9</sup> While PwC does not believe significant additional risks to the NEM are presented by the FOA model, it recommends:

- if the AEMC requires the termination risk to be covered an additional day could be added to the MCL period for a participant's FOA.
- the variation margin calculation be changed to include reference to the maximum spot price in the outstandings period as opposed to the variation margin calculated on the basis of the FLP, to bring into line the volume of MWh on which the retailer is required to make variation payments and the volume of MWh for which the retailer has received a reduction in its MCL.
- existing or revised AEMO load assessment processes should be used to address unique risks to each market participant in relation to its load profile rather than adjusting through a standard futures discounting factor.
- introducing a requirement that, a floor on the value of the SDA account is introduced, equivalent to the value of the accumulating spot over the period to address the differences between the margin payments required by AEMO under the proposed model and the obligations of a retailer to AEMO that may arise from time to time.

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<sup>8</sup> AEMC, *Working Examples of Futures Offset Arrangements (FOA) Models for Risk Assessment*

<sup>9</sup> PwC, p 4



**Table 2: Our understanding of the Futures Offset Arrangement proposal**

Elements of the Futures Offset Arrangement	Key Components <sup>10</sup>	Issues/comments
<p>Conditions entered into by a retailer relating to the nominated futures positions</p>	<ul style="list-style-type: none"> <li>• Agreement that future cash flows relating to the nominated futures positions will not be netted against other futures positions (1.2.2.1)</li> <li>• Agreement that margin payments received for the nominated positions will be forwarded to AEMO (5.3)</li> <li>• Obligation to provide information on futures prices, and related contract variations and positions (1.2.2.2, 1.2.2.4)</li> <li>• Agreement to the performance of random audits by AEMO of nominated contracts and futures positions (1.3)</li> <li>• Nominated futures positions to be set up under separate, unencumbered client sub accounts (5.1)</li> <li>• Agreement to notify AEMO 10 days before the termination of the nominated security (5.2, 8.2.3)</li> </ul>	<ul style="list-style-type: none"> <li>• A number of these conditions are designed to provide AEMO with some protection in the event of a default by a retailer on its futures positions, resulting in the termination of the nominated futures position, the application of any expected margins on the nominated futures position to margin calls on other positions and the possible claw back of funds held in the SDA to meet the retailer’s obligations to the SFECF, the SFE or other creditors.</li> <li>• The most significant of these, the agreement that the cash flows will not be netted off against the cash flows of other futures positions, may not be enforceable in the event of default (5.1.2; PwC, p 40)</li> </ul>
<p>Reduction in the retailer’s Maximum Credit Limits (MCL)</p>	<p>For the load covered by the nominated futures contracts, the participant’s MCL is reduced by:</p> <ul style="list-style-type: none"> <li>• the Futures Lodgment Price, set by the closing futures price for the relevant futures contract on the day the retailer enters into the FOA</li> <li>• offset by a beta factor<sup>11</sup></li> <li>• multiplied by a reduced credit time limit (the</li> </ul>	<ul style="list-style-type: none"> <li>• The retailer selects the Futures Lodgment Price by determining when an FOA is established. This introduces possibilities for the retailer to benefit from inefficiencies in the futures market. For example, the retailer benefits from entering into an FOA when the FLP is low, relative to the price assumed in the MCL equation and will choose the lodgment date based on its view of future prices. In a</li> </ul>

<sup>10</sup> All references are to the AEMC, *Proposed FOA Model 2* unless otherwise noted.

<sup>11</sup> Not supported by PwC and, in the form included in the Working Examples, not operating as intended to modify the reduction in the MCL.



Elements of the Futures Offset Arrangement	Key Components <sup>10</sup>	Issues/comments
	<p>reaction time period is not included in the credit time period), (7.2)</p>	<p>uniformly liquid futures market, market manipulation may not be possible but the potential may exist from time to time in any futures market and, depending on the development of the Australian electricity futures market, may be available more frequently than at present.</p> <ul style="list-style-type: none"> <li>Given the possibility for manipulation, the criteria for deciding that a given market is liquid are very significant and need to be considered in the evaluation of the model.</li> </ul>
<p>Alteration in the form of the prudential security held by AEMO</p>	<ul style="list-style-type: none"> <li>AEMO receives an unconditional bank guarantee for the MCL up to the Futures Lodgment Price (PwC, p32)</li> <li>Use of the Security Deposit Account restricted to use as a security only (6.11.1)</li> <li>To the extent that the retailer's obligations to AEMO increase with rising prices, then the positive margins on the nominated futures contracts to be received by AEMO are assumed to provide an offset. If this does not occur, AEMO suggests the application of a shortfall equation (6.8, 6.8.1) and PwC suggests a floor on the value of the SDA account equal to the accumulating spot over the period (PwC, p 38)</li> <li>To the extent that the futures price falls, but remains above the Futures Lodgment Price and provided that the retailer's total obligations to AEMO are less than the retailer's total SDA account balance, negative margins can be returned to a retailer or, on application, withdrawn subsequently from the SDA (6.3, 6.6.3.2, 8.4)</li> </ul>	<ul style="list-style-type: none"> <li>Both AEMO and PwC appear to recognise that the relationship between futures and spot prices may not hold for periods of time and that the promise of cash may not present a sufficient security for the NEM.</li> </ul>

### 3.3 Our Evaluation

The questions we believe need to be answered about the FOA model are:

- Does the proposed reduction in the MCL associated with an FOA present a risk to the prudential framework of the NEM that would increase the (risk of a) loss to participants in the event of default?
- Does the altered form of the security associated with an FOA present a risk to the prudential framework of the NEM that would increase the (risk of a) loss to participants in the event of default?
- Are the restrictions imposed in the proposed FOA likely to be effective in safeguarding the position of the NEM in the event of default?
- Are there significant net benefits to the NEM that should be considered in evaluating the proposal?

Based on our assessment of the modelling and other work undertaken by PwC, we believe that these questions have not been answered in a way that would allow the AEMC or market participants to assess the merits of the proposal.

Briefly, in our view, the first of our questions cannot be answered without previously specifying the underlying distribution of potential losses in the NEM and the intention of and expected effect of the current prudential arrangements, in line with the discussion in Section 2.

The answer to the second of our questions requires more sophisticated analysis than that undertaken by PwC: if NEM participants are to accept the promise of future cash as part of the prudential requirements for some NEM participants<sup>12</sup>, then the expectation that that future cash will be adequate and available for application by AEMO to a defaulting participant's obligation needs to be soundly based. Our analysis suggests the work undertaken by PwC to demonstrate this proposition is inadequate and our recommendations as to the necessary analysis are given below.

The third of our questions goes to the issue of availability both of the final margin payment in the event of default and of previous payments received, in the event that AEMO's receipt of previous margin payments is challenged. AEMO and PwC appear to share our view that, in default, the prohibition on netting is unlikely to be observed by the defaulting retailer's SFEC<sup>13</sup>. We are also concerned that apparent separation between the clearing house and AEMO achieved by AEMO recalculating SFE closing prices will not be effective protection against claw back in the event of insolvency. Legal advice should be sought on this question.

Finally, the extent of the estimated benefits to the NEM appear to be very high, judged by the experience of RA penetration, the practical disadvantages relating

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<sup>12</sup> Effectively, the relationship between futures margin payments and a retailer's total outstandings is required to reassure NEM participants that the cash will be there, should it be required. Both AEMC and PwC recognise that the promise of cash may be insufficient, requiring other security in the event that the relationship fails.

<sup>13</sup> AEMC, *Working Examples of FOA*, Model 2, 5.1.2; PwC, p 40



to the frequent adjustment of bank guarantee levels and the cost of the portfolio restrictions imposed by the FOA model. PwC's calculation of the Net MCL relief<sup>14</sup> also significantly overestimates the benefits by including the difference between the Prudential Margin and the Example MCL. In addition, PwC overestimates the benefit to the NEM by including the total reduction in prudential requirements in the calculated benefits. To the extent that bank guarantees are used to provide the NEM prudentials, the direct cost to participants is the cost of the bank guarantee, not the full amount of the requirement<sup>15</sup>.

### ***Have the proposals been tested appropriately?***

Our analysis of PwC's tests has focused on Section 4.3.2 of the PwC Report. Section 4.3.2 considers the adequacy of the FOA on average. All the analyses presented in this section and PwC's conclusions are reliant on the observation that the spot and futures prices move in correspondence, an assumption corroborated by favourable Pearson's R-squared test for correlation.

- The measurement of correlation between spot and futures prices would be better served by a more appropriate measure than the Pearson's correlation coefficient.
  - Pearson's correlation coefficient describes only the linearity in the relationship between spot and futures prices, inadequately summarising the relationship. An additional test such as Granger's causality test may prove more informative given the causal nature of the relationship. This test has become commonplace in testing linkage between financial variables. In addition, recent advances in the Granger's test remove the imposition of normally distributed errors in the relationship, improving its usefulness.
  - Substituting the Granger's causality test for the Pearson's correlation coefficient is unlikely to produce a radically different result. However, correlation tests are not our preferred analytical approach.
- Multiple summary tests should be used to describe the relationship between spot and futures prices, including Pearson's correlation coefficients, Granger's causal tests and standard non-parametric tests of difference. The distribution of the relationship between changes in spot prices and changes in futures prices needs to be more completely investigated, particularly examining the frequency and magnitude of difference of events where the spot and futures price process diverge. Such an analysis will better capture the risks associated with the proposed hedging arrangements than the current correlation analysis.

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<sup>14</sup> PwC, p78

<sup>15</sup> There are indirect costs in maintaining a capital structure consistent with the use of capital guarantees for prudential requirements, but we have not considered them. Smaller NEM participants, without access to the bank guarantee market, may be obliged to maintain higher levels of working capital than otherwise, to meet their prudential requirements, but arguably, the benefit of a reduction in the prudential requirements is the opportunity cost of that working capital.



- Looking at the analysis PwC includes, the graphical results show a divergence of futures from spot prices on numerous occasions<sup>16</sup>. These divergences occur with even greater frequency in states other than NSW, but are not discussed in PwC's analysis, either in the NSW case or for other states.
  - In assessing the risks of the proposed FOA system, it is critical that the impact of adverse experience be quantified, whereas it currently goes unconsidered.
  - To quantify the risks and to be able to calibrate a forecasting model for stress-testing, some modelling of the spot-future price differential distribution's tail should be undertaken.
  - Simple threshold models are available in standard statistical packages, and would allow the analysis of the frequency and magnitude of adverse price disparity on historical data.
  - Given the size of the Australian futures market, and the exceptional volatility of futures with no underlying deliverable in futures markets generally, we believe that a threshold analysis of price differentials is a minimum requirement to understanding the risks of the FOA.
- PwC's analysis is dedicated almost exclusively to the risk associated with a single futures contract offsetting price risk. Little consideration is given to the additional risk to the Retailer (and its counterparties) from the implementation and operation of a hedging program. This lack of consideration is natural given that it is assumed the future and spot price correspond. However, this correspondence is unproven.
  - International electricity futures markets show "extreme volatility, mean-reversion, skewness and kurtosis of returns, jumps and spikes, and seasonal behaviour"<sup>17</sup>.
  - Recent studies on futures market hedges for electricity in European markets suggests that while optimal hedging strategies are shown to decrease the variance of the portfolio, the portfolio remains far from perfectly hedged. Critically, the restrictions on the trading of hedged positions that the FOA introduces<sup>18</sup> could force a static or naïve approach to hedging by the Retailers. In European markets, this was shown to produce minimal reductions in portfolio volatility<sup>19</sup>.
  - While we recognise the distinctions between the Australian and the European market places, the analysis does demonstrate the need for more thorough technical analysis.

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<sup>16</sup> For example, in Figure 4.3.2.d (PwC, p 36) for the Q2 NSW futures contract in 2005, 2006, 2007 and 2008, as well as the Q4 NSW futures contracts in 2005, 2006 and 2007. The comparable charts for Queensland (7.2.2.h) and Victoria (7.2.2.j) suggest that, contrary to the conclusions drawn by PwC on the basis of the NSW data, the SDA balance is only likely to exceed NEM requirements in the Q1 contract.

<sup>17</sup> Madaleno, M & Pinho, C (2008) "The hedging effectiveness of electricity futures"

<sup>18</sup> Table 2; PwC, Section 4.3.1.

<sup>19</sup> Madeleno & Pinho, 2008

***Can you evaluate the proposals from the information provided?***

Key details of the proposed changes are unclear and/or underspecified, making the implications for the NEM prudential framework difficult to assess reliably. For example, the FOA model does not detail any requirement for the futures position to be a bought position, or for it to be in the same region as the underlying exposure. Whilst these specifications may be implied or obvious, they are not explicitly mentioned. The supporting analysis does refer, however, to the increased risk (due to a divergence of spot and futures prices) in the event where a futures position is in a different region to the spot market exposure, suggesting that the intention is that the FOA model will be restricted to futures contracts for the relevant market.

- There is no volumetric restriction placed on the maximum (or minimum) size of an FOA a retailer can lodge
  - Consideration should be given to the need for minimum volume levels for an FOA to meet any cost/benefit and risk assessments. For example, it may not be beneficial to have just 1 MW of a futures position as an FOA. This is consistent with the current approach adopted by AEMO for requiring minimum levels of bank guarantees to be lodged for even start up retailers.
  - There has been no analysis of the implications of a retailer lodging an FOA at volumes equal to its expected load. The report discusses the disincentive for retailers to lodge FOAs at greater than their expected load due to the need to lodge guarantees equal to the FOA level<sup>20</sup>. However, there is no analysis on the implications for a retailer and its credit profile in the NEM of lodging FOAs equal to their expected load.
  - Analysis should be undertaken to determine the minimum and maximum levels of FOA that should be accepted by AEMO.
- Similarly, the implications of the difference between the flat load profile of a futures contract and the actual load profile are only briefly referred to<sup>21</sup> and the recommended adjustment by AEMC not analysed for its impact on the FOA model benefits.
  - Both this issue and the issue of the minimum and maximum FOA limits are likely to be important to the estimated LGD and they need to be considered in the analysis.
- The report identifies that a response to the potential risk associated with the termination of an FOA as a result of either retailer failure or termination of the underlying futures contract by the clearing participant could be to add an additional day to the MCL period.

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<sup>20</sup> PwC, Section 4.4.3 p44

<sup>21</sup> In proposing that the AEMC modifies the proposed FOA model for individual participants to reflect an individual participant's load profile, PwC has not assessed the implications of errors in assessing load profiles and may also have reduced the value of the FOA model to retailers, something which is not accounted for in the benefit/cost analysis.



- This solution is designed to cover the time lag between the call for additional security by AEMO and the failure of the retailer to pay the required amount.
- In a default situation, if spot prices are high, as is likely, one day's additional prudential cover is likely to be insufficient to cover this incremental risk. Any incremental prudential cover needs to allow for the conditional nature of the risk (the event of failure is considerably more likely when prices are high) and the resulting high correlation between the termination event and high spot prices<sup>22</sup>.
- The effectiveness of an FOA as a means of credit support is entirely dependent on the retailer providing the margin payments to AEMO within the required timeframe. In the absence of the requirement for a transfer to the SDA (say, for example, no margin payment was due, or a negative margin payment is payable), AEMO will rely on the participant's continued compliance with the Rules and its own information gathering to monitor performance.
  - AEMO's information gathering and analysis will need to be designed to take account of this monitoring task. In the absence of this, there is the potential for the exposure of the NEM to be longer than a day and the incremental risk to the NEM to be underestimated.
- No trigger events are described that would enable the AEMC or AEMO to review the availability of the FOA or, if necessary, terminate FOAs in place for a given region. The analysis and conclusions reached are based on the implicit assumption that going forward there will be a liquid futures market that also has a strong relationship to the underlying spot market in NSW, Victoria and Queensland. The FOA model should be further detailed to outline:
  - The minimum required 'thresholds' for AEMO to offer the ability for retailers to lodge an FOA in a given region, e.g. minimum level of liquidity, minimum degree of correlation between spot and futures prices
  - A review process to monitor these thresholds on a regular basis. In addition, AEMO needs to consider how it works with the SFE to ensure that changes such as, for example, those introduced recently to the trading period, are consistent with the continued use of the FOA model.
  - A process to suspend, amend or terminate the FOA for a given region should any of the required thresholds be breached.

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<sup>22</sup> The underlying reason for the additional day in this instance is different to the reason for the additional day in the RA (see Section 4.2 below), but our concern with the identified remedy is similar: an average day's cover is unlikely to be adequate in the event of a default or termination.



### 3.4 Our Recommendations

Based on our review of PwC's draft report, we suggest that:

- In light of the identified gaps in PwC's analysis, the recommended statistical approaches are used to reanalyse the FOA and its impact on the prudential arrangements, with particular reference to the size and duration of divergences between futures margins and pool exposures and the potential for market participant losses during these periods.
- In addition to these analyses, the AEMC should clarify the likelihood that SFECs will quarantine nominated futures positions in the event of a default of a futures market participant on other futures positions and provide participants with legal advice on the effectiveness of other proposed mechanisms to reduce the risk of claw-back in the event of default<sup>23</sup>.

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<sup>23</sup> In particular, the suggestion that the duplication of the SFE's calculations by the AEMC provides protection against claw-back.

## 4 Proposed Changes to the Maximum Credit Limit and Reallocation Agreements

### 4.1 Maximum Credit Limit: PwC's Recommendation

In undertaking their analysis PwC looks at four different MCL approaches, namely:

- The Current MCL (Current MCL)
- Futures MCL (FUT MCL) – developed using spot futures and applying a volatility factor derived from the spot futures
- Stress Test MCL (Admin MCL) – developed by using one week of the Cumulative Price Threshold (for the reaction period) coupled with 4 weeks of futures (outstandings) and a week of futures (accumulating outstandings) scaled to incorporate a volatility factor.
- Hybrid Model (MCL V1) – utilising spot prices for the 4-week outstandings period and futures prices for the one week of accumulating outstandings and administered pricing for the one week reaction period. A volatility figure, utilising futures prices, is calculated for the one week of accumulating outstandings only.

PwC concludes that for NEM regions with sufficient trading activity, currently NSW, QLD and VIC, a forward looking approach using futures “be strongly considered”<sup>24</sup> for implementation, based on the apparent merits of the Futures MCL when compared with the Current MCL. The existing approach would be retained under their proposal for South Australia and Tasmania.

#### 4.1.1 Our Evaluation

An understanding of the likely distribution of losses by size of potential loss and a clear framework for the NEM’s prudential arrangements are necessary to understanding the operation of the current prudential arrangements and providing a basis for evaluating alternatives. Section 2 discusses the framework that we recommend should be used to identify the intention of the NEM Prudential Arrangements and to determine the level of protection provided by the current arrangements and its consistency with market participants’ understanding of the protection provided.

In forming its recommendations on alternatives to the MCL, PwC appears to rely on an assumption that the underlying distribution of losses in the event of default resembles a normal distribution, with remote events at the 99.5 percentile similar in scale of potential loss and significantly less frequent than events at the 98 percentile<sup>25</sup>. PwC interprets the current arrangements as

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<sup>24</sup> PwC, p6.

<sup>25</sup> PwC’s discussion of the use of the 99.5 percentile as the point up to which the Current MCL aims to provide participants protection against loss in the event of default assumes that this shift would will only “incrementally increase the effectiveness at a serious



intending to provide protection to participants against the risk of a loss in the event of default in 98 percent of all pricing information in the evaluation period, or once in 48 months<sup>26</sup>. The operation of the current prudential arrangements is a factual question and can be investigated using NEM statistics. International and Australian studies of the performance of electricity markets, however, consistently conclude that the distribution of underlying performance is not consistent with a normal distribution, suggesting that PwC's assumption is likely to underestimate the potential losses to participants<sup>27</sup>.

#### 4.1.2 Have the proposals been tested appropriately?

Looking at the analyses that PwC has undertaken, the volatility calculation used to demonstrate the performance of the inclusion of futures prices in the MCL has the following statistical flaws:

- The calculation of the volatility factor for the FUT MCL is atypical. Using historical data is appropriate, but using highly-dependent futures spot prices in standard volatility estimation is inappropriate. Alternative approaches which consider volatility variation are more complex, but need to be considered given the evidence of the relationship of volatility in the NEM with demand, price, season and time of day<sup>28</sup>.
  - Typically, estimates of volatility follow some maximum likelihood estimation of the natural logarithm of the asset price. This estimate comes from the underlying assumption of constant volatility – resulting from prices which are assumed to follow geometric Brownian motion. Estimating volatility using this approach would likely result in a lower estimate for the volatility, suggesting price volatility has been historically overestimated for the MCL.
  - However, this conclusion would be flawed, as the assumption of constant volatility is demonstrably false in the NEM. A GARCH model is popularly used for modeling the randomness of volatility in the futures prices.
- Multiplying the weekly volatility by the square root of six implies independence in the volatility of futures markets week-to-week. It is plausible and consistent with the evidence that highly volatile futures returns one week inform volatility the next week. This correlation is particularly potent in the tails of futures return distributions and would be of material interest to combining 98th percentiles. The volatility

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impairment to the efficiency of the MCL" (p 46), suggesting that the distribution underlying their analysis is similar to a normal distribution.

<sup>26</sup> PwC, pps 45-46, 50. PwC's does not directly conclude that a month is the appropriate period, but its subsequent analysis of the Current MLC uses monthly data and its evaluation of alternatives relies on quarterly data.

<sup>27</sup> For example, Duffie, D and Gray, S, "Volatility in Energy Prices", *Managing Energy Price Risk*, Risk Publications, 1995; John Field Consulting Pty Ltd, *Characterising pool price volatility in the Australian electricity market: report produced for National Electricity Code Administrator*, 2003

<sup>28</sup> John Field, 2003, pps 9-10

multiplier calculated in the absence of considering this relationship is underestimated.

- Given the reduction of the MCL that is part of the FOA model, the volatility multiplier calculation takes on increased significance, affecting the potential LGD.<sup>29</sup>
- The proposed FUT MCL volatility calculation is determined only by futures prices weighted by time, with no load adjustment made at all. In our view, this is inconsistent with the original basis of the MCL to represent the "reasonable worst case" estimate of the NEM's potential exposure to the participant.
  - This resulting volatility multiplier will be lower than the existing volatility multiplier because that calculation was demand-weighted<sup>30</sup>.
- In our view, it would be appropriate to explicitly recognise load volatility in the calculation of the MCL.
  - An additional volatility multiplier could be added to capture the load volatility by considering the ratio of the volatility of load in dollars to the volatility of spot prices (or more appropriately a transform thereof). Such an adjustment would be able to explicitly separate price and load risks.
  - In including load volatility, the reduction in the MCL modeled by PwC would be reduced, possibly significantly, and the benefits to participants of the proposed changes correspondingly overstated.
- Further analysis is recommended. Even a simple load volatility multiplier such as that discussed above has flaws, such as not reflecting increased correlation in price and volume during extreme events. The relationship between price and load (at both an expected and extreme event level) needs to be better understood through modeling and incorporated into the MCL calculation for the MCL to achieve its objectives.

#### 4.1.3 Can you evaluate the proposals from the information provided?

The tests of the alternative MCL proposals lack the information required for a reader to make an informed judgement about performance. Specifically:

- The annual summary in Figure 5.3.7.a of the PwC report is too broad to understand the underlying behaviour. A finer summary – potentially weekly to reflect the settlement period – would provide more useful information on autocorrelation in MCL breaches, that is, whether or not

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<sup>29</sup> There are other possible interactions with the MCL not explored by PwC. Given the backwards looking nature of the current MCL calculation and the demonstrated seasonal pattern in futures prices, it may be the case that the FOA model only provides a reduction in the MCL for certain quarters of a year. Q1, where futures prices are typically high, may not be one of those quarters.

<sup>30</sup> PwC, p 65



there are any tendencies for breaches to be related, as a result, for example of one high priced day following another.

- While the probability of the breach is necessary to judge each MCL alternative, it is not sufficient. The expected shortfall in the MCL relative to total outstandings (loss in the event of default) given the existence of a breach is necessary also. Without this information, it is impossible to determine the likely impact of each alternative.

#### 4.1.4 Our Recommendations

The inclusion of a forward looking element in the calculation of an MCL is likely to improve its effectiveness and efficiency. However, further work is warranted before a final methodology change is determined:

- The AEMC and market participants analyse the current prudential arrangements in the light of the intention of the Rules, the understanding of the market participants and standard loss provisioning techniques. That analysis should use the extensive data available on the performance of the NEM and consider the literature on the performance of the Australian and other similar electricity markets.
- Potential changes to the MCL should also be analysed in the light of the performance of the NEM over time. In particular, recommendations that relate to the need for additional prudential cover should take into account the relationship between load, price and the probability of default in considering what additional support is required to offset the risk to market participants.

## 4.2 Reallocation Agreements: PwC's Recommendations

PwC's report discusses the risk associated with the termination of a Reallocation Agreement following a generator default which then causes a retailer default<sup>31</sup>. The AEMO process in this instance could result in the RA being terminated and the retailer being required to provide additional support within 24 hours. If the retailer fails to provide the required support then PwC estimates the NEM is potentially exposed to a full day's exposure for that retailer.

PwC makes a number of recommendations relating to the RA, including:

- RAs should continue to be supported by AEMO as a means to minimise the prudential support burden for NEM participants.

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<sup>31</sup> PwC's analysis suggests that there are no occasions where a retailer default *not* preceded by a generator default would give rise to a loss to the NEM, although there are occasions where the generator counterparty would incur a loss. A retailer could default on its other OTC positions, not the subject of a RA, and still meet its NEM prudential requirements, provided that it continued to perform on its RAs. In this example, AEMO may act to bind both participants to the RA until suspension occurs. The effect of AEMO's actions needs to be better examined in the event where the participant becomes bankrupt.



- If the AEMC is concerned regarding the mitigation of the one day termination risk, the best way to address this is by adding an additional day to the 7 day prudential margin.
- Market participants would benefit from AEMO providing formal documentation of the process undertaken by AEMO in their review of any reallocations as this would provide additional reassurance of the robustness of the process.
- A review of the NEM rules to ensure that 3.15.1 correctly represents AEMO's role in the settlement process for RAs should occur.
- A modification to NEM rule 3.15.1 to minimise AEMO's involvement in the settlement process of swaps and options should be made.

#### 4.2.1 Have the proposals been tested appropriately?

The recommendation to manage the identified incremental NEM exposure to a risk of loss by extending the MCL by adding an average day's outstandings to the prudentials required suffers from the issues affecting the evaluation of the MCL and its alternatives. PwC's assessment fails to take account of the contingent nature of the particular risk (the identified risk depends on the risk of a prior event, in this case, the failure of a generator) and that probability of default is at its highest when spot prices are high. Adding one day to the MCL period would increase the MCL by the level of the average spot price multiplied by the volatility factor, which is sufficient for 'average events'. In practice, the actual cumulative spot price after such an event could be much greater.

- For example, if a generator defaulted it would be reasonable to assume that there is a higher probability of high spot prices. In these circumstances, the average spot price for the day could be at least \$300/MWh, if not significantly more. When this is compared to the historic values implied from AEMO's MCL calculations, the difference can be easily as high as \$150/MWh. In this example, an additional two day's coverage would need to be added to cover for this contingent risk, not one day.

#### 4.2.2 Our Recommendation

Potential changes to the RA should be analysed following the recommended analysis of the performance of the NEM and the intention of the MCL. Following this analysis, we recommend that further analysis is undertaken to determine whether there is a more suitable increment to the MCL period than the one day recommended to cater for these conditional events.



## A. Scope of Work

### National Generators Forum (NGF)

#### **Project: Critique of PwC prudential risk review**

#### **Background:**

The AEMC is conducting a review into the NEM prudential regime (“the review”). This review is considering some potential risks in the existing reallocation arrangements, as well as the proposed Futures Offset Arrangements, and alternatives to the NEM’s existing Maximum Credit Limit (MCL) formulation.

To date, the AEMC has formed a working group (on which the NGF is represented) to assist the Commission’s staff in conducting this review. As part of its deliberations this working group has identified a number of risks and questions around the subject areas of the review. The AEMC has commissioned PricewaterhouseCoopers (“PwC”) to assess these risks and provide recommendations on their materiality, and how they may be mitigated.

#### **NGF positions:**

NGF members are the main creditors to the NEM pool. As such they are keenly interested in ensuring that pool credit quality is maintained.

In considering this AEMC review, the NGF has worked to the principle that:

*The NGF would support improvements to the NEM prudential regime that improve its efficiency, provided that the changes enhance or at a minimum do not reduce the credit quality of the NEM.*

#### **The Brief:**

It is expected that a draft of the PwC report will be released for comment on Monday 12th of October. A very brief 3 week consultation period is expected to allow participants to thoroughly consider this key report.

It is expected this report may recommend adoption of a Futures Offset Arrangement, and some changes to the MCL regime (including use of futures price in establishing MCL’s).

The NGF requires a desktop analysis of the PwC report to:

- review PwC’s risk analysis;
- to identify any additional risks not contained in the PwC report that may increase the risk of pool short payment;
- review the proposed Futures Offset Arrangement, including (but not limited to):
  - does the proposed FOA model increase credit risk for the pool?
  - how does the credit position of the pool with the FOA arrangement, compared with the credit position of generators under the existing arrangement?



- has the quantitative assessment methodology conducted by PwC appropriately assessed the risk of short payment under credible pool stress events?
- is the FOA arrangement robust in the event of retailer failure?
- review the MCL analysis, including identification of any key gaps in the PwC analysis, material risks not considered by PwC, or other issues that could impact on pool credit quality;
- review the PwC reallocation analysis, with emphasis on how this may be used as a comparator to the FOA approach in comparing with existing pool credit quality, and the appropriateness of any such comparisons implied by PwC.

As the draft PwC report has yet to be released, some adjustment of these questions may be required by the NGF on the basis of the report delivered.



## B. References

Australian Energy Market Commission	Working Examples of Futures Offset Arrangements (FOA) Models For Risk Assessment, 2009
Duffie, D and Gray, S	"Volatility in Energy Prices", <i>Managing Energy Price Risk</i> , Risk Publications, 1995
John Field Consulting Pty Ltd	<i>Characterising pool price volatility in the Australian electricity market: report produced for National Electricity Code Administrator</i> , 2003
Madaleno, M and Pinho, C	"The hedging effectiveness of electricity futures", <i>European Financial Management Conference</i> , October 9, 2008
PricewaterhouseCoopers	<i>Review into the role of hedging contracts in the existing NEM prudential framework</i> ,(Draft), AEMC, September 2009